THE INTEGRITY AND DURABILITY OF STRUCTURES AND MACHINES

John Knott*

INTRODUCTION

For a variety of engineering enterprises, a full assessment of 'structural integrity' should incorporate not only the "one-off" appraisal of the margin between safe operation and failure at a given moment in time, but also a prediction of future behaviour. There are three areas in which such predictions are important: i). in specifying appropriate inspection periods for existing plant, ii). in making decisions on possible plant life extension (PLEX), iii). in setting the design life for new plant. Since *failure is defined as loss-of-function*, the *function* of the enterprise should always be considered, to ensure that the relevant failure modes are being considered: not only failure by fast fracture or by tensile plastic collapse, but other modes, such as the buckling of slender cross-sections subjected to compression. Note, for example, that the first stage rocket motor casing for the *Saturn* rocket could not, un-pressurised, support the weight of the rocket without buckling, and a gantry was needed to support the rocket before take-off.

DEVELOPMENT OF STRUCTURE INTEGRITY ASSESSMENT TECHNOLOGY AND METHODOLOGY IN CHINA

Zhong Qunpeng[1] Luo Hongyun[1] Wu Sujun[1] Zhang zheng[1]
Chen Gang[2] Li Peining[3] Chen Xuedong[4] Li Xueren[2]

This paper reviews the development history and main research achievements of engineering structural (pressure vessel and pressure piping etc.) integrity assessment theory, technology, methodology, criteria and standards in China, from the point of view of failure mode, criteria of evaluation, assessing technique and assessing conditions. Following an introduction of the successful applications of the regulatory and standards of the safety assessment and failure analysis on the pressure vessels, pressure piping and engineering trusswork in the industries of aeronautics, mechanical, special equipment, petrochemical and port mechanical, the research developments and prospects of engineering structural integrity assessment theory and technology in recent

years are summarised. The paper concludes by describing the theories, technology and applications of engineering structural integrity in China and abroad from the macroscopic view while the outstanding innovative points of which are proposed.

A STUDY ON METHODOLOGY FOR ASSESSING STRUCTURE INTEGRITY BY USING A NEWLY DEVELOPED TECHNIQUE OF EXTENCIS FOR PROCESS EQUIPMENT

Shu-Ho DAI*

Extension engineering method is a peculiar to Extencis which is a newly developed and rapidly evolving discipline. A brief statement of Extencis, the matter-element theory, the extension set theory, extencis in structure integrity applications for process equipment proposed in the form of case study all those will be discussed in the present work.

INTRODUCTION

The assessment of structure integrity is of great significance for ensuring safe and high efficiency operation in modernized large-scale and high parameter facilities of chemical, petrochemical, nuclear and electric power plants.

The technique for assessing structure integrity for process equipment is a comprehensive technology dealing with the use of experience of multi-disciplines. It is because of that the functions, constructions, operating conditions and media are quite different in different process equipment; thus the failure models present a wide variety of mechanisms, and the techniques for assessing structure integrity used in process equipment must give special consideration to individual cases, so that there is no generalized method given in this framework[1].

However, based on the fuzzy set theory, the author has suggested a method of approximate and plausible reasoning for analysis of integrity for pressurized components[2,3]. And now a newly developed technique of Extencis as an another useful tool used in integrity assessment for evaluating the status of operating condition of process equipment will be proposed and discussed below.

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ON THE STRUCTURAL INTEGRITY OF BIOLOGICAL MATERIALS: BONE AND TEETH ——ABSTRACT

Robert O. Ritchie*

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The age-related deterioration of both the fracture properties and the architecture of "hard" mineralized tissue, such as bone, coupled with increased life expectancy, are responsible for increasing incidences of bone fracture in the elderly segment of the population. In order to facilitate the development of effective treatments that counter this elevation of the fracture risk, an understanding of the mechanisms underlying the structural integrity of bone and in particular how fracture properties degrade with age has become essential. In this talk, the origins of the toughness of human cortical bone (and dentin, a primary constituent of teeth and simple analog of bone) are examined by considering the salient micro-mechanisms of failure over a broad range of characteristic dimensions from molecular to macroscopic length-scales. It is argued that although structure at the nanoscale is important, it is microstructural features at the scale of one to hundreds of microns that are most important in determining fracture risk. It is further shown that biological aging, disease states, and certain therapeutic treatments, e.g., steroids, can cause deterioration in "bone quality" which markedly raises this fracture risk, principally by affecting the toughening mechanisms over a broad range of dimensions.

DYNAMIC EVOLUTION OF MAJOR ACCIDENTS

—— CONCEPTS AND RUDIMENTS

LIU Tiemin*

To further research on the generative and evolutionary machine of major accidents, on the base of comparative studies of typical major, special major accidents, the paper applied theory of system dynamics to analyze dynamic characteristics of inoculation, generation, development and qualitative change of major accidents, explore behavioral process and main influencing factors of major accidents and probe into governing rules of closed loop feedback system of major accidents. The author proposed to apply theory and methodology of system dynamics to establish a decision-making laboratory to elevate risk control ability of major accidents.

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China Academy of Safety Science and Technology

ADVANCES IN RESEARCH OF HIGH-TEMPERATURE STRUCTURE INTEGRITY OF PRESSURE-BEARING EQUIPMENTS IN CHINA

Chen Xuedong[**1],Tu Shandong[2], Fan Zhichao[1], Guan Weihe[1], Jiang Jialing[3], Gao Zengliang[4]

The direction of efforts at present and in the future for Chinese scholars is to assure the safety of high-temperature pressure-bearing equipments and to form the defect evaluating code of high-temperature structures. In this paper, the present research situation, existing problems and future development direction of high-temperature structure integrity of pressure-bearing equipments in China are discussed in the aspects of NDT of high-temperature defects, structural integrity assessment of high-temperature defect-containing structures, high-temperature fatigue-creep behavior and life prediction and damage assessment etc.

INTRODUCTION

During 1995~2000, investigations were carried out four times on the safety conditions of pressure-bearing equipments in petrochemical enterprises in China. As a result, it is found that many failure cases are all related to high-temperature environments, e.g. creep, high-temperature fatigue, high-temperature corrosion, high-temperature embrittlement, high-temperature carburization, high-temperature hydrogen damage and high-temperature oxidation, etc. In addition, the pressure-bearing equipments in high-temperature environment have characteristics of high failure probability (about 13%) and severe failure consequence. At present the high-temperature integrity assessment codes of developed countries, e. g. R5 “Assessment procedure for the high temperature response of structures”, mainly aim at creep-dominated failure assessment of nuclear industry. However, the service conditions of Chinese pressure vessels and process characteristics of petrochemical enterprises are somewhat different from foreign countries. On the one hand, the typical process temperature range of Chinese petrochemical enterprises is generally from 200℃ to 550℃, in this case the dominating mechanism of creep failure is not significant. On the other hand, part of the process temperature of the petrochemical enterprises exceeds the creep temperatures of C-Mn, C-Mo steel and Cr-Mo steel, and approaches the creep temperature of stainless steel. Hence, under certain conditions, the high-temperature pressure-bearing equipments may also encounter the fatigue-creep interaction. These differences above mentioned make it impossible to directly borrow and copy the foreign codes for the integrity assessment of high-temperature structures of countries. Therefore, it will be of great practical significance and urgency to develop the mechanical behavior, damage assessment and defect inspection research of high-temperature pressure-bearing equipments according to their present service conditions and characteristics in our country.

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AN INTRODUCTION TO OIL AND GAS STATION INTEGRITY MANAGEMENT SYSTEM

Shui Biyuan*

T his paper gives out a description of oil and gas stations integrity management system. This station integrity management system includes three parts: documents, standards and management platform. Under the instructions of the documents and standards, the integrity management can be executed through a pattern consistent with pipeline. The basic philosophy is to manage the stations through risk analysis methods (RBI/RCM/SIL) based on database. It is recommended that the station integrity management system be incorporated with that of the trunk pipeline.

INTRODUCTION

The American standard, API 1160, points out that the integrity management pattern of oil and gas stations should be similar to that of the trunk pipeline. In this standard, it provides a procedure frame which can be referenced by both stations and pipeline. But the detailed technical implementation scheme is not mentioned. Although it is almost accepted by the industry that the Asset Integrity Management (AIM) technology is suitable for the chemistry plants or refineries, up to now there isn't one AIM system specially prepared for the oil and gas stations or terminals. Based on this and considering the status of Petrochina pipelines management, this paper gives out a profile of stations integrity management system.

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ADVANCEMENTS IN THE AUTOMOTIVE DURABILITY PROCESS

Mark Pompetzki and Brian Dabell *

Structural integrity in terms of automotive durability is not just a calculation or a code, but a detailed process that incorporates many technical areas. The current durability process for automotive applications involves understanding operational load inputs, the stresses and strains caused and the response of the material, performing fatigue tests, calculating fatigue life and interpreting results. There are many variations on this process depending on the application, materials, available information, methods, etc. This paper presents a general approach for the durability process in automotive applications and highlights a number of new advancements. These advancements include understanding the service operating load conditions through improved usage based monitoring, characterizing new materials together with their associated damage models, enhancing and automating data manipulation through straightforward, consistent and rapid process based analysis, creating test profiles for random loading and accelerating CAE based durability analysis. The impact and importance of the advancements is illustrated by reference to each part of the durability process as well as the process itself.

NEW NEED OF STRUCTURAL INTEGRITY TECHNOLOGY FOR COATING-BASED SYSTEMS

Xu Bin-shi[a], Zhang Xian-cheng[a,b], Wang Hai-dou[a]

Surface Engineering is today becoming an increasingly important discipline to industry where the performance and lifetime of both tools and products are sought to be improved and extended. For instance, coatings are commonly used in several industrial applications. Both soft and hard coatings can inhibit adhesion between the substrate and the counter face resulting in decreased wear, corrosion, etc. Generally, the coating properties are strongly influenced by the deposition method and the selected deposition conditions. The following properties are of great interest for coatings: residual stresses, hardness, and plastic properties, elastic moduli, interfacial adhesion strength. The structural integrity technology has been widely used with great success for the design, manufacture and failure prevention of modern constructions such as chemical and petrochemical plants, power generation and energy conversion systems. However, the researches on the structure integrity, especially the thermomechanical integrity are relatively few.In this paper, the thermomechanical integrity of the coating-based systems with residual stresses was investigated. Different topics were involved, such as residual stress distribution and redistribution in a coating on a substrate, optimal designing methodologies on the basis of residual stress and structural design of crack and delamination resistances for coatings etc.

THE FATIGUE ANALYSIS OF HELICOPTER HUB BASED ON FE-SAFE

Nianzhao Jiang[1], Hui Chen[1], Yong Dai[1], Zhiqing Zhang[1], Kexuan Wang[1], Hongbo Wu[1]

Jinping Tao[2]

Helicopter hub receives the centrifugal force of rotor blade which transfers from blade root. At the same time, it must support the flapping and lagging force of blade. So the load applying to hub is complex and the stress is alternating. Thus, the combined load and the cyclic stress can lead blade hub to fatigue failure. In this paper, the load of helicopter hub has been described and the stress has been computed. With this static stress and a random

load-spectrum which considered different flight condition about helicopter, the fatigue analysis of hub based on FE-SAFE software has been carried out. The treatment of fatigue load spectrum in this paper represents not only hovering flight condition but also anther flight condition such as level and forward flight. Furthermore, the flight test result has proved that the solution method of hub's life is feasible and the fatigue life is correct.

THE APPLICATION OF UML AND COMPONENT TECHNOLOGY TO AIRCRAFT CALENDAR LIFE CALCULATION AND EVALUATION SOFTWARE SYSTEM

Chaohua FAN [1,*] , Yuting HE [1], Hongpeng LI [1] and Ronghong CUI [1]

Calculation and evaluation of the aircraft structural calendar life is very complicated, and it is necessary to establish a special software system. In this solution, we analyzed the components and function of the Aircraft Calendar Life Calculation And Evaluation Software System according to object-oriented technology, and designed UseCase diagram, Activity diagram, Class diagram and Interaction diagram using Unified Modeling Language (UML). Finally, the implement scheme of the system with component technology is discussed.

INTRODUCTION

Researches on calendar life of aircrafts have its own characteristics as in Chen et al.[1]: complex environments, various material properties, flying spectrum and different structure types, etc. A special software system is necessary to help researchers to perform mathematical calculation and do repetitive works, such as processing a mass of data. Additionally, people have not created a kind of theoretical calculation model of aircraft calendar life which is applicable to complicated corrosive environments and easy to use. Thus, while realizing the computerization of theoretical calculation, it is necessary to perform accelerated corrosion tests to reflect the influence of service environments. The theoretical value and the equivalent value obtained from the test data should be compared and analyzed so as to amend the theoretical model or test scheme and equivalent relation.

Aircraft Calendar Life Calculation And Evaluation Software System will give

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support to create more accurate theoretical models and test schemes. This software system's structure is huge and its functions are complex, so the latest achievement of software engineering is introduced in the analysis and design of the system, such as object-oriented(OO) technology, Unified Modeling Language(UML) and component technology.

HOW INFLUENTIAL IS LOAD HISTORY IN IMPROVING THE RELIABILITY OF A WELDED STRUCTURE

D. J. Smith* and A. Muhammed, #

Experimental evidence for changes in toughness and residual stress are incorporated into probabilistic models. The models are used to investigate the sensitivity of the input parameters to measures of the survivability of a welded component. Predictions are compared to experimental evidence from large scale tests. Importantly, it is revealed that by including prior loading into an assessment of the performance of a welded structure we may be able to claim that the structure's reliability is consistently better than that expected at start of life.

INTRODUCTION

It is common practice in many engineering sectors to subject components to a prior load or proof loading as a measure of assurance for future use. Its main aim has been, and continues, to assure the quality of component or structural fabrication by revealing manufacturing "defects". Overall, we might expect that if a component survives a prior load event that its future reliability has been enhanced. This expectation arises because the anticipated weaknesses or defects are shown effectively not to exist.

Fracture toughness and residual stress are well known to be modified by load history [1]. The effects of prior loading, such as proof loading and warm prestressing (WPS), are also considered in guides for assessing the integrity of structures (British Energy, 2001 [2] and BS7910, 2005 [3]). The first part of the paper provides statistical evidence for the effects of prior loading on fracture toughness [4] together with data for residual stress distributions in welded components [5]. The second part reports results from the application of a probabilistic analysis using this statistical evidence.

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FATIGUE DESIGN, ASSESSMENT, MONITORING AND MANAGEMENT IN ENGINEERING

Xiaobin Lin*

This paper briefly describes the principals of fatigue life prediction that have been widely adopted to deal with fatigue durability of engineering components and structures in industries. It also explains the basic inputs to fatigue analysis and presents a typical process, which involves some engineering tasks, such as in-field data collection, experimental or finite element based stress analysis, material data preparation, fatigue life analysis, laboratorial fatigue testing and final sign-off testing of components or structures. Modern engineering applications in fatigue design, fatigue life assessment, fatigue life monitoring and durability management are the focus of the paper.

INTRODUCTION

It has been recognised that the failure of engineering components and structures subjected to cyclic or alternating stresses is largely due to fatigue. It is very important for manufacturers to avoid such failure in the product service period, and at the meantime to avoid the over-design of their products, which may increase the costs and decrease the product competitiveness in the market. In order to achieve this, an effective durability procedure must be implemented in the product development cycle.

During the last two decades, nCode International have been working closely with some leading manufactures in the ground vehicle, aerospace and general machinery industries, and have developed an integrated durability solution. This includes hardware systems for data acquisition and software tools for data processing and management and experimental and virtual fatigue life analysis. The nCode durability products have been used world-widely as industrial standards in a variety of industrial sections, and have helped some well-known manufacturers, such as Ford, General Motor, John Deer, Caterpillar, Lockheed Martin and the US army, to reduce the development costs and shorten the development time without lowering the durability performance of their products.

The technical background of the nCode durability solution will be briefly described, and several engineering applications are presented in the following sections. They range from fatigue life design of ground vehicle components, remaining life assessment of pressure vessels, and life monitoring of steel bridges.

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DEVELOPMENTS IN FRACTURE MECHANICS-BASED STRUCTURAL INTEGRITY OF WELDMENTS

Kamran Nikbin*

Fracture mechanics based remaining life prediction methods are routinely applied to equipment operating in the creep and creep/fatigue range by assessing crack initiation and growth from existing defects. These procedures are relevant to fossil, nuclear power generation, chemical and aerospace industries. The methodologies have in most cases been developed for homogenous materials. However weldments which could contain inhomogeneity and micro-cracks as well as residual stresses in their microstructure are invariably the weak link in the structure. Hence extension, improvement and validation of predictive methods are the logical next step. Under the auspices of the Versailles Agreement on Materials and Standards (VAMAS) committee standardization methods for testing analysis and novel applications are developed. This information is filtered into standards and Codes of Practice such as in ASTM, BSI and the British Energy's R6/R5, the French A16 and the US API codes. This paper highlights the methodologies for testing analyzing and assessing crack initiation and growth in weldments. Factors that need to be identified in life assessment of weldments and welded components are discussed and related to the objectives in the VAMAS TWA31 working on 'Creep/Fatigue crack growth of weldments containing residual stresses'.

INTRODUCTION

The efficiency of conventional steam and gas turbine power plant can be significantly improved by increasing the operating temperature, leading to reduced fuel consumption and lower levels of harmful emissions. Aging plant also need to have replaced component parts with new material to allow extension of their lifetimes. These changes lead to possible unknown in the predictions of remaining plant lifetimes. Therefore more accurate and reliable experimental data for use in improved predictive modelling of component lifetimes at elevated temperatures are needed. More recently welded section is under scrutiny as repairs and subsequent failure are most likely to be found in these regions.

Inhomogeneity in weldments of components and tress concentrators will invariably be the weakest region where failure could occur. In addition residual stresses arising during welding as well as fabrication and repair and un-planned

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overloads is a factor that needs to be quantified in order to improve lifetime predictions. Post weld heat treatment (PWHT) can reduce the magnitude of residual stresses, but not completely remove them nor can they fully remove any prior strain damage in the weld region. Current codes for design and assessment of high temperature components do not take full advantage of recent advances in mechanistic understanding of the deformation and failure processes involved. Thus, they often lead to too small a critical defect sizes and short remaining lifetimes, particularly when pessimistic assumptions are made about residual stress.

INTEGRATE METHOD BY FATIGUE FRACTURE CALCULATION WITH VIRTUAL DESIGN AND MONITOR ANALYSIS TO REALIZE SAFETY AND ENERGY-SAVING OPERATION FOR POWER MACHINERY

Yu Yangui* [2]Li Ying [2]Wan Changjiang [3]Xu Feng [4]Ma Yanghui [4]SunYiming

Aim at power machinery, to solve the problems that are failure and accidents in engineering, analyze some hidden insecurity trouble in general design, calculation and operation, adopt analytical method in relation to fatigue, damage, fracture, design programs on strength failure analysis and life evaluation, and propose holistic and local calculation for key components. Appling methods integrated by virtual design and virtual assemble technique with general design, to advance manufacture precision of machines, eliminate some fracture accidents result from vibration, design intelligent system on real time detection, calculation and analysis, realize safety alarming, optimizing modulation and control, so as to meet optimizing index. Thus using the methods fatigue fracture calculation with technique of virtual reality and monitor analysis, to accomplish the target of safe run and energy-saving for power machinery.

INTRODUCTION

Advancing the mechanical efficiency and reducing the specific-power were related to many fields of technology. If took some efficient measurements, such as optimization

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in mathematical modeling for heat calculation, dynamical calculation and intensity calculation in designing compressors, advancing the mechanical efficiency and reducing the specific-power would be possible. However, if the structure of gas valve is not applicable, the air tightness factor must be reduced that would result in increasing the specific-power. The poor assemble precision give birth to vibration for the machine directly or indirectly and lowering the mechanical efficiency. In addition, if ignore the necessary optimization in intensities design, there could not get favorable results.

In this paper, concerning the problems stated above, how to take advantage of the methods combined with the modern design and the operation were proposed as reference for it.

SIMULATION & COMPARISION OF MAINTENANCE STRATRGEISTHIS ON MEAN TIME TO FIRST FAILURE

Huang Longcheng*, Jin Xin*, Hong Yanji*, Xin Chaojun*, Ye Jifei*

To analyze and compare the impact of different strategies, Mean time to first failure (MTTFF) of system should be calculated well and truly. Based on reliability diagram modeling and judgments of state of units and system by minimal path sets, a Monte Carlo sampling simulation method of MTTFF is obtained for complex systems under two maintenance strategies of which are that the importance units have the priority of being repaired over others and the first-failed ones have the priority. Results of an example indicate that the first strategy is better than the second. In addition, we find that Monte Carlo Method is an effective way to calculate MTTFF of complex systems.

INTRODUCTINON

MTTFF is an important parameter of system availability which is time measurement for the first failure of system. Maintenance strategies have direct impact on it. And there are two common immediate maintenance strategies at the present time (Zhang [1], Zhang [2]). One is that the importance units have the priority of being repaired over others (IUPR), the other is that the first-failed ones have the priority (FUPR). In the design of the maintenance strategies, what we care is that which one is better. MTTFF of system maybe give us some hints. Thus it should be calculated well and truly.

Markov process analysis is usually used in the calculation of MTTFF of system (Jin [3], Guo [4]). However, to the best of our knowledge, it is applied in some simple systems and it requests that service life & maintenance time of units of the system are exponential distributions. Therefore, Monte Carlo method has drawn considerable attention for its merits in reliability engineering [5]. In this paper, a Monte Carlo sampling simulation method was proposed to calculate MTTFF of complex systems.

DYNAMIC STRESS INTENSITY FACTOR AND SCATTERING OF SH-WAVE BY AN ELASTIC CYLINDRICAL INCLUSION AND A CRACK IN HALF SPACE

YANG Zailin[1, a], CHEN Zhigang[2, b], YAN Qiuhong[3, c],LIU Diankui[4, a]

An analytical method is developed for dynamic stress intensity factor and scattering of SH wave by a half space containing an elastic cylindrical inclusion and a crack. A suitable Green's function is constructed, which is the fundamental solution of the displacement field for a half space with an elastic cylindrical inclusion impacted by an out-plane harmonic line source loading at an arbitrary point in half space. And then a crack in any position and direction can be constructed in half space by means of crack-division which is expressed in terms of the Green's function. Moreover, the displacement field and stress field are established in the case of coexistence of elastic cylindrical inclusion and crack. The expression of dynamic stress intensity factor (DSIF) at the tip of crack is given, and the numerical examples are provided to show the influences of the parameter combinations of different media upon DSIF.

I INTRODUCTION

In recent years, the scattering of elastic waves by the inclusion and the crack has been attracted much research attention[1, 2, 3]. Most studies focus on the scattering of SH-wave by the radial cracks along the radius and originated at the boundary of the inclusion. In practice of engineering, the cracks are often found near the inclusion when the forces applied to the composite materials containing inclusion. But for the problem that interaction of the crack with any position in basal body and the inclusion impacted by incident SH-wave, there are few publications on it. As a result, it is important to study this problem especially for non-destructive inspection and strength designing of the composite materials.

THE STUDIES ON COLLAPSE RESISTANT CAPACITY OF MULTI-RIBBED COMPOSITE SHEARWALL EMBEDDED STEEL

XIONG Yaoqing*, YAO Qianfeng

Based on contrast multi-ribbed composite wall structure and full RC shear wall structure, the multi-ribbed composite shear wall embedded steel (MCSS) is put forward and introduced in this paper, which is a new energy-dissipation structure on the basis of controlled seismic response theory. The finite element model of MCSS is created to simulate its seismic performance by ANSYS programs. Such key factors as elements selecting, constitutive relation and failure criteria of materials, connection of different members, and cracking of concrete are considered. The bearing capacity, deformation performance, energy dissipation ability and skeleton curve of MCSS are presented and compared. The results of analysis indicate that full-course of MCSS failure go through elastic stage, plastic stage and failure stage with lateral loads and moment action increasing. It is proved that the steel pillar embed in the fringe frame of MCSS could strengthen moment action resistant capacity, and the pre-cast multi-ribbed composite slabs infill in the abdomen of MCSS could reduced its deadweight and ratio of steel. The Studies show that the excellent collapse resistant capacity is provided by MCSS.

INTRODUCTION

In earthquake disasters, fragility of cities is shown more and more obviously. How to strengthen the self-protection ability of cities is one of the serious challenges faced the domain of civil engineering. It concerns safety of life and property to improve the structural seismic behavior and construct the safety buildings[1,2]. The RC shear wall structure system is favorable act as the lateral force resistant wall structure for high-rise residential buildings owned with many wall. But because of its large deadweight and strong lateral stiffness, consequently bring on its violent seismic response. At the same time, according to current native design code, the horizontal and vertical distributing rebar in the abdomen of RC shear wall basically is designed in the seismic conformation require. In order to take full advantage of the excellence

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of steel and concrete, the multi-ribbed composite shear wall embedded steel (MCSS) is put forward in this paper. MCSS mainly is made up of two parts, which are the pre-cast multi-ribbed composite slab infilled as abdomen of shear wall and the fringe frame embedded steel. The unique structural character of MCSS ensures that two-part members of the bearing capacity system can play a key role in releasing earthquake energy successively, consequently makes the structure in possession of several aseismic defending lines. Accordingly, MCSS is a new energy-dissipation structure based on controlled seismic response theory[3,4].

PULL-TYPE CLUTCH DIAPHRAGM SPRING OPTIMIZATION DESIGN BASED ON PARTICLE SWARM OPTIMIZATION ALGORITHM

Wei Bo ZHANG*

The characteristic of the diaphragm spring has great influence on the performance of the clutch, so the diaphragm spring optimization design is very important in the clutch design work. In this paper, Particle Swarm Optimization (PSO) algorithm with global convergence is used for multi-objective optimization design of pull-type clutch diaphragm spring. Through optimization design, the better performance of diaphragm spring is obtained

1. INTRODUCTION

Clutch is an important automobile transmission part, has great influence on the automobile performance such as power, fuel efficiency and comfort ability. During clutch design, the main working performance is mainly decided by the characteristic of the diaphragm spring, so the diaphragm spring optimization is very important in the whole design work. Several optimization models are established by a few researchers and different optimization methods are used for resolving the solutions (Guo[1], Xia[2], Ran[3]). In this paper, Particle Swarm Optimization (PSO) algorithm with global convergence is used for multi-objective optimization design of pull-type clutch diaphragm spring. Through optimization design, the better performance of diaphragm spring is obtained.

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ROLE OF WELDING IN AN OPERATING LNG MANUFACTURING ENTITY

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It is well-known fact that welding is the most important tool in fabrication and erection of continuous process units. However its role is no less in running such facilities. Here welding is used as repair and maintenance instrument and also for modifications and extensions. Natural Gas, the green fuel, is gaining increasing importance for Power Generation. Liquefaction of natural gas is enabling it to be transported to long distances, making it a more popular fuel because of this viable option. The paper describes the author's experiences of a decade in utilizing welding as an implement for the above in operating a manufacturing unit of LNG - 'Qatargas', one of the leading LNG producers in the world, that is integrated in nature, namely from extracting from mother earth to supplying it to the user end, including the phase conversions. It also discusses role of welding in replacements & repairs for the reasons of combating corrosion, erosion, different typing of cracking mechanisms. Many grades of Carbon steels, low alloy steels of high strength, elevated temperature resistant, low temperature tough steels, high alloy steels, broad range of stainless steels, Aluminium & Nickel alloys, Copper and Copper alloys and Titanium materials are conversed in the forms of valves, equipment, tanks, structures piping etc.

INTRODUCTION TO LNG INDUSTRY & QATAR

LNG or **L**iquefied **N**atural **G**as (**LNG**) is the liquid that contains Methane (C1), Ethane (C2) in major percentages and has Propane (C3), Butane (C4) and Nitrogen (N_2) in minor levels. Natural Gas, the 'green' fuel, when cooled down to minus 161^0 C at atmospheric pressure liquefies and reduces its volume by 600 times. This factor made it a profitable proposition to transport it very easily. Supply of Natural Gas as LNG is considered to be economical if the distance between source and the market exceeds about 4,000 km[1]. Qatar with its estimated reserves of over 900 tcf of natural gas enjoys 3rd position in the world. Qatar is targeting at 77 million tones per annum of LNG production and Qatargas with its ambitious plan of expansion to 42 mtpa production aims to be the world's leading supplier of LNG by turn of this decade. Figure 1 shows Qatargas onshore facility in the night lights.

RECENT ADVANCES IN MASTER CURVE TECHNOLOGY

Kim R. W. Wallin*

The Master Curve (MC) methodology has evolved, from only being a brittle fracture testing and analysis procedure, to a technological tool capable of addressing many more structural integrity issues like constraint and parameter transferability. The MC enables a complete characterization of a material's brittle fracture toughness based on only a few small size specimens. The MC method has been shown to be applicable for practically all steels with a body-centered cubic lattice structure, generally identified as ferritic steels. The method has been described in detail in several publications. The method combines a theoretical description of the scatter, a statistical size effect and an empirically found temperature dependence of fracture toughness. The fracture toughness in the brittle fracture regime is thus described with only one parameter, the transition temperature T_0. The basic MC method has been standardized in the ASTM standard E1921, the first standard that accounts for the statistical specimen size effect and variability in brittle fracture toughness. Recently, the MC methodology has evolved, from only being a brittle fracture testing and analysis procedure, to a technological tool capable of addressing many more structural integrity issues like constraint, effect of ductile tearing, the warm pre-stress effect and parameter transferability. In this presentation some of the more resent advances of the MC technology are highlighted.

INTRODUCTION)

Normally, fracture toughness testing standards require the use of comparatively large test specimens to obtain so called valid fracture resistance values. Extreme standards in this respect are the linear-elastic K_{IC} standard and the CTOD standard that require elastic behavior of the test specimen or full section thickness specimens, respectively. Often, like for operational structures, it is impossible or inappropriate to obtain large material samples for standard fracture toughness determination. This is especially the case with irradiation damage assessment of reactor pressure vessels, but also many other applications have the same restrictions. These specimen size requirements are a major obstacle for applying fracture mechanics in structural integrity assessment outside aviation, nuclear and off-shore industries.

At VTT, development work has been in progress for over 20 years to develop and validate testing and analysis methods applicable for fracture resistance determination from small material samples. The VTT approach is a holistic approach by which to determine static, dynamic and crack arrest fracture toughness properties

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either directly or by correlations from small material samples.

FITNESS-FOR-SERVICE ANALYSIS OF STRUCTURES USING THE FITNET PROCEDURE: AN OVERVIEW

M Koçak*, RA Ainsworth**, JJ Janosch***, S Webster****, R Koers*****

This paper gives the overview of the newly developed FITNET Fitness-for-Service (FFS) Procedure within the framework of the European **fit**ness-for-service **net**work – **FITNET** project. The FITNET project was a four and half years project with the objective of developing and extending the use of FITNET FFS Procedure for welded and non-welded metallic structures throughout Europe. It is partly funded by the European Commission within the fifth framework program and launched at February 2002. The network worked with over 50 organisations from sixteen European and three non-European countries representing various industrial sectors and academia.

The FITNET FFS Procedure provides sets of analysis options and flaw assessment guidelines for engineering structures by aiming to achieve better design principles, support for fabrication of new components and prevention of service failures due to **fracture, fatigue, creep** and **corrosion** damages. The FITNET FFS Procedure is developed, validated and processed within the framework of the CEN Workshop Agreement W22 under the guidance of the Italian standardization organization (UNI). Therefore, it aims to become a European (CEN) standard for assessing the significance of postulated or real flaws (cracks, welding defects, and corrosion damage etc.) on structural integrity and safety. http://www.eurofitnet.org.

INTRODUCTION

Engineering structures may contain imperfections (pores, flaws, defects, local thin area or cracks) during the fabrication stage or during the service life. The structural significance of such imperfections, particularly crack-like flaws needs to be assessed to prevent failure of the component during service. If a flaw is found in a structural component during in-service inspection, an assessment is needed in accordance with a respective code whether the flaw should be removed (repaired) or component replaced or flaw is being left in the component to continue to use the component. Therefore, engineering assessment procedures [1-14] containing analytical expressions need to be developed to assess (primarily to provide conservative estimation of the critical condition) the structural significance of the flaws or damage.

Conventional design approaches and operation principles implicitly assume that the component (load-carrying) is defect-free. However, even components fabricated by "good workmanship" principles may contain or develop cracks and hence need to be assessed using. modern FFS methodologies for provision of structural safety, improvement of in-service inspection intervals and/or for establishment of life extension measures.

The presence or occurrence of damage in engineering components may have different origins and growth mechanisms depending on the application area, the type of the component and loading conditions etc. Four major failure modes; *fracture, fatigue, creep and corrosion* have generally been identified as the most frequent failure modes of engineering structures and hence different FFS methodologies have been developed to cover these failure mechanisms. Certainly, failure of a component may include combinations of these four failure modes and their interactions at different stages of the damage process in service.

For example, fabrication flaws or cracks occurred during the service may subsequently propagate during the high temperature exposure as a consequence of the combined effects of creep and cyclic loading. In such circumstances, the assessment of high temperature structural integrity should also be covered by the use of more than one approach or procedure.

Additionally, welded structures require special procedure for structural integrity assessment of the weld flaws or cracks at the vicinity of the weld joints. First of all, most of the structural welds exhibit microstructural, geometrical and mechanical heterogeneity (strength mis-match, residual stresses etc.) which should be taken into account during the fitness-for-service analysis. Advanced welding technologies are emerging (e.g laser beam, hybrid and friction stir) and hence increasingly used in new designs and structures as an effective method to reduce the fabrication cost, distortion and residual stresses etc. Newly developed FFS procedures should cover such structures by taking into account of the special features of these welds.

TO ACCOMPLISH INTEGRITY CALCULATION OF

STRUCTURES AND MATERIALS WITH CALCULATION

PROGRAM IN WHOLE EVOLVING PROCESS ON

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FATIGUE-DAMAGE-FRACTURE

Yu Yangui* Li Zhihua Bi Baoxiang MaYanghui Xu Feng

The paper puts up systematically to analyze for their intersectional relations in whole evolving process from micro-crack initiation to macro-crack forming, growth till fracture for materials behaviors on fatigue-damage-fracture, to accomplish so as to connect each other, to design and program its calculation procedures in whole process, which include the strength calculations of engineering materials at the first and second stage, the damage evolving rate, crack growth rate and life at each stage etc. And it also programs lots of the databases on the material constants, equations, curves and figures of describing material behaviors. On the other hand, as the typical structures with a crankshaft and cylinder block to calculate its strength, damage evolving rate, crack growth rate and relative life at each stage under multilevel complex loading. Thereby establish a base for integrity calculation of structure and also provide some calculation examples for engineering application.

INTRODUCTION

In the modern scientific-technical and engineering domains, there are large numbers of microstructures and large-scale structures, and in all structures they all come down to both subjects about the strength and life. And designs and calculations of these structures are invariably applied from modern the fatigue-discipline, damage- and fracture-mechanics.

In the solid mechanics of modern times, people sometimes are as the damage for slippage of crystal grain, micro-bore, -hole, -crack for $\leqq 10^{-5}$m, which is studied in bound as the damage-mechanics or micro-fracture-mechanics; and is studied in bound of these new disciplines as the macro-fracture mechanics for those bore, hole, macro-crack and bug of size for 10^{-4} to 10^{-3}m. Come to light, under fatigue loading the structures experience generally two stages from un-crack to fracture. The first stage is called to be the crack forming stage. At this stage some new variable D_1, a_1 and its curves and equations are used to damage calculations and life estimations of a structure material. At The second stage, it is from macro-crack forming, growth of steady going, until to course of celerity fracture, it is called to be the crack growth stage. At this stage another new variable D_2, a_2 and its curves and equations are also used to calculating and analysis to the intensity and life of a structure material.

If design a program to analyze their intersectional relation in whole process in fatigue-damage-fracture of materials, to find out some alike or different law of material behavior at each stage, to find some correlations each other, to make these calculating variable D_1 and D_2, a_1 and a_2,, and their curves, pictures and equations can

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be all connected one with another on physical and geometrical meaning, and under certain condition can be also converted each other at both stage, accordingly form a comprehensive and profound cognition for varying law of material behavior in whole process. Then design and program a big procedures consist of a lot of calculation one and database about data, curves, picture, equations for structure material, thereby calculate and analyze the damage evolving rate, micro-crack growth rate and macro-crack growth rate and their corresponding life at each stage. Thus it would be accepted and applied extensively in engineering domains for each new branch discipline of fatigue-damage-fracture, and also have practical significance for integrity design and calculation of structures.

RELIABILITY ANALYSIS ANALYSIS OF EXISTING BRIDGE STRUCTURES WITH FUZZY AND RELIABILITY RESTRICT

Wong Wang [1], Zhu Yanfeng [1], and Yu Zhitao

Models of fuzzy reliability analysis were established and calculation methods of the models were discussed with considering uncertain factors. In this model, the fuzziness of multi-objective function and the stress control criterion are all solved. Using the methods presented, the reliability of load-bearing capacity for an actual reinforced concrete bridge was analyzed and estimated .The computation results demonstrate that the model is reasonable and feasible.

INTRODUCTION

Parameters in reliability research of structure need to be considered their randomness and fuzziness. Remaining Residual service life residual service life of bridge structure should be estimated according to available probability standards. Uncertainty of bridge structure exists objectively.

Availability information should be gotten through test. Then we can fully utilize this information that we adjust variability of variation and parameters. Next fuzzy information can be gotten in large existing bridge structure bored load in service. Probability is fuzzy condition probability. [1-5]

In Models of fuzzy reliability analysis were established and calculation methods of the models were discussed with considering uncertain factors. Using the

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methods presented, the reliability of load-bearing capacity for an actual reinforced concrete bridge was analyzed and estimated. Loading test is too expensive and technology is too high to be used largely. So the load level bored in service life of remaining bridge structure can be utilized as proof load. For example we can take the maxim bearing load of bridge structure in service life as test load.

RESEARCH ON THE SITUATION AND MEASURES FOR HAZARDOUS CHEMICAL SAFETY STANDARDS IN CHINA

Wu Zongzhi[a,*], Gao Jianming[a], Wang Yuhang[a]

Compulsive Hazardous chemical safety standards are important part of the Chinese work safety regulation system. This paper introduces the situation, classification of hazardous chemical safety standards in China. It points out the lacking of systematicness, and poor infrastructure and insufficient technical study are the main problems of Chinese safety standards. Proposals are to establish high efficiency working mechanism for the development of hazardous chemical safety standards, properly planning the standardization work, improve the standard systems, strengthen the study input and push the progress of the standardization, and increase international collaboration on the hazardous chemical safety standards development.

1 INTRODUCTION

China is a leading country on the production and usage of chemicals. There are over 45,000 categories of chemicals produced in China. And China lists at the top level as for the production volume of over twenty kinds of chemicals[1]. Now days, there are over 300,000 companies or factories are engaged with hazardous chemicals, which employed over 5 million workers.

Chemical industry belongs to high risk industries in China. The chemical safety situation is very serious[2]. Accidents statistics from 2001 to 2006 show that more than 200 people die from hazardous chemical accidents every year[3]. The main causes are the implementation of safety standards are inffective, the lack of scientific and mature hazardous chemical safety standard systems, and chemical safety standards are backward. It is very necessary and urgent to research and develop hazardous chemical safety standards systems in China.

THE BACKGROUND OF THE FITNET FRACTURE TOUGHNESS ESTIMATION METHODOLOGY

Kim Wallin*

The fracture toughness is one of the key-inputs for any structural integrity assessment. The desirability of having appropriate reliable toughness data cannot be emphasised too strongly, and it is vital that toughness data be obtained from properly documented welding procedure test samples at the time of construction and extracted from all the critical weld regions including the heat-affected zones and the weld metal. The structural integrity assessment procedure FITNET fracture toughness assessment part is based on the Master Curve (MC) method for analysis of brittle fracture test results. FITNET contains as basic level a lower tail modification of the MC analysis. In an ideal situation, appropriate fracture toughness data for use in structural integrity assessments are generated through the use of suitable fracture mechanics based toughness tests. If this is not possible, it is necessary to base the analysis on a reliable correlation between Charpy impact energy and fracture toughness for the particular case being assessed.

INTRODUCTION

The fracture toughness is one of the key-inputs for any structural integrity assessment. The desirability of having appropriate reliable toughness data cannot be emphasised too strongly, and it is vital that toughness data be obtained from properly documented welding procedure test samples at the time of construction and extracted from all the critical weld regions including the heat-affected zones and the weld metal.

The structural integrity assessment procedure FITNET [1] fracture toughness assessment part is based on the Master Curve (MC) method for analysis of brittle fracture test results. The basic method is intended for macroscopically homogeneous ferritic steels only. In reality, the steels in question are seldom fully macroscopically homogeneous. The materials' toughness may depend on the specimen location in the sample. Inhomogeneity may be deterministic or random (or a mixture of both) in nature. Deterministic inhomogeneity can be accounted for, provided that the specimen extraction histories are known and enough specimens are tested. Random inhomogeneity is much more difficult to handle. The structural integrity assessment procedure FITNET contains as basic level a lower tail modification of the MC analysis (Wallin et al. [2]). This enables conservative lower bound type fracture

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toughness estimates also for inhomogeneous materials. The problem is that the method, does not provide information of the tougher material. A probabilistic description of the complete material is thus not possible. Therefore, FITNET includes also an extension of the MC for inhomogeneities governed by two separate MC distributions (Wallin et al.[2]). The extension is efficient in describing e.g. weld heat-affected zone (HAZ) data. In addition, a simple method for the analysis of random inhomogeneous material consisting of mixed data is included (Wallin et al. [2]). The method is also applicable for data sets including several different materials

A GENERAL FORMULATION FOR DETERMINING THE DEFORMATION RATE OF TWO-MATERIAL CT SPECIMENS WITH AN INTERFACE CRACK AND ITS APPLICATION IN PREDICTING C* INTEGRAL

Z. J. Hu[1,2]*, T. H. Hyde[2], W. Sun[2] and S. Halighongde[2]

A general formulation for predicting the deformation rates, for structures which approximate to statically determinate structures, is proposed; it is based on analytical solutions for steady-state creep deformation rates for two- and three-material components with simple geometries. As an example, a CT specimen consisting of two materials, with an interface crack, was studied and the method for predicting the deformation rates, by using the proposed general formulation, has been established. The advantages of this method are related to the fact that only a small number of finite element (FE) analysis are required to enable a simple and compact method to be used to predict the deformation rates for any combination of material properties. Based on this method, a simple equation for predicting the C* integral of CT specimens, consisting of two materials with an interface crack, is proposed and used to investigate the accuracy of the general formulation. By comparing the results of C* integral obtained from the equation and FE analyses, for a wide range of material mismatch properties, it was found that the predicted C* values were in very good agreement with the FE results.

INTRODUCTION

In engineering practice, it is very important to assess behavior of components operating under high temperature conditions in order to meet the need for increased

efficiency, to reduce costs and to improve the reliability. One of the most important parameters used to describe the properties of materials with creep crack growth is the path independent integral under steady state creep condition, C*. This is mainly measured by use of standard compact tension (CT) specimens according to ASTM E1457 [1]. As part of this, it is very important to determinate accurately the load line deformation rates of CT specimens in order to accurately determine the C* integral.

MANY METHODS HAVE BEEN DEVELOPED TO DETERMINE THE DEFORMATION RATES OF COMPONENTS. IN ADDITION TO THE EXPERIMENT METHOD PROPOSED IN ASTM E1457, A FEW ANALYTICAL STUDIES [2-4] HAVE BEEN DEVELOPED TO PREDICT THE STRESSES AND DEFORMATIONS WITHIN MULTI-MATERIAL COMPONENTS. DUE TO THE COMPLEX NATURE OF MULTI-MATERIAL PROBLEMS, IT IS VERY DIFFICULT TO DERIVE CLOSED-FORM ANALYTICAL SOLUTIONS, EXCEPT FOR A FEW STRUCTURES WITH SIMPLE GEOMETRIES. THEREFORE, NUMERICAL METHODS, SUCH AS FE METHOD, ARE COMMONLY USED TO OBTAIN SOLUTIONS FOR SPECIFIC MATERIALS, GEOMETRIES AND LOADINGS. BASED ON THE FE, PARAMETRIC ANALYSIS OF DEFORMATIONS HAS BEEN PERFORMED AND A GENERAL FORMULATION WAS PRESENTED BY HYDE [5-7] FOR PREDICTING THE DEFORMATION RATES IN THREE-MATERIAL THICK-WALLED PIPE WELDS. THESE STUDIES INDICATED THAT THE GENERAL FORMULATION CAN ACCURATELY PREDICT THE DEFORMATION RATES IN ANY INTEREST POINT FOR STATICALLY INDETERMINATE STRUCTURES [6]. APPLICATION OF THE FORMULATION FOR PREDICTING C* VALUES

It has been shown [8] that the full model of CT specimens with two materials can be divided into two half homogenous models, as shown in Fig. 4 and that the contour integral, $C_{1,2}^{*}$, can be approximately written, as follows, based on the ASTM E1457

$$C_{1,2}^{*} = \eta(n, a/W) \cdot \frac{P(\dot{\Delta}_1 + \dot{\Delta}_2)}{B(W-a)} \qquad (6)$$

Using Equations (2) and (4), Equation (6) can be rewritten as follows

$$C_{1,2}^{*} = A_1 \cdot \sigma_{nom}^{\,n+1} \cdot W \cdot g(n, \dim) \cdot (1 + \frac{1}{M}) \cdot \eta(n, a/W) \qquad (7)$$

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where $\eta(n, a/W)$ is the function which can be obtained from ASTM E1457, and σ_{nom} is the conveniently chosen nominal stress ($\sigma_{nom} = P/B(W-a)$) for the CT specimen, and $M = A_1/A_2$ is the material mismatch factor for the CT specimen.

For a CT specimen with two-material and an interface crack, the $g(n, \dim)$ function can be obtained from a small number of FE calculations. Hence, the contour integral, $C_{1,2}^{*}$, can be approximately determined from Equation (7). The comparison of the contour integral C*, based on Equation (7) and FE results for different M factors varying from 0.01 to 100, and a/W = 0.50 is shown in Fig. 5. It can be seen that the contour integral, predicted by Equation (7) are in good agreement with the FE results. Therefore, it is proposed that Equation (7) can be used to predict C* values for practical engineering use.

FITNET ASSESSMENT OF LOW CONSTRAINT COMPONENTS, PROPOSAL FOR AN OVERALL CONSTRAINT ASSESSMENT METHODOLOGY AND ITS VALIDATION

S. Cicero[1], F.Gutiérrez-Solana[1], J.A.Álvarez[1], S.Webser[2], A. Horn[2], R A. Ainsworth[3]

Fracture assessment of a structural component by the standard and advanced J-integral based options (Options 1-4) given in the FITNET Fracture Module [1] utilises fracture toughness data derived from deeply notched fracture mechanics test pieces. These represent a high level of constraint (high stress triaxiality) that may result in excessive conservatism. A source of the conservatism is that the triaxiality of the stress field in the vicinity of a shallow flaw in a structural component can be lower than that in a deeply notched test specimen. Such a situation is usually referred to as “loss of constraint”. In addition, stress fields with low triaxiality occur near non-sharp defects. The ability to allow for the loss of constraint is potentially of great practical significance. The advanced Option 5 (Constraint Analysis) of the FITNET Fracture Module and Section 12.5 (for treatment of non-sharp defects) provide fracture assessment tools which take into account in-plane loss of constraint (triaxiality).

INTRODUCTION

A conservatism implicit in many fracture assessment procedures is that the assessment uses a value of fracture toughness obtained from tests on deeply cracked bend specimens performed according to established testing standards. These are designed to ensure plane strain conditions and high hydrostatic stresses near the crack tip in order to provide material properties independent of specimen size and geometry. However, there is considerable data showing that the material resistance to fracture is increased when tests are carried out on specimens with shallow cracks or on specimens in tension [2-3].

Structural components may also contain non-sharp defects. It would be overly conservative to conduct structural integrity assessments of these components by assuming that the fracture behaviour of a non-sharp defect is identical to that of a sharp crack.

There has been considerable research on these low constraint effects in order to quantify the geometry dependence of the material resistance to fracture using so-called constraint parameters. This has led to constraint-modified fracture assessment methods within the SINTAP [4] and R6 [5] procedures. The FITNET proposals for the treatment of constraint have built upon these assessment methodologies. It has also benefited from developments carried out by members of FITNET (Cicero [6]) and also those in other European projects such as VOCALIST [7] and NESC IV [8].

ANALYSIS WITH GREEN'S FUNCTION FOR IR-THERMOGRAPHY NDT OF ELECTRO-THERMAL CONCRETE

Huang Li*, Li Zhuoqiu and Song Xianhui

By using of the electro-thermal property of carbon fiber reinforced concrete (CFRC), inspecting crack in it by IR-thermography can be realized. The mechanism causing the temperature difference comes down to the heat transfer problem with internal heat sources deriving from electric field. Adopting certain assumptions, this paper presents the method to obtain the approximate temperature field by using Green's function, and gives the solution of a two-dimensional rectangular field with a flaw in it. The results tally with the

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experimental results, and prove its reliability.

INTRODUCTION

Nowadays, infrared thermography has evolved into a powerful investigative tool of nondestructive test (NDT). In fact, there are many reports on its use in detecting defects in concrete [1]. Due to the low heat conductivity of concrete itself, extra powerful heating is usually needed for concrete object in general infrared NDT. Differently, carbon fiber reinforced concrete (CFRC) is adopted in this paper. Because the electrical resistivity of CFRC is much lower than that of conventional concrete, heating CFRC by electric current can be realized to generate enough high temperature difference. This method is faster, and more controllable than general infrared NDT method [2]. By adopting certain assumptions, this paper presents a method to obtain the approximate temperature field by using Green's function, and gives the solution of a two-dimensional rectangular field containing a flaw. By contrast, the results tally with the experimental results well.

REMOTE BASED MULTI-CHANNEL LEAK MONITORING SYSTEM USING CORRELATION

*LIANG Wei, ZHANG Laibin, WANG Zhaohui

Oil and gas transportation pipelines are the key equipment in petroleum and chemical industry. At the heart of the leakage monitoring and detection procedures are the report of leakage event timely and of leakage point precisely. This paper presents a more realistic approach for using rarefaction-pressure wave technique in oil pipelines, which aims to two targets, one is the improvement of remote and intelligent degree, and the other is the improvement of the leakage location ability. It also introduces a basic concept and structure of the remote based multi-channel leak detection system. Primarily, an SVD embedded leak-detection package is designed to exchange the diagnostic information with the PLC data package of Modbus protocol, and then via fiber network, the SCADA-based remote monitoring and leak detection system is realized. The applied results show that the whole running status of pipeline can be monitored effectively, and a higher automation grade and an excellent leak location precision of the system can be obtained.

1. INTRODUCTION

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The position of a leak in crude oil pipelines may be determined by accurate estimation of the time delay of two measured acoustic signals [1]. The data collection precision, which is used to demarcate the time label between two neighbored points of determined signals, is central to this process. How to develop a remote leak detection system with a high ability to point the leak location without changing the structure of pipeline supervisory system becomes a demand. This paper presents the basic principle of SVD technique, its improvement and a correlation way to quantitatively position the leak point. The applied results show that the whole running status of pipeline can be monitored effectively, and a higher automation grade and an excellent leak location precision of the system can be obtained.

CRACK LOCALIZATION IN TIMOSHENKO BEAM BASED ON THE ANTI-RESONANT FREQUENCY

D S Wang*, H P Zhu, X H Wan

An alternative technique for crack localization in Timoshenko beam based on the first anti-resonant frequencies is proposed in this paper. Subsequently, the proposed method is verified by a numerical example of a simply supported beam with a crack. The effect of crack size on the anti-resonant frequencies is also investigated. The position of the crack of the simple supported beam can be determined by the anti-resonance technique. It is found that the proposed technique is effective and an appropriate use of anti-resonant frequencies may avoid non-uniqueness of the damage localization problem, which occurs in symmetrical beams when only natural frequencies are employed.

INTRODUCTION

Unlike the natural frequency and mode shape, the anti-resonant frequency is a local parameter of structures, and is easily and accurately measurable. So the anti-resonance information can be used to detect crack damage in beam structures. Bamnios et al. [1] first investigated the influence of a transverse open crack on the mechanical impedance of cracked cantilever beams both analytically and experimentally. Their work shows that the location of single moderate crack of beam can be identified by monitoring the change in the first anti-resonance as a function of

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the measuring location along the beam length. Wang and Zhu [2] systematically proposed an anti-resonance approach for crack identification in beam structures. They utilized the method to identify the locations of cracks in a multi-cracked beam. In this paper, an anti-resonant frequency technique to detect beam crack is proposed, which is based on Timoshenko beam formulation. The proposed technique is also verified by a numerical example of simple supported steel beam with a crack.

STUDY ON THE ACOUSTIC EMISSION CHARACTERISTIC OF CFRP BARS STRENGTHENED CONCRETE BEAMS

Liu zhong da, Dong xue hua ,X u zhi hong*

On account of the advantages of acoustic emission that a whole structure can be monitored from a few locations and the structure can be tested in use (without taking it out of service) and continuous monitoring, acoustic emission (AE) becomes more and more important in the domain of non-destructive evaluations (NDE). In this paper, by analyzing the energy and frequency of AE signal that captured from the CFRP bars strengthened concrete beams and the plain concrete beams, it can display correctly inside change of structure.

INTRODUCTION

In recent years the CFRP (carbon fiber reinforced polymer) material has been widely applied in Civil Engineering, either as reinforcement for concrete structures or for repairing and strengthening of existed structural elements. Comparing with steel reinforcement, the CFRP bars are higher in strength-to-weight ratio, better in corrosion resistance, lower relaxation, non-magnetic properties, easier of handling and cutting. But few mature techniques can estimate the damage mechanics of the CFRP bars strengthened RC beams. Those internal invisible cracks are potentially dangerous for the structure. Abrupt accidents of the structure will occur at any time.

In order to avoid the occurrence of this kind of disaster accidents, and to provide enough information about structure maintenance and diagnosis, non-destructive evaluation (NDE) becomes more and more important. As a detection technology in non-destructive domain, acoustic emission (AE) is an effective means that transient elastic waves generated by the rapid release of energy from localized fault in material. As structures are loaded, the elastic potential power is released along with the new crack surface and induces the AE signals. The counting intensity of these signals can indicate the damage level of the structure. In this paper the behavior of CFRP bars

reinforced concrete beams under three-point bending load were studied. A set of acoustic emission system was applied to monitor the damage of CFRP bars strengthened concrete beams. By comparing with the AE signals' energy, frequency and cracks of the beams, it was found that the AE signal can reflect the different stages of the test and the damage degree in concrete beams. It was also found that the characteristic value of the AE signal from the concrete and CFRP bars were different and the internal damage mechanism of the CFRP bars strengthened concrete beams can be estimated.

PREDICTION OF STRUCTURAL DAMAGE BY THE WAVELET-BASED NEURAL NETWORK

Ju Yanzhong* Qu Chengzhong Zhang Xunjiang He Guangyuan

In this paper, the application of wavelet-based neural network ART-2 for the damage detection of structure is discussed. A method combining dyadic wavelet with neural network of ART2 is presented and the damage location can be well identified with this method. The basic theories of artificial neural network and wavelet transform are given and their features and the principle of detecting damage are analyzed. The wavelet-based neural network is constructed by making wavelet transform the pre-processor of neural network. Then the wavelet de-noise and detection of changes of a signal and the ability of damage detection of wavelet-based neural network are tested by numerical samples. At the end, the effectiveness of this method is attested further by a model frame structure. The results show the method presented in this article is feasible and it has the advantages of few requirements of historical data, automatic increase of identification category, and the ability of anti-noise.

INTRODUCTION

In this paper, the wavelets transform works as a pre-processor of the neural network, which provides the network with more truthful data that reflect the property of the structure). It is more effective to combine wavelet transform with neural network. Wu, etc. (1992) applied BP network to damage detection of architecture structure and utilized the blur-matching ability of the neural network for determining the location and degree of the structural damage [1]. Tsou, etc. (1994) studied the problem of adopting BP network to damage detection of sprung system with multiple degree of freedom and mass point. [2]. Rhim and Lee (1995) did some research on beams with the BP network, in which they carried out a numerical simulation by making use of transfer function as the input parameter [3]. Kaminski (1995) researched on the

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damage location of beams with natural frequency being the input parameter, and indicated that choices and expressions of the input data of the network would directly influence the results of damage identification [4]. Mitsuru and Masri (1998) studied the damage detection of pivot-spring single-degree-of-freedom system and multistory structure [5]. A general BP network is some kind of tutor network, basing on the premise that there are lots of historical data. However, we cannot give the prediction and data of actual structure damage in every condition. This paper adopts ART2 network to deal with data pretreated by dyadic wavelet transform.

A STATISTICAL APPROACH FOR CONDITION MONITORING FOR MAINTENANCE MANAGEMENT IN RAILWAY

Fausto Pedro García Márquez

This paper presents an approach for detecting and identifying faults in railway infrastructure components. The method is based on pattern recognition and data analysis algorithms. Principal Component Analysis (PCA) is employed to reduce the complexity of the data to two and three dimension. PCA involves a mathematical procedure that transforms a number of variables, which may be correlated, into a smaller set of uncorrelated variables called "principal components". In order to improve the results obtained, the signal has been filtered. The filtered has been carried out employing a State Space system model, estimated by Maximum Likelihood with the help of the well-known recursive algorithms Kalman Filter and Fixed Interval Smoothing. The models explored in this paper to analyse system data fits within the so called Unobserved Components class models.

EXPERIMENTAL RESEARCH OF INTEGRATED ULTRASONIC TECHNOLOGY OF PHASED ARRAY AND TOFD FOR DETECTING PIPELINE DEFECTS

Weibin Wang[1], Yuqin Wang[1] , Ke Wang[1], Jinyu Yang[2], , Jianhe Song[3], Fuxiang Wang[1]

A segment of pipe was made up with various kinds of welding defects for experimental research. The pipe was inspected by an ultrasonic system using integrated technology of phased array and time of flight diffraction (TOFD).

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All the echo feature of different defects such as crack, corrosion, lamination etc. was analyzed. The experiment results shows that the integrated technology of phased array and TOFD has satisfying reliability and high precision. Other methods such as normal ultrasonic measurement and x-ray radiography technique were also used to compare with and verify the results gained by the integrated ultrasonic phased array and TOFD technique.

INTRODUCTION

To assess the working states of the oil and gas pipelines precisely and evaluate the safety factors especially at the location of welds, it is extremely important to know the reliability of the pipelines and decrease the possibility of leaking and rupture. If there are incidents, people and companies will have disastrous loss and casualty.

Pipeline NDT is different during different periods in China. Before 1999 manual ultrasonic detection methods were used. The technology efficiency at that time is so low that defects were easily missed.

Along with the rapid scientific and technological development in recent years, the United States, Canada and other countries make development in the ultrasonic detection technology to a mature level. Phased Array Ultrasonic detection technologies at home and abroad have been widely used in the long-distance pipeline girth welds testing. Compared with the traditional manual ultrasonic testing, the advantages of Phased Array are: high speed, accurate positioning defects, high detection sensitivity, visual detection, real-time displaying, which are the development trend of NDT.

OmniScan Phased Array Ultrasonic Inspection System with the phased array probes and the TOFD Weld probes were used to inspect embedded defects in welds. Analysis of the different defect detection echo signal characteristics was made and the characteristics of the defect recognition technology and experience were summarized, which provide a theoretical basis and technological support for the practical inspection.

PRECISION MEASUREMENT OF LOCAL DEFORMATION IN WELDED MEMBERS USING A VISUAL MONITORING SYSTEM

J. G. Han*, K. H. Chang*, G. C. Jang**, K. K. Hong*. Y. K. Lee***

In the loading tests for welded steel members, local deformation and strain in

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welded joints are difficult to accurately measure due to the effect of welding residual stress and weld metals. Therefore, a precision measurement system is required to observe the local deformation of welded members. In this paper, to accurately measure the welded steel members, a visual monitoring system(VMS) used a three-dimensional digital photogrammetry is developed by the authors. And distributions of strain adjacent to welded joint are investigated by using the VMS.

INTRODUCTION

Recently, in the loading tests for steel members, the deformation and the strain are measured by calculating a distance of both cross-head using LVDT. This method can be induced unexpected troubles on the course of deformation measuring by various environmental factors, such as initial slip, material in-homogenety and etc. Especially, the local deformation of welded steel members plays an important role in the estimation of the overall behavior. However, in the case of welded members, the local behavior is difficult to accurately measure by using the exiting test instruments. This is due to the non-uniformly deformation behavior in welded joint by the effect of welding residual stress and weld metals. Therefore, a precision measurement system is required to observe the local deformation of welded members.

In this paper, to accurately measure the welded steel members, a visual monitoring system(VMS) used a three-dimensional digital photogrammetry is developed by the authors. And distributions of strain adjacent to welded joint are investigated by using the VMS.

ON-LINE ESTIMATION OF INDICATED TORQUE IN AUTOMOTIVE ENGINES USING A SECOND ORDER SLIDING MODE OBSERVER

Wang Yunsong*, Zheng Weihua*, Shen Ming*, Liu Hongxi*, Sun Ning*

A second order sliding mode observer based on unknown system input estimation is proposed in this paper. The above observer is able to estimate the indicated torque as well as load torque, from the easily accessible measurement of engine crankshaft angular speed and transmission output shaft angular speed. The computer simulation shows the possibility and validity of using it for indicated torque reconstruction in on-board multi-cylinder engines. In addition, the dynamic properties of three components of the engine crankshaft, clutch and vehicle, are all considered into the physical system model for the

indicated torque estimation such that it exhibits strongly nonlinearity and fits most of the engine working conditions.

1. INTRODUCTION

In recent years, the model-based fault detection methods have been developed. Indicated torque can be estimated instead of calculation by direct measurement, avoiding hard direct detection of cylinder pressure. The estimation can be based on engine speed variance or observers. The classical sliding mode methods are deemed to be robust, but not exact, because of the intrinsic so-called chattering phenomena. Hence, the goal of the paper is to design a second order sliding mode observer, which is robust and exact, for the indicated torque estimation.

REAVEALING, IDENTIFYING AND ASSESING FLAW DEVELOPMENT IN HIGH CHROMIUM STEELS BY QUANTITATIVE ACOUSTIC EMISSION NON-DESTRUCTIVE INSPECTION METHOD

Prof. Dr. G. Muravin, Dr. B. Muravin, Dr. L. Lezvinsky*

The research has shown that the appearance, development and interaction flaws in high chromium steel is accompanied by continuous and burst AE, whether under stable or increasing single or cyclic loading. The peculiarities of the AE data make it possible to reveal, recognize, and quantitatively assess flaws with low and high stress intensity. So, Quantitative Acoustic Emission Nondestructive Inspection Technology created by authors was used to distinguish between flaw-free specimens, welded specimens with a limited number of industrial flaws, and those that had undergone significant embrittlement and contained fatigue cracks and/or micro- cracks.

INTRODUCTION

It is known (G. Muravin et al[1]) that the active use of high chromium martensitic alloy steels make it possible to: reduce wall thickness by nearly two-thirds; achieve

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faster startup and shutdown; reduce thermal stresses and increase allowable operational stresses up to 150%, increase thermal –fatigue life 10-12 times, and oxidation limit by 100 deg F; decrease cost of piping (the overall saving in the cost of the piping supplies and their fabrication is about 40% compared with P22).

Nevertheless, the high chromium steels do not retain their unique properties, if flaws and mistakes are made during industrial production or if external factors change the microstructure of the steel. Taking all the above to an account, we investigated**;** earliest indications of high chromium steel degradation as result of operation at service temperature in the creep range, as well as technological, industrial and maintenance mistakes. We established that indications, which are used currently for characterizing high chromium steel structural integrity and degradation (the dislocation density, martensite lath width, precipitates diameters, subgrain sizes, volume of fractions, and micro-hardness, ultimate strength and fracture toughness) are necessarily but not enough. This became worse because structural degradation of high chromium steels "is not always detectable with the standard QA tests" (G. Muravin et al[1]). As a result, the initiation of a fracture may occur in different unpredictable locations, without any visible indications.

To eliminate such obstacles, we improved our Quantitative Acoustic Emission NDI method (QAE NDI) ,G. Muravin [2], that enables revealing earliest indications of flaw development, location, identify their type and assess the danger level of flaws according to fracture mechanics criteria. In the following we shall consider the capability of QAE NDI to identify and assess individual flaws as well as systems of interacting flaws in specimens from high chromium steels.

ASSESSMENT OF STRUCTURAL INTEGRITY OF WIDE RANGE OF REINFORCED CONCRETE STRUCTURES BY QUANTITATIVE ACOUSTIC EMISSION NON-DESTRUCTIVE METHOD

Prof., Dr. G. Muravin, Dr. L. Lezvinsky, Dr. B. Muravin*

Quantitative Acoustic Emission Non-Destructive Inspection method was created and used to evaluate the state of tunnels and metro- stations conditions; to estimate the influence of various factors such as fires, earthquakes, rock-mass movement, explosions, seismic activity, and vibration on the tunnel's stability; discontinuities in the concrete itself and between it and the

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surrounding rock, bad adhesion between the concrete and the surrounding rock, analysis of the efficiency anti-failure measures.

INTRODUCTION

Our literature investigation revealed that one failure per 20 km of tunnels occurs every year. Damage is caused by: the development of cracks, mountain shock, and landslip - 35%; overloading of tunnels elements due to design errors during construction - 15%; use of low quality material and bad construction - 15%; extreme situations and natural catastrophes (fire, explosions, earthquakes, seismic activity) - 25%; errors in geological investigations and incorrect evaluating mountain pressure - 10%.

In some cases, failure occurred without any previously apparent warning signs, while in others, those responsible either ignored the warnings or had no way of assessing the level of risk arising from continued operation of the tunnel. More often, in the absence of suitable methods of early fracture diagnosis, the signs of impending disaster were not analyzed.

Our experience and analysis of the literature has shown that the high sensitivity of the AE method has great advantages as a tool for revealing defects at an early stage of their development and for monitoring damage accurately. Nevertheless, procedures for decoding AE data are imperfect and are not suitable for determining the type of different defects and their danger level according to fracture mechanics criteria. To overcome the problem, the development of Quantitative Acoustic Emission Non-Destructive Inspection (QAE NDI) method has been commenced at the beginning of 1980s (G. Muravin [1]) and we continue to update it. Below we review techniques used for solving above mentioned problems.

AN EXPERIMENTAL STUDY ON DRILLING TOOL DEFICIENCY TESTING USING METAL MAGNETIC MEMORY TECHNIQUE

Xu Haibo Fan Jianchun Zhang Laibin Wen Dong Wang Jinfeng

It is well known that the status of the drilling tools is a significant problem in the oil drilling industry. In present, many forms of non-destructive testing methods are used to test drilling tools in the oil industry, but there are still some considerable deficiencies in these methods. To solve this problem, a new non-destructive testing method—metal magnetic memory technology (MMMT) is presented in the paper. A new scientific type of test device and a test method are designed in the experimental research. The experiment is mainly to gain the characteristics of magnetic memory signals of the samples from drilling tools in static tension and pressing crack experiment. Through analyzing the experimental data, the primary relationship between stress value and magnetic memory signal is established.

1. INTRODUCTION

During the drilling process, drilling tools failures, such as corrosion, pierce, rupture, fracture etc, result from pulling stress/tension, pressure, bend, wrest, vibration and alteration stress. Research results show that these failures result from stress concentration of some parts of drilling tools. The concept of Magnetic Memory Technology is that magnetostrictive and magnetic domain self-organizing directing and irreversible reorientation occurs in the areas of stress and distortion concentration, because of the service load and the magnetic field of the Earth during the drilling process. The irreversible magnetic phenomenon is reserved after the working loads disappear, which forms magnetic leakage field. And the intensity of magnetic leakage field holds the stress concentration of drilling tools. Consequently, the status of stress concentration can be confirmed through researching on the stressed drilling tools using magnetic memory technology, further more, the service status and service life of drilling tools can be forecasted.

THE ANALYSIS ON CORROSION PROPERTY OF GRAY CAST IRON TREATED BY GAS MULTI-ELEMENT PENETRATION

Zhou Hai　Wan Hancheng　Chen Fei　Yang Yingge　Chen Shaohua

The surface of gray cast iron can form the nitride layer by gas multi-element penetration，the analysis of nitride layer was made by the XRD and SEM about the phase structure and section appearance. The results show that the surface of material treated by gas multi-element penetration in a short time formed the

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white layer which was composed of Fe2N and Fe3N, diffusion layer was composed of iron nitride and carbide. And so the corrosion resistance improved obviously.

1 INTRODUCTION

Gray cast ion HT200, as a kind of high strength casting, has better strength, wearability, heat resistance and casting property, and is widely used for the casting of workpieces such as oil cylinder, pump body and valve. Because such workpieces all must have the ability of resisting corrosive media, gray cast ion is required to be subjected to the corrosion resistance treatment[1]. The gas multi-element penetration technology mainly features gas nitriding in middle- and low-temperature conditions, coupled with non-metallic elements such as carbon, oxygen, sulfur to form a layer mainly comprised of nitride on the surface of gray cast ion, thus improving its corrosion resistance.

A STUDY ON THE METHOD FOR THE PORT MACHINE SAFETY DESIGN BASED ON STRUCTURAL INTEGRITY

Zhang Yubo[1], Liu Jinchuan[1], Luo Hongyun[2]

This paper introduces the design methods and the actuality of the port machine structures and the main failure types of the existing port machines are analyzed. So far the most of the designers didn't consider the existed defects' in the structures influenced on the machines' safety, and in fact a lot of port machines' structures became failure as a result of ignoring these defects. In view of these conditions this paper brings a new method for designing the port machines' structures based on the failure analysis theory. This method was put forward with combination of failure analysis theory and specifications of safety assessment according to many engineers' practical experiences and a lot of tests' results. When we design a structure we can suppose that one or more defects have existed in the structure, then according to the stress, the material's capability, apply the failure assessment curve (FAC) to assess the structure's safety. After the machine is manufactured we measure the key stress points' defects, once the defects exceed the case which we supposed, we can consider that the machine is not safe to be used. In the end a typical example of this approach is presented.

CRACK IDENTIFICATION IN BEAM STRUCTURES BASED ON FINITE ELEMENT METHOD AND GENETIC ALGORITHMS

Yu Zhigang[*, †], Xu Xin[†], Xiao Kaiqing[†] and Chu Fulei[*]

In this paper, a genetic algorithm based method for crack identification is proposed and described, which formulates the crack detection in beam structures as an optimization problem by means of finite element method and utilizes genetic algorithms to effectively search the crack parameters. Due to the nonlinear essence, time response of structural vibration is employed. Numerical simulations have been carried out and the results demonstrate that good predictions of the crack location and magnitude are possible and the proposed method is feasible. The study also indicates that the proposed method has the potential to solve a wide range of inverse identification problems in a systematic and robust way.

INTRODUCTION

Crack diagnosis, identification and even prognosis in early stage in structures have been a field of challenging ongoing research for the safe and economic operation of the machinery. Many local damage detection techniques have been developed such as ultrasonic inspection since they can provide a direct assessment of integrity of structures during service. However, these are usually very time-consuming and labor-intensive. In order to overcome these drawbacks, vibration based inspection methods(VBI） have been developed to offer potential advantages for crack detection in a global scale. Among the VBI approaches for crack detection reported in literature, frequency domain methods have been one of the most popular ones in use (Ngwangwa et al. [1]). However, they are not applicable for the cracked structures exhibiting non-linearity. Meanwhile, they will cause the loss of important information when time records have been transformed into the frequency domain (Andreaus et al [2]). In this paper, the time-domain based crack identification method has been proposed naturally. Using this methodology, we establish the finite element (FE) model of a cracked beam to predict the time response. Then the crack identification is converted as a minimization task with an objective function composed of measured and analytical vibration data. Finally, genetic algorithms (GA) are used to solve the optimization problem.

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DISLOCATION DISTRIBUTION FUNCTION OF THE EDGES OF MODE Ⅰ DYNAMIC CRACK SUBJECTED TO MOVING UNIT-STEP LOADS AND MOVING IMPACT LOADS

Nian-chun Lü[1, a ,3,], Yun-hong Cheng [2,b], Jin Cheng [3,c]

By the methods of the theory of complex functions, a problem on dislocation distribution function of the edges of mode I dynamic crack subjected to moving unit-step loads and moving impact loads was researched respectively. Analytical solutions can be gained by the measures of self-similar functions. The problems considered can be changed into Riemann-Hilbert problems and their closed solutions are attained rather simple by this ways.

INTRODUCTION

Mode I moving crack was regarded as a running consecutive distributive edge dislocation[1-2]. Based on this idea, dislocation continuous distributive model of mode Ⅰ crack for an orthotropic anisotropy was built. By the ways of theory of complex function, the problems studied can be translated into Riemann-Hilbert problems, which are very readily solved by literature [3]. The relation between displacement v and dislocation distribution function $\phi(x)$ has the following:

$$v = -\frac{b}{2}\int_{vt}^{x} \phi(x)dx, \qquad \text{or} \qquad \phi(x) = -\frac{2}{b}\frac{\partial v}{\partial x} \tag{1}$$

Here $\boldsymbol{b}$ is *Burgers* vector, $\phi(x)$ is dislocation distribution function.

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STRESS CORROSION CRACKING BEHAVIOR OF PIPELINE STEEL X60 IN NEAR-NEUTRAL PH SOIL ENVIRONMENTS AROUND SHANGHAI

G. F. Li[1] , G.L. Zhang[1], C.B. Huang[1], W. YANG[1], Z.H. Sun[2], D.F. Yan[2], J.H. Fang[2]

Near-neutral pH stress corrosion cracking (SCC) behavior of pipeline steel X60 in typical soil environments around Shanghai has been investigated for structural integrity assessment. The effects of soil type and electrode potential from cathodic protection point were evaluated through slow strain rate tests

(SSRT) at various electrode potentials in three solutions containing different typical soils. Results showed that the SCC susceptibility generally increased with decreasing electrode potential in all the three environments, with quick increase happening in the range of -1200 ~ -700mV(SCE). It is suggested that hydrogen induced cracking should dominate the SCC at low potentials. In cathodic potential range, the rank of the SCC susceptibility for soil type was Near-city soil > Cyan-purple soil > Cyan-yellow soil. In anodic potential range, SCC susceptibility curves mixed each other in the three solutions.

INTRODUCTION

SCC from the soil side has become one of the most important issues in the structural integrity of high pressure pipeline, which have resulted in many severe failures of underground pipelines for long distance transmission of gas or oil in the world. The SCC of pipelines is usually divided into two basic forms, that is, high pH SCC occurring in concentrated carbonate-bicarbonate solution and near-neutral pH SCC taking place in dilute carbonate-bicarbonate solutions containing small amount of chloride and sulfate. The latter form was firstly reported in Canada in 1985, with transgranular cracking mode, which has become a common failure mode (Parkins [1]. Many researches have been attracted to the cracking behavior and prediction methodology. The soil type and electrode potential have been regarded as vital environmental factors in the cracking characterization and prediction, from both academic and engineering points (Chen [2], Beavers [3, 4], Guo [5]) . However, the effects and the mechanism have not been made clear enough. In this work, SCC behavior of X60 used for high pressure gas pipeline network around Shanghai in near-neutral pH soil environments has been studied for structural integrity assessment.

DETERMINATION OF FRACTURE ENERGY OF CEMENT PASTE AND MORTAR USING THREE-POINT BENDING TEST

Yu Zhu, Shilang Xu*

Fracture energy is an important parameter for non-linear fracture mechanics research. However, there exist size effects when three-point bending test is used to determine fracture energy of concrete, rock and other materials. Therefore, three-point bending beams of cement paste and mortar with different sizes and ligament lengths were tested. A complete load-deflection (P- δ) curve was directly obtained. The variation regularity of fracture energy

with size and ligament length of cement paste and mortar were also given in the paper. It was found that fracture energy of cement paste and mortar was very great affected by the tail of the *P*- δ curve, and a fit was made for the tail of the *P*- δ curve using power and exponential function, respectively, and then the fitting results of the two functions were compared. After considering the influence of tail curve, fracture energy of cement paste and mortar are size-independent.

INTRODUCTION

Fracture energy G_F is an important parameter to research non-linear fracture mechanics. It is defined as the energy to create a unit area of fracture surface. The earliest concept of G_F was proposed by Hillerborg et al in the fictitious crack model Hillerborg et al. [1]. Petersson first studied fracture energy of concrete by using the three-point bending test (TPB) Petersson [2]. This method is widely used, because it is easily performed and needs less equipment. On the basis of many results by different researchers, RILEM TC-50FMC has recommended a series of rules on determination of the fracture energy of concrete by TPB [3].As a material parameter, fracture energy should be a constant and independent of specimen size. However most researchers have found that there exist size effects when TPB is used to determine the fracture energy of concrete, rock and other materials. Therefore, three-point bending beams of cement paste and mortar with different sizes and ligament lengths were tested. In the test, we also find that fracture energy of cement paste and mortar are variational with the change of specimen size and ligament length. Based on our analysis of experimental results, and considering the influence of tail curve, fracture energy of cement paste and mortar are size-independent.

WEIGHT FUNCTIONS FOR STRUCTURAL INTEGRITY ASSESSMENT – METHOD AND APPLICATIONS

Xue-Ren Wu*

An overview is presented on the weight function method for fracture-mechanics-based structural integrity assessment with regard to crack-like defects. The weight function method provides a powerful tool for the determination of key parameters, such as stress intensity factor and crack opening displacement for cracked structural components. For two dimensional

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(2D) crack problems, weight functions were obtained in closed form for both center- and edge-crack configurations. For three dimensional (3D) cases, a combination of the closed-form 2D weight functions and the slice synthesis technique makes it possible for rapid determination of stress intensity factor at any point along the crack front. The versatility, efficiency and accuracy of the weight function method, especially for treating crack problems with complex loadings, were demonstrated with various examples.

INTRODUCTION

One of the most frequent causes of failure is the presence of crack-like defects, because they can lead to catastrophic structural failure well within the original design envelope without early warning. Fracture mechanics is a most valuable tool for examining the safety of cracked structures, for developing effective remedial measures and determining their remaining useful life. The key prerequisite for the application of linear elastic fracture mechanics (LEFM) is the knowledge of accurate fracture parameters, e.g. stress intensity factor (SIF) and crack opening displacement (COD) for cracked bodies subjected to the loading in consideration. Because of the singularity at the crack-tip and, the crack length as one additional variable, analysis of crack problems are much more difficult and time-consuming than uncracked cases. Various analysis methods for crack problems within the LEFM frame have been developed over the past decades. However, many of the methods are inefficient in handling complex load cases. The weight function method provides very powerful, reliable, easy-to-use and cost-effective means to overcome such difficulties. The present paper gives an overview of this versatile approach.

THE STRUCTURAL STRESS METHOD FOR THE FATIGUE ANALYSIS OF WELDED STRUCTURES

Pingsha Dong[1], John Draper[2]

The stress concentration in a welded joint dominates the fatigue behavior of the joint. However, traditional finite element methods are not capable of consistently capturing the stress concentration effects due to their mesh-sensitivity.

A robust stress analysis procedure has recently been developed at Battelle and extensively validated by various industries. The method is called Verity™ mesh-insensitive structural stress method and serves as a FE post-processing

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procedure to commercial FE packages. The Verity™ method has been integrated into fe-safe™ and is available from Safe Technology Limited. The method is based on the mapping of the balanced nodal forces/moments along an arbitrary weld line into the work-equivalent tractions (or line forces/moments). A complex stress state due to notch effects can then be represented in the form of a simple stress state in structural mechanics in terms of through-thickness membrane and bending components at each nodal location. The resulting structural stress calculations are mesh-insensitive as long as the overall geometry of a component is reasonably represented in a finite element model.

In addition to its mesh-insensitivity, the effectiveness of the structural stress parameter has been further validated by collapsing several thousands of fatigue tests available from literature into a single fatigue life curve, referred to as the master S-N curve.

INTRODUCTION

Fatigue design and evaluation of welded joints are typically carried out by a weld classification approach in which a family of parallel nominal stress based S-N curves are used according to joint types and loading modes [1]. In all the global based stress analysis procedures (such as nominal stress, extrapolation based hot spot stresses, etc.) for fatigue evaluation purposes [1-6], the ultimate goal is to identify an appropriate stress parameter which can be consistently calculated in practice, and can be used to effectively correlate S-N data from various joint types and loading modes. This can be restated as both the necessary and sufficient conditions for seeking a global stress-based fatigue correlation parameter as follows:

(a) A global stress parameter must be able to be calculated consistently with a minimum mesh-sensitivity (mesh sizes, element shapes, element types, etc.) at a fatigue prone location such as at weld toe;

(b) Such a stress parameter must be demonstrated to be capable of correlating different fatigue behaviors (such as S-N data) observed in various joint types, loading modes, etc.

Obviously, nominal stress definition, if applicable for some joint configurations, satisfies the necessary conditions (a), since it can be calculated by simple formulae, i.e., without mesh-sensitivity. However, it is well known that the nominal stress definition does not satisfy the sufficient conditions (b), since it cannot be used to correlate S-N data from various joint types and loading modes. This is why a family of essentially parallel S-N curves has been used with respect to the nominal stress parameter as shown in Fig. 3 [1].

The fact that those S-N curves (Fig. 3) are essentially parallel to one another suggests the existence of a master S-N curve. A scaling parameter that correctly

measures the stress concentration in various welded joint types and loading modes should be able to collapse all the parallel S-N curves in Fig. 3 into a single master S-N curve. It is the purpose of this paper to present such an approach by formulating an effective global stress parameter which can be used as a basis to establish such a master S-N curve. In this context, the nodal force (always implying moments in this paper) based mesh-insensitive structural stress method (5-9) will be briefly highlighted for its consistency in stress concentration characterization as required by the necessary conditions stated above. Then, the nodal force based (referred to as structural stress method throughout this paper) structural stresses are shown to possess a unique property which can be used for a rapid estimation of the stress intensity factors (K) in an arbitrary joint within a fracture mechanics context. As a result, a two-stage crack growth model has been proposed and validated by a large amount of experimental data. The two-stage growth law unifies both the conventional "short crack" anomalous crack growth and long cracks. By integrating the two-stage crack growth model, a unique scaling parameter encompassing the structural stress based stress concentration effects, loading mode effects, and thickness effects is then formulated and validated by a massive amount of historical weld fatigue S-N data from 1947 to present.

ELASTIC-PLASTIC FINITE ELEMENT ANALYSIS OF FATIGUE CRACK TIP PLASTICITY AND CORRELATION OF FATIGUE CRACK PROPAGATION RATES UNDER TENSION-COMPRESSION LOADING

Song Xin[1]* Tang Hui [2] Zhang Jiazhen[1]

Elastic-plastic finite element analysis has been performed in order to obtain the fatigue crack tip parameters under tension-compression loading. The crack tip plastic zone size, reverse plastic zone size, crack tip opening displacement have been obtained. These results show that the compressive loading part of the fatigue load cycle has a significant effect on these crack tip parameters and therefore has a strong effect on fatigue crack growth rate under tension-compression loading. The obtained parameters from finite element analysis have been used to correlate the experimental obtained fatigue crack

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propagation rate, and good agreement has been obtained.

INTRODUCTION

The affection of pressure has been omitted for a long time in the life prediction research of the fatigue crack propagation [1]. It is considered that the crack is closed when the load is zero or is compressive. Therefore, in a tension-compression loading, the calculation of the stress intensity factor range, ΔK, is usually based on the stress range in the tensile load part of the fatigue load cycle, as recommended by the ASTM E647-95a.

Recently, Topper and Yu [2] found that for aluminium alloy 2024-T351 the compressive stress has a significant effect on the fatigue crack propagation rate. Tack and Beevers [3] had also observed that in steels the fatigue crack propagation rate under a negative stress ratio R is greater than for R=0.1. Halliday and Zhang [4] found that for aluminium alloy 2024-T351 tensile overload does not have any effect on fatigue crack growth rate at R=-1, but has a significant retardation effect at R=0.05. Pommier et al. [5-6] observed that for a N18 superalloy there is a strong compressive loading effect on the fatigue crack propagation rate. They attributed this behaviour to plastic properties of the material. Silva [7,8] found that for several materials the compressive part of the fatigue load cycle plays a significant role on fatigue crack propagation and the concept of fatigue crack closure is not adequate to properly describe fatigue crack growth rate at $R<0$. More recently Fonte et al. [9] found that for 7049 aluminium alloy there is a significant difference in fatigue crack propagation rate between R=0 and R=-1. Zhang et al[10-13] have observed that the fatigue crack growth is successive in the ultra fine grain aluminium alloy IN 9052 specimen by high resolution in-situ SEM, and develop a two parameter fatigue crack propagation model under tension-compression loading based on a new parameter, $da/d\sigma$.

In this paper, elastic-plastic finite element analysis has been performed in order to analyze the variety of the fatigue crack tip parameters under tension-compression loading, and research the effect on the fatigue crack growth rate. The obtained parameters from finite element analysis have been used to correlate the datum in the reference [13], and good agreement has been obtained.

CALIBRATION THE SY MODEL FOR STRUCTURAL STEEL BASED ON CRACK CLOSURE MEASUREMENTS

Tomasz Machniewicz*

Predictions on fatigue crack growth in structural steel under constant amplitude loading and after a single overload are performed using a strip yield model implementation by the Authors. The model calibration has been performed according to a novel methodology, which offers the means to select the constraint factors based on a physical foundation. Comparisons between the observed and predicted results indicate that the model quantitatively covers all trends in crack growth observed in the present tests.

INTRODUCTION

Among non-linear concepts that have been proposed for fatigue crack growth predictions, the so-called strip yield (SY) model based on the Dugdale conception of crack tip plasticity, but modified to allow for the plasticity induced crack closure (PICC) mechanism, remains a particularly versatile predictive tool convenient to use in the case of mode I fatigue crack growth under arbitrary variable amplitude loading histories. The basic material input for the SY model are the fatigue crack growth rate vs. the effective stress intensity factor range (da/dN-ΔK_{eff}) data. To account for the 3D nature of PICC, appropriate constraints on yielding the plastic strip elements should be imposed. As elucidated in more detail by Skorupa and Skorupa [1], an equally important role of the constraint factors is to calibrate the SY model for a given material in order to account for processes, which can affect crack growth but cannot be modelled in a rigorous way.

The predictive capabilities of a well known and most widely used SY model implementation included in the NASGRO software have been systematically evaluated by the present authors under a variety of fatigue loading conditions for both aluminium alloys (Skorupa et al. [2]) and structural steel (Skorupa et al. [3]). It has been concluded that altogether unsatisfactory prediction quality stems from an inadequate conception of the constraint factors incorporated in the NASGRO models.

FRACTURE PARAMETRIC STUDY ON CEMENT-BASED MATERIALS FROM THREE-POINT BENDING TEST

Shilang Xu, Yu Zhu*

For two most basal cement-based materials, cement paste and mortar, their fracture parameters were studied by 84 geometrically similar three-point bending beams of which strength and size were varied. Complete load versus crack mouth opening displacement (*P-CMOD*) curves were directly obtained, and their fracture toughness were determined. In the test, a sudden brittle fracture was not found in cement paste and an apparent stable crack propagation before unstable failure was observed both in cement paste and mortar. The process of crack initiation, stable extension and unstable failure were investigated using resistant strain gauges. There exist obvious size effects both in the critical crack mouth opening displacement and critical crack tip opening displacement of cement paste and mortar. Due to the influence of shrinkage crack and the precritical crack propagation length, the initial fracture toughness K_{Ic}^{ini} and unstable fracture toughness K_{Ic}^{un} are not size-independent.

INTRODUCTION

Cement-based material is a heterogeneous composite, consisting of cement, aggregates of different size and water. And some authors had made many researches on the effect of inclusions on fracture properties of cement-based composites, such as the aggregate content Amparano et al. [1], the type of coarse aggregates Hassanzadeh [2] and the coarse/fine aggregate ratio Zhang et al. [3] and so on. As two most basal cement-based materials, fracture properties of cement paste and mortar are the basis of studying fracture performance of cement-based materials. With a view to study the basic fracture behaviors of cement paste and mortar, three-point bending beams with different sizes and strengths were tested to determine fracture parameters of cement paste and mortar. The process of crack initiation, stable extension and unstable failure were investigated using resistant strain gauges. The critical crack mouth opening displacement ($CMOD_c$) and the critical crack tip opening displacement ($CTOD_c$) of cement paste and mortar were directly obtained, and their precritical crack propagation lengths (Δa_c) were also given in the paper. Fracture toughness of cement paste and mortar were determined according to the double-*K* fracture criterion Xu and Reinhardt [4, 5].

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NUMERICAL SIMULATION FOR CRACK GROWTH

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Crack growth is simulated with the improved extended Finite Element Method (XFEM), which can directly evaluate stress intensity factors (SIFs) without extra post-processing. In the improved extend finite element method, the finite element approximation of the nodes surrounding the crack tip is enriched with not only the first term but also the higher order terms of the crack tip asymptotic field using a partition of unity method. The crack faces behind the tip(s) are modeled independently of the mesh by displacement jump functions. When the crack faces are closed, the large time increment method (LATIN method) is recommended to resolve the nonlinear boundary value problem. Numerical simulations illustrate that the improved XFEM can effectively model the stationary and dynamic discontinuities, and it has wonderful practical merits.

INTRODUCTION

Belytschko et al. [1] proposed the XFEM, and applied it to solve the discontinuous problems. In the XFEM, the geometry of crack is independent of the computation mesh. In the past several years, the method was applied to solve different discontinuous problems in some fields.

NUMERICAL MODEL FOR FRACTURE PROCESS OF CONCRETE WEDGE-SPLITTING SPECIMEN

Li Yunfeng*, Duan Shujin**

Concrete is a kind of tensile strain-softening material. There is a fracture process zone near the crack tip with cohesive stresses. The Fictitious Crack Model (FCM) is suitable to represent the characteristics. But the theoretical solution of FCM can not be easily yielded out. Based on the Duan-Nakagawa's model, the problem can be well resolved by using the weight integral method. The model has proposed a new concept of finite stress concentration near the crack tip and a fracture process zone model with continuously stress distribution and crack opening displacement. In this paper, the fracture process of concrete wedge-splitting specimen is simulated by Duan-Nakagawa's model taking the one times weight function. Calculation result shows that the whole

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process from crack initiation, extension to failure is well agreed with the test.

ELASTIC-PLASTIC ANALYTICAL SOLUTION FOR AN ECCENTRIC CRACK LOADED BY A PAIR OF TENSILE POINT FORCES

Xie Qiang +,* Zhou Xiao-ping * Zhang Yong-xing *

The near crack line analysis method is used to investigate an eccentric crack loaded by a pair of tensile point forces in a finite plate in an elastic-perfectly plastic materials, and the analytical solution are obtained under plane stress condition in this paper. The solutions include: the elastic-plastic stress fields near crack line, law that the length of the plastic zone along the crack line is varied with an external loads, the maximum lengths of the plastic zone, the bearing capacity of a finite plate with an eccentric crack loaded by a pair of tensile point forces, and the unit normal vector of the elastic-plastic boundary near the crack line. The results of this paper are sufficiently precise near the crack line because the assumptions of the small scale yielding theory have not been made and no other assumption has been taken.

1. INTRODUCTION

The elastic-plastic analysis for a cracked plate with finite dimensions is one of the most difficult fields of elastic-plastic mechanics. To analyze and describe failure of an elastic-perfectly plastic material containing a crack loaded by a pair of tensile point forces in a finite body, various different methods have been developed. Among others, near crack line analysis method [1-4] has proved its usefulness in many applications.

A CRACK IN AN INFINITE PLATE OF FGMS SUBJECTED TO AN ANTI-PLANE SHEAR IMPACT LOADING

Xianshun Bi*, Jianxun Zhang and Xuefeng Cai

The problem of a plane crack in an infinite plate of functionally graded materials (FGMs) subjected to an anti-plane shear impact loading is considered. The assumed property variations is exponential of shear modulus and mass density. The Poisson's ratio is assumed to be constant. The mixed boundary value problem is reduced to a pair dual integral equations through the use of Laplace and Fourier integral transform. In solving the dual integral equations, the crack surface displacement in the Laplace transform domain is expanded in a series using Jacobi's polynomials. The influence of the characteristic length on the crack-tip stress is studied by making using of numerical inversion of Laplace transform technique. The numerical results show that the crack-tip stress fields does not retains the stress singularity. The crack-tip stress tends to increase with time at first and then decreases in amplitude and the peak values of stress decreases with increasing the characteristic length.

INTRODUCTION

Recently, the study of nonhomgenous solids has gained renewed importance with the advance in the fields of FGMs. Most previous works on FGMs can been seen from the reviews articles. Erdogan[1]，Jin and Batra[2], Gu and Asaro[3] provide the quais-static stress intensity factor for cracks in FGMs for different geometry and loading conditions. Nakagaki *et al.*[4] investigated dynamic fracture in FGMs using numerical method. In all these studies, the crack-tip stress fields still retains the inverse square root singularity. In this paper, a crack problem for an FGMs plate subjected to an anti-plane shear impact loading is analyzed by using the non-local theory[5]. The influence of the characteristic length on the crack-tip stress is studied through the use of numerical inversion of Laplace and Fourier integral transform technique.

CHARACTERIZATION OF CREEP CRACK INTERACTION FOR HIGH TEMPERATURE STRUCTURE WITH MULTIPLE

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EMBEDDED CRACKS

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The interaction and coalescence of multiple cracks may significantly influence the service lives of high-temperature structures. Plane strain multiple cracks problems are considered to investigate the interaction effect on the *C**-integral. Using the FEA, the *C**-integral are calculated for wide ranges of the relative crack distance and material constants. Finally, an empirical relation of the interaction factor is proposed for all cases considered. Furthermore, the proposed equation provides a good engineering tool for the multiple cracks interaction analysis under creep conditions.

INTRODUCTION

The structural integrity of high-temperature components should be assessed by taking into account the influence of flaws. The interaction of multiple flaws under linear-elastic and elastic-plastic conditions has been widely studied (Tu and Dai [1], Collins and Cartwright [2]), and some recommendations (ASME [3], BS7910 [4]) have been applied by re-characterization. However, the interaction of multiple flaws under creep regime has been paid little attention thus far. Therefore, it is necessary to investigate the interaction effect of the *C**-integral, which is now widely accepted as the crack-tip fracture parameter under creep conditions (Xuan et al. [5]). The investigation (Si et al. [6]) shows the interaction effect of the *C**-integral is larger than that of the stress intensity factor.

In the current study, two identical collinear cracks subjected to remote tension are considered, as shown in Fig.1 (a).

THE FINITE ELEMENT ANALYSIS OF TRAIN BOGIE WELDING CRACK UNDER DYNAMIC LOAD

Cheng Kai, Li Qihan, Liu Jianmin,Ju Haomin,Ji Youmhang

In the paper finite element model is built based on train bogie welding frame of some factory. According to the straight way, the curve way and the slope way, dynamic load is loaded in Ansys finite element analysis. By seeing about the stress and strain state of the welding line in post-process, reasons and laws are

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analyzed, furthermore, corresponding reformative methods are put forward.

CRACK GROWTH PREDICTION IN A GRAPHITE SAMPLE UNDER MIXED MODE LOADING

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Cracked components made of graphite are usually susceptible to brittle fracture due to mixed mode I/II (tensile-shear) loading. Some experimental and theoretical techniques have been proposed in the past for evaluating mixed mode brittle fracture. However, the reported test data for mixed mode fracture toughness of a graphite sample can not be predicted by the available fracture theories. In this paper a modified criterion is employed for analyzing the fracture toughness data given for this graphite sample. It is shown that the modified criterion provides very good predictions since it takes into account the effect of nonsingular stress term around the crack tip in addition to the conventional stress intensity factors.

INTRODUCTION

Defects and cracks are frequently found in brittle materials. Graphite is among brittle materials and is frequently used for various engineering parts and components. Due to its desirable properties, this material has wide applications in many industries. For example, graphite electrodes are used extensively in electric arc furnaces for steel making and also in electric smelting furnaces for producing industrial silicon. These electrodes can be susceptible for mixed mode brittle fracture. Strength evaluation of such materials under the existing loads requires a good knowledge of fracture toughness for the given material. In order to predict the onset of brittle fracture under mixed mode I/II loading, some theoretical fracture criteria like the maximum tangential stress (MTS) criterion [1] have been proposed. These criteria can be used for estimating both the crack initiation direction and the mixed mode fracture load. From an experimental view, there are also various techniques and test methods for investigating mixed mode I/II brittle fracture. The Brazilian disc (BD) specimen is one of the favorite configurations for conducting fracture tests in quasi-brittle materials. The BD specimen is a circular disc of radius R and thickness t with a central crack of length $2a$. When the specimen is subjected to a compressive load P, depending on the crack orientation angle (α), different combinations of mode I and mode II can be obtained. However, the mixed mode I/II fracture toughness data for a

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number of graphite samples tested with the BD specimen [2] are not corroborated with the conventional MTS or other similar mixed mode fracture criteria. The reported fracture toughness data for the graphite samples are significantly higher than predictions by the MTS criterion. It is shown in this paper that the enhanced mixed mode I/II fracture toughness of graphite is due to the effect of large negative T-stresses existing in the BD specimen. Thus a generalized MTS (GMTS) criterion based on the three fracture parameters K_{I}, K_{II} and T is used for an improved evaluation of test results.

RESEARCH ON THE PARTIAL SAFETY FACTORS OF THE DEFECT ASSESSMENT

Zhi-cheng WANG, Jian-ping ZHAO*

Two sets of PSFs are recommended by API579 and BS7910 are widely used all over the world. However the PSFs recommended by GB/T19624-2004, which is national standard of the defect assessment procedure of China, are still based on the PD6493, the pre-edition of BS7910.So it is urgent to establish a new set of PSFs fitting for China. With this intention, the derivation of the two sets of PSFs given by API579 and BS7910 is discussed in this paper, and the PSFs are given by the first order second moment (FOSM) method. A new set of PSFs is given by an example, which was used to be compared with the PSFs provided by the API579 and BS7910, respectively. Based on the research, the PSFs given by API579 is more conservative than these of BS7910 when the COV is low, while it is reverse when the COV is high, what's more the PSFs given by this article is creditable from the compare.

The Partial safety factors (PSFs) is one of the most effective methods for dealing with the uncertainty of parameters in the assessment of structural integrity. Recently years, there are great progresses in the structural integrity assessment including PSFs, and it comes into being two sets of PSFs: API579 and BS7910, which are now widely used all over the world.

GB/T19624-2004, which is national standard of the defect assessment procedure of China, are still based on the PD6493, the pre-edition of BS7910. So it is urgent to establish a new set of PSFs based on the actuality of China.

A GENERAL ENGINEERING METHOD FOR PLASTIC LIMIT AND SHAKEDOWN ANALYSES OF STRUCTURES

Chen Gang[1] , Liu Yinghua[2]

How to apply reasonably numerical methods to give systematic computational formulae for complicated practical engineering problems is the difficulty and key of application of limit and shakedown theories in practical engineering, and also the cutting-edge subject of application research of the theories. A general engineering method is presented and summarized for solving systematic engineering problems of limit and shakedown analysis. Some typical and successful engineering application cases are illustrated.

1 INTRODUCTION

Limit and shakedown analysis of structures is an important sub-discipline of plasticity, which can determine the load carrying-capacity and provide theoretical foundations for engineering design and safety assessment. Compared with conventional design(elastic design), limit and shakedown analysis can reflect the performance and practical safety extent of structures, and further bring into play the load carrying-capacity of materials. The fundamentals of limit and shakedown analysis were early established and have been developing [1-3]. However, for most practical engineering structures, analytical solutions are generally difficult to get due to the difficulty of mathematics. With rapid development of computers, the research emphasis from 1980's was turned to study the strategy of application, establish and develop efficient and reliable and feasible numerical methods so that limit and shakedown theories can find their applications in engineering practice and solve more individual practical problems. However, because of the dispersing of computational results, the great amount of data preparation and process and of the unknown influence relations of parameters, it is very difficult to apply these numerical methods to solve complicated systematic engineering problems. Up to now, only some limit and shakedown analysis problems have been solved for typical simple structures under different loads.

How to apply reasonably numerical methods to give systematic computational formulae for complicated practical engineering problems is the difficulty and key of application of limit and shakedown theories in practical engineering, and also the cutting-edge subject of application research of the theories. In the eighth five-year, ninth five-year and tenth five-year science and technology key programmes of China, the authors of this paper developed constantly some efficient and reliable numerical methods for plastic limit and shakedown analyses of structures[9, 10], and applied these methods to solve key technology difficulties by establishing a series of different types of structural design formulae and defect assessment methods and further

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summarized a general engineering method for solving complicated practical engineering problems[4-8]. This paper will introduce concisely this engineering method and illustrate it by some typical and representative examples. More details can be referred in the monograph[4].

STRENGTHEN SUPERVISION AND PROMOTE TECHNOLOGY INNOVATION TO ENHANCE SPECIAL EQUIPMENT SAFETY SUPERVISION AND INTEGRITY ADMINISTRATION

Zhang Gang*

This paper introduces the concept of China special equipment and its safety conditions, reviews the scientific & technical researches and achievements in the fields of special equipment safety supervision and integrity administration in the past twenty years in China. In the end, the paper expounds the measures to continue expediting the application of integrity administration in the field of special equipment safety from the aspects of regulation, supervision and technical innovation.

DEFORMATION TESTING OF THE ROUND-LINK CHAINS FOR THE SCRAPER CONVEYER BASED ON THE WEAK MAGNETIC TESTING TECHNOLOGY

Fengyun Yu[1a] and Jingchong Zhang[,b]

Metal Magnetic Memory (MMM) technology to detecting the mining round-link chains was applied in this paper. And the distribution law of the residual magnetic intensity of round-link chains under different wearing states was obtained by making MMM test to four kinds of round-link chains, which experienced different service time in certain coal washery. The test results indicate that the more sadly the round-link chains were worn, the more greatly the residual magnetic intensity fluctuates and the more increasing the standard deviation of the residual magnetic intensity. According to the residual magnetic intensity and the standard deviation, the deformation of the

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round-link chains can be determined. And qualitative evaluation was processed to the deformation of round-link chains based on the study conclusion of paper [1], and the results were consistent with the actual situation, which suggested a new method for damage evaluating of the round-link chains.

MODAL PARAMETER IDENTIFICATION OF CIVIL ENGINEERING STRUCTURES BASED ON HILBERT-HUANG TRANSFORM

Jianping Han[1, 2, †], Dawen Li[1], Hui Li[1]

Modal parameter identification of the structure is one of the most attractive research topics in the structural health monitoring area. Hilbert-Huang transform (HHT) has been proved as a powerful tool to process non-stationary and nonlinear signals adaptively. In this paper, two approaches were proposed to identify the modal parameters. The first one is based on the HHT and the random decrement technique (RDT). The second one is based on the empirical mode decomposition (EMD), RDT and the ITD methods. Then, the original signals measured from the field ambient vibration test of an arch bridge and the shaking table test of a RC frame model were processed and modal parameters were identified respectively. Results indicate that the proposed approaches are feasible.

INTRODUCTION

HILBERT-HUANG TRANSFORM (HHT) IS AN EMERGING NEW TECHNOLOGY FOR PROCESSING NONLINEAR AND NON-STATIONARY SIGNAL. THIS METHOD CONSISTS OF TWO SUCCESSIVE PARTS, I.E., EMPIRICAL MODE DECOMPOSITION (EMD) AND HILBERT SPECTRAL

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ANALYSIS (HSA), AND THE KEY ONE IS EMD. EMD METHOD CAN SMOOTH THE UNSTABLE SIGNAL VERY WELL. FURTHERMORE, HSA PROVIDES THE MEANS OF DESCRIBING INSTANTANEOUS CHANGES OF SIGNAL. BOTH RESEARCH AND SOME LIMITED APPLICATIONS DEMONSTRATE THAT THE HHT METHOD CAN GET THE RELIABLE PARAMETER IDENTIFICATION, WHETHER TO NON-STATIONARY OR STATIONARY SIGNALS FUZZY STRUCTURAL INTEGRITY ANALYSIS FOR TECHNICAL CONDITION OF THERMAL CONTROL SHUTTER MECHANISM ON XX SECONDARY SATELLITE

Lai Yinan[*1], Cui Sihai[*1], Zhao Yang[*2],Yu Yangtao[*1]

There exits lots of uncertain and fuzzy technical condition during the working process of thermal control shutter mechanism on XX secondary satellite, such as wearing, sealing, deflecting and loosing of parts and components. The paper discuses the evaluation effect and method of technical condition and gives the definition of structural integrity about shutter mechanism. A comprehensive model to fully describe structural integrity of parts using structural error is given, with the characteristic of series connection reliability. So the evaluation index of complex system is simplified based on fuzzy membership function, which provides a fast and easy evaluation method about the whole structural integrity.

INTRODUCTION

No matter the products are checked and accepted or used, the technical condition evaluation is important. Although almost all mechanical equipment is a typical and complex system composed of many parts, in most of case, the evaluation conclusion is simple. So we need a comprehensive index to decide the technical condition [1,2].

Thermal control shutter mechanism is designed to adjust heat exchange in the interior and exterior of XX secondary satellite. It undergoes various environments such as cold and warm in the process of transportation, launch, orbit and flight. And its components will go through all kinds of bad conditions such as wear abrasion and erosions during the process of work. Structural shape, surface, location and clearance will change so that technical performance retrogresses. Because of the increase of retrogressing, technical performance will deviate more and more from designed parameters. Shutter mechanism will fail to function so as to influence normal running of XX secondary satellite. Combining structural feature, the model to evaluate technical condition of shutter mechanism is built based on structural integrity.

THE STUDY OF THE SYSTEM OF AN CONDITION MONITORING AND FAULT DIAGNOSIS FOR A RECIPROCATING COMPRESSOR

Lin Zhang*, Yikuang You, Zhenghong Wang, Peng Zhao, Jianhua Zhang, Lei Xue

A reciprocating compressor is a machine widely used in petrochemical industries. However, the fault rate of reciprocating compressors is very high in technologic processes because of the complexity of their structure and movement forms. An on-line condition monitoring and fault diagnosis system for reciprocating compressors has been developed according to their fault characteristics. Some important condition parameters such as working pressure and working temperature inside the cylinders, vibration of horizontal, vertical and transversal directions, working speed and the displacement of the piston rod, etc can be monitored on-line and transmitted to remote-distance computers by networks. The working principle, hardware design，software design are presented. The predictive condition maintenance of reciprocating compressors can be realized. The monitoring system can ensure that the reciprocating compressors work reliably and safely.

INTRODUCTION

A reciprocating compressor is a machine widely used in petrochemical industries. However, because of the complexity of their structure and movement forms, the fault rate of reciprocating compressors is very high in technologic processes. Many

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enterprises have reported a lot of faults and accidents about reciprocating compressors every year [1-4], which make huge economic losses. They hope to know conditions of reciprocating compressors by using on-line condition monitoring system, and achieve predictive equipment maintenances of reciprocating compressors.

Although there are many faults of reciprocating compressors, they are divided into two modes of mechanical dynamic performance faults and thermodynamic performance faults. The mechanical dynamic performance faults are often represented in forms of unusual noise, vibration, superheat etc. The thermodynamic performance faults are often represented in forms of the decrease of the discharge flux, unusual fluctuation of the pressure and temperature. Measuring vibration and noise can monitor the mechanical dynamic performance faults. Testing the pressure and temperature inside cylinders can monitor the thermodynamic performance faults. The operation conditions of reciprocating compressors can be described by an indicator diagram, so monitoring the compression indicator diagrams of reciprocating compressors are the most efficient method to know thermodynamic performance faults. An on-line condition monitoring and fault diagnosis system has been studied and developed according to familiar fault modes. The system has been applied in petrochemical industries. General thermodynamic performance faults and mechanical dynamic performance faults can be diagnosed on-line. Predictive equipment maintenances can be realized, and some evil accident can be avoided

NOVEL STRUCTURE DAMAGE BASELINE BASED ON SYMMETRY FOR DAMAGE DETECTION OF TRUSS

PEI Qiang[1, 2], GUO Xun[3]

Structural Health Monitoring and damage identification are playing an important role in civil engineering in recent two decades. Much more efforts to Structural heath monitoring and damage detection had been made in worldwide range. In general, local and global methods were used to detect damage. For local methods, the potential damage region must be prior to know; but for global methods, comparing the structural dynamic parameters under damaged and undamaged state, damage can be identified and located. That is to say, when using global method to identify damage the parameters of intact structure are regarded as structural health baseline. But generally, the responses of damaged and intact structure were not obtained under the same noise level.

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Thus, new health baseline is defined and researched in this paper.

INTRODUCTION

Recent years, many projects in infrastructural construction are developing rapidly. Many infrastructures such as highways, bridges, habitations and considerable construction items have been set up. And with the development of economy and the improvement of living standard, security of civil structures in their life-span is regarded as more and more important. So Structural Health Monitoring and damage identification of civil structures are active areas of research in recent years. The structural damage identification methods that have been developed in recent years include local and global ones. The local method is established on the basis of either visible identification or non-destructive inspection theory, whereas non-destructive evaluation and non-destructive inspection are used to evaluate the state of structure under the condition of being not to destroy the structure. Housner et al. [2] introduced some non-destructive inspection methods in 1997, such as acoustics method, stainable infiltration method, electrical stream method, magnetical powder method, radical photograph formation method, ultrasonic method, heat method, X-ray method, as well as eyeballing method, but these methods request that the damage region must be known in advance [3].

Compared with aerospace, mechanical and industrial structures, civil structures has its particularity, such as huge volume, space distributive and so on, which may make the components to be identified unapproachable or dangerous, therefore the global damage detective technology vibration-based achieved rapid development. Usually, the method uses parameters such as frequency, damping, mode shape of the structure as the damage index, then contrast the parameters' information of undamaged structure with that of damaged structure, if change happens (usually are the decrease of frequency and sudden change of mode shape, etc.)when the structure is damaged accordingly. But because of the complication of the civil engineering structure, this information is usually not sensitive enough to the local damage of the structure (many scholars have already researched and proved it), moreover, intact structure parameters sometimes can not be acquired completely, which may bring some difficulties to the damage identification. This paper illuminated the key problem of the damage identification is how to choose damage baseline and damage index.

As regards to the issue of healthy baseline of structure, most of the previous scholars choose the original information of structure as the baseline of damage identification, for example, Ahmed Elgamal et al. [4] thought in 2001 that the on-line monitor to the structure which using the traditional or modern advanced health monitoring technology should be done immediately after the completion of structure, which was aimed to establish baseline data of structural health state, then using the

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data in hand to make a contrast with the data in use to identify the damage in the structure. Shi et al. [5] calculated and compared the mode strain energy of damaged and undamaged structure to identify and locate damage. Fig. 1 showed a method to choose intact structure as health baseline.

STRUCTURAL INTEGRITY AND THE PETROCHEMICAL INDUSTRY

Iain Le May*

The importance of engineering structural integrity in the petrochemical industry is discussed in the context of the history of many serious accidents that have taken place in refineries, storage facilities and processing plants in recent years. A number of critical incidents from around the world are reviewed, and several cases investigated in North America by the author are cited. These demonstrate the important role of well conducted regular inspections, based on sound advanced planning, in maintaining in-service assessment of fitness-for-purpose of plant. The significant contribution of risk-based inspection procedures, together with the need for a sound knowledge of potential degradation mechanisms, is emphasised. Finally, it is noted that there is a need for a safety-conscious organisational culture underpinned by robust, relevant and continued training and development, for the entire workforce including management and supervisory staff.

INTRODUCTION

The petrochemical industry is one that has inherent severe hazards; it involves a potentially volatile mix of flammable liquids and gases, high temperatures and high pressures, together with materials in which corrosion and wear can be expected from contact with the said liquids and gases.

Engineering structural integrity (ESI) assessment is playing an increasing role in many industries, and not least in the petroleum and petrochemical industries, in which many serious incidents (or “accidents”) have occurred in recent years. One result has been the development of new Codes and Standards dealing with the assessment of operating equipment, most being based on assessment of risk, together with the application and use of risk based inspection (RBI). The procedures and guidelines indicated in the codes and standards are only recently becoming more widely used

and understood; meanwhile, major incidents with severe financial and human costs continue to take place.

The writer has been involved with inspection planning and with the inspection of petrochemical industry plant; investigations into of a number of failures of equipment; and with the assessment of suitability for continued operation of such equipment, over a number of years. A considerable time has been spent on the committees working to develop the recommended practices

and standards for continued safe operation of in-service equipment.

This paper provides an overview of a number of serious occurrences to set the context in which the new recommended practices and standards were, and are being, developed; provides case studies on the examination of some specific failures with which the author has been involved, the findings from which contributed to the revision of then current Standards; and discusses the philosophy of the new in-service assessment procedures and their application, together with the imperatives for industry to implement such procedures.

RELIABILITY ANALYSIS OF RAILWAY TUNNEL CONSTRUCTION PROCESS WITHIN SOFT AND WEAK ROCK MASS

Yuan HUA* Taiquan ZHOU

A formulation to compute the reliability of soft and weak rock mass, in which physical non-linearity is taken into account, is proposed. The two dimensional finite element analysis is proposed to analyze the Jinhua Mountain railway tunnel construction process. The two dimensional analysis is performed to consider the excavation stage effect and the unloading effect on the rock mass. The unified elasto-plastic material is used to model the rock mass considering the intermediate stress effect on rock mass strength. As a case for study, the reliability analysis of Jinhua Mountain railway tunnel within soft and weak rock mass is studied using the proposed method. Computation result shows that the rock mass is in stability.

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INTRODUCTION

The rock in underground engineering, such as tunnel engineering, is often acted under complex triaxial stress state. When the tunnel rock mass is excavated during the tunnel process, the rock mass stress releases gradually with the tunnel face moving along and the tunnel lining structure must be installed in the approximate time to utilize the self-bearing capacity of the tunnel rock mass. With the rock mass stress being released, the stress state of the rock mass gradually changes from the triaxial stress state to the biaxial stress state, thus causing the rock mass yield and failure. The intermediate principle stress plays an important role in rock material strength according to the rock engineering experimental results. The unified elasto-plastic strength is presented by Maohong Yu [1] to account for the fundamental characteristic of rock, which has different tensile and compressive strengths. In this paper, the unified elasto-plastic model is implemented in finite element analysis program and it is applied in a railway tunnel construction process reliability analysis.

FAILURE ANALYSIS OF TAPPING SCREWS FRACTURE FOR ENGINEERING APPLICATION

Fahai Ba* Guoqiang Yan

Self-drilling screw of Φ10mm broken off after assemblage, and there were also a few screw fractured during embrittlement test for this lot products. In this paper metallograph, fracture and microhardness were tested and analyzed. The examination results showed that the fracture character were mainly brittle fracture with intergranular fracture form. The carburization penetrated the section between head and shank, and the microhardness test proved that the strength in the fracture area exceeded that of 10.9 bolt as the micrhardness exceeded 40HRC, which directly resulted in increasing greatly fracture sensitive hydrogen induced. According above, the fracture was caused by hydrogen embrittlement in conjunction with higher microhardness of fracture area and lower toughness resulted from carburization . Finally the improving suggestions were put forward and applied.

INTRODUCTION

Bolt and screw fasteners were widely used in machinery, electronic, astronaut & aerospace and

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telecom communication engineering, etc. In recent years the failures of fasteners had taken place frequently, which resulted in many significant accidents and economical loss. In this paper the tapping screws fracture failure was analyzed by metallographic examination, SEM fracture analysis and contrast experiments. The processing information about screws was as following: material type WCH22A（1022）, Surface cleaning→pulling wire and polishing→header made→rub thread→carbonization→heat treatment (preheat to 900℃, 30min then quenching into oil and temperature 395℃ 60min)→electroplating→passiration→hydrogen removing→finish, case hardness HRC40~50，core hardness HRC28～38. However, a few screws fractured after assemblage. And in fact, before that, 13 screws had already been used for hydrogen brittleness test in which torque 0.28Nm(85% of designing failure torque 0.32Nm)，and keeping 24h while seating then unloaded and after that reloaded again. But, of which there always had 1-3 screws fractured in a lot while retighten. It was worth doubting whether caused by hydrogen?

ANALYSIS OF FATIGUE FAILURE OF DRILL PIPE IN AIR DRILLING

ZHAO Guanghui*, LIANG Zheng*

On the basis of the working condition of Puguang gas field in Sichuan province of China, dynamic analysis of the drill pipes (DP) near the bottom-hole assembly (BHA) in air drilling and prediction of fatigue life were carried out roundly. Influence of the drilling parameters on the DP's fatigue life was presented. It's found that the bending wave caused by backward precession of BHA has a main effect on the DP's fatigue fracture. Small increasing of torque on bit (TOB) shortens fatigue life greatly. Higher speed of rotation (SOR) corresponds to shorter fatigue life for it aggravating axial and transverse vibration. Increasing weight on bit (WOB) reduces fatigue life due to decreasing tension of DP, increasing transverse vibration and TOB.

INTRODUCTION

Puguang gas field is the largest one found in Sichuan and air drilling has been adopted. Rate of penetration in air drilling could be improved to 5~7 times of traditional mud drilling, but damage of drillstring is also much more serious. By means of analyzing the data from fieldwork, it was found that BHA and the DPs near the BHA are danger zone in air drilling. Expending of fatigue crack had the main

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responsibility for fracture of drillstring. Fatigue fracture is caused by alternating stress, which is the result of various kinds of vibration. Considering backward precession of DP's joint, Lin et al. [1] forecasted fatigue life of DP. Ai et al. [2] researched fatigue fracture of DP caused by longitudinal and torsional vibration. In this paper, data and parameters are taken from fracture accident of DP at the hole depth of 2348.54m in Puguang PD-1 well. Drilling parameters are: SOR n=65rpm， WOB T=120kN. BHA of the fish is 314mm cone bit*0.3m + 228mm bumper*4.66m + 241mm DC*27.3m + 228mm DC*17.45m + 203mm DC*26.88m + 127mm DP.

INVESTIGATION INTO CONTROLLABILITY OF SPIRAL GROOVE MECHANICAL SEALS

Zhou Jianfeng *, Gu Boqin

To maintain the integrity of the fluid film and to control the leakage rate are the most important means of long period and safe operation of spiral groove mechanical seals. The fluid film form corresponding to the given closing force was obtained by the coupling analysis. Thereby, the temperature of the sealing rings and the leakage rate were determined. The temperature of the stationary ring and the leakage rate were regarded as feedback parameters, and the closing force was regarded as adjusting parameter. On the basis of the control method proposed in this paper, the controllable operating of the seals can be realized.

INTRODUCTION

The spiral groove mechanical seals are used to seal fluid or gas medium in rotary machines, as illustrated in Fig. 1. The control of spiral groove mechanical seals can be realized by means of regulating some of their main running parameters to make the sealing systems operate under optimum operational state. The change regularities of leakage rate and temperature in sealing rings with closing force are investigated, and the method for realizing the controllability of spiral groove mechanical seals is proposed.

RITICAL SAFETY WHEEL WEAR SIZES OF CHINESE RAILWAY FREIGHT CARS

M. F. Feng[1], Y. X. Zhao[1,2*] and B. Yang[1]

The critical safety wheel wear size is investigated through considering the fatigue safety effect on the RD2 type axle of Chinese railway freight cars. The wheel wear size increase results in a rise of the wheel-rail contact forces, which increase the fatigue stress history of the axle in service. Therefore, the size must be controlled to maintain the axle safety in service before the next overhaul inspection action. A field investigation was firstly made on the wear size change regularity. Then, the size related wheel-rail impact forces are solved by a non-linear Hertzian contact theory with a vehicle multi-body dynamic model. And a statistical method is further developed for incorporating the impact forces into the wheelset service load history. Finally, a wear size related critical state equation is established for ensuring the axle safety in service. A stationary solution is statistically obtained for the critical wear sizes with respect to the axle circumferential crack and Semi-elliptical crack. It is concluded that the critical safety wear size should be controlled in the range of 100 mm at the statistical level of survival probability 0.99 and confidence 95%.

INTRODUCTION

Plastic flow accumulation under wheel contact forces and braking forces incorporating with local contact high temperature may result in wheel surface local unbalance wearing or sintering [1-4]. It brings not only noise and vibration of vehicles but also the increase of vehicle wheel-rail contact forces to promote the service loads of wheelset and other vehicle components. To ensure the transportation safety and to maintain necessary fatigue lives of the related components, the load increase effect should be taken into account for managing the wheel wear extent.

Some researchers have paid attentions on the problems. The local unbalance wearing or sintering was simplified as “wheel flats”. Newton-Clark [5] presented early “rounded flat” model to analyze the response of wheel-track contact forces. Wu-Thompson [6] presented a hybrid model for wheel-track interaction due to the flats. Johansson-Nielsen [7] and Dukkipati-Dong [8] introduced a great of field tests to observe the responses connected the wheel removal criterion. In addition, many researches were made on the effects of noise and track damage [6, 9-11].

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Present work pays attention on the critical safety wheel wear sizes of Chinese C64A and C64H type freight cars. Standpoint is to control the axle dynamic load increase which results from the wheel wear to ensure the axle safety in service before the next overhaul inspection action. Main production problem is that, since 1 April 1997 China started to carry out the trains promoted speed strategy, the fatigue cracks the RD2 type axle's load relief grooves have at least result in six derailed accidents [12-13].

FINE POWDER GROWN FROM LIQUID-PHASE NITRATES EXPLOSIVE

Xie Xinghua[1,*], Zhou Huisheng[1], Yan Shilong[1], Wu Hongbo[1], Xu Ming[1], Li Xiaojie[2]

Nanostructured spinel lithium manganese oxide (LiMnO) with about 20nm in diameter was synthesized for the first time by explosive method. The detonation products were characterized by scanning electron microscopy. Powder X-ray diffraction and transmission electron microscopy were used to characterize the products. Lithium manganate with spherical morphology and more uniform secondary particles, with smaller primary particles of diameters from 10 to 20 nm and a variety of morphologies were found. Lithium manganate with a fine spherical morphology different from that of the normal spinel is formed after detonation wave treatment due to the very high quenching rate. It might also provide a cheap large-scale synthesis method. Explosive detonation is strongly nonequilibrium processes, generating a short duration of high pressure and high temperature. Free metal atoms are first released with the decomposition of explosives, and then theses metal and oxygen atoms are rearranged, coagulated and finally crystallized into lithium manganate during the expansion of detonation process. For detonation of the water-solubility explosive, the detonation pressure, the detonation temperature and the adiabatic gamma were 2 – 5 GPa, 2000 – 3000 K and close to 3.

1 INTRODUCTION

A. Singhal [1] thought that nanostructured intercalating electrodes offer immense potential for significantly enhancing the performance of rechargeable rocking chair. Shuhua Ma et al. [2] said

that Spinel structure Li–Mn–O compounds are the most promising lithium ion insertion electrode materials for rechargeable lithium ion batteries because of a number of advantages over their alternatives, e.g., a lower cost compared with $LiCoO_2$ or $LiNiO_2$, a high cell voltage, and a high environmental tolerance, etc. The excess of Li and substitution of Cr to Mn and small surface area impeded the occurrence of the split. The split is presumably considered relating to the disproportionation dissolution of stoichiometric spinel intensified by the elevated temperatures in slightly acidic electrolyte due to residual water impurity. LiMnO can selectively insert Li from an aqueous solution [3]. Mitsuharu Tabuchi [4] reported that the excess Li could substitute the Mn ion on the 16d site in the spinel structure. And they introduced excellent cycling behavior for nonstoichiometric $Li_{1.0}Mn_{1.93}O_4$. Jong-Uk Kim [5] investigated characteristics of charge/discharge cycling of $LiMn_2O_4$. I.J. Davidson [6] reported that using solid-state reactions method, however, the powder preparation route is also quite complicated, for example, several times calcinations and subsequent physical grindings. Moreover, its electrochemical properties are greatly dependent on its crystalline particle size [7]. Zhanqiang Liu [8] synthesized nanostructured spherical spinel lithium manganese oxide (Li-Mn-O) with about 200nm in diameter for the first time by mild hydrothermal method, and studied systematically the influence of the reaction temperature and the time of formation of the nanostructures.

RESEARCH ON VIBRATION RESPONSE OF WEDGED-RING JOINT STRUCTURE UNDER RANDOM EXCITATION

Zhao Rongguo[*,†], Chen Zhongfu[‡]

The axial and transverse vibration experiments to a wedged-ring joint structure are carried out at various power spectrum density (PSD) values. The theoretic model used to predict dynamic responses of the structure at higher PSD values is built according to the experimental data obtained from the experiments at lower PSD values, and then the vibration transfer curves of measurement points are constructed using the vibration transfer model. Based on the analysis of experimental and theoretic response spectrum curves, and fundamental frequencies as well at various PSD values, the relation between response frequencies and random load spectrum values are studied, and the soft nonlinearity of the structure is found and verified. To the axial random vibrations, the theoretic peaks at fundamental frequencies predicted are moderately fit with experimental ones even PSD up to a higher value. To the transverse random vibrations, the theoretic peaks at measurement points on the lower cylinder are well fit with the experimental ones, while for measurement points on the upper cylinder, the peaks predicted by the transfer model are smaller than those obtained by tests, which suggests that the nonlinearity in the

joint of the wedged-ring joint structure has an obvious magnification effect, and such effect increases with increasing PSD values.

INTRODUCTION

Wedged-ring joint, as a new type of joint, possesses excellent properties of making structural joint surface smoother, additional mass less, assembly and disassembly more convenient and joint structure tighter, has been utilizing in such engineering structures as torpedoes instead of bolted joint. A wedged-ring joint structure is usually a multi-deformable-body combined structure some of whose components contact with each other. The previous literatures focused the eyes on the static analysis and design of the structure, such as the force analysis of wedged-rings [1], the reliability optimization design [2,3], static contact behaviors [4], and the effect of dimensional tolerance on displacement and stress in the joint [5]. Few works have been done to study the dynamic response of the structure, especially the vibration responses under random excitations.

In this work, the transfer model of single input and multi-output vibration system is firstly derived from the transfer property between input and output of random vibration environment tests, and then the vibration transfer curves of measurement points are constructed, the relation between response frequencies and random load spectrum values are studied. Finally, to axial and transverse random excitations, the theoretic and experimental peaks at fundamental frequencies are discussed.

LAYERED LITHIUM ZINC OXIDES GROWN FROM AN EMULSION EXPLOSIVE

Xie Xinghua[1,*], Zhou Huisheng[1], Liu Feng [1], Wang Meng[1], Guo Jin[1], Liu Wei[1], Li Xiaojie[2]

Layered lithium zincate nanoscale sheets have been synthesized through the deflagration of the unconventional emulsion explosive. The present situation of lithium zinc oxides synthesis and emulsion explosives is summarized in this paper. To solve the problems in research for lithium ion batteries, it is suggested

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that lithium and zinc oxides should be used as cathode materials for lithium ion batteries. So, we design unconventional emulsion explosives, and synthesize lithium and zinc oxides by means of deflagration. Also, microstructures and morphology of nanometer thin layers in the deflagration soot of emulsion explosives are measured in our experiments. It is concluded that nanoparticles of lithium and zinc oxides can be synthesized through deflagration of the unconventional emulsion explosive. Main contents and research results are as follows: First, unconventional emulsion explosives for synthesis of the layered lithium zincate are designed uniquely. Second, we tested microstructures of nanometer thin sheets of lithium and zinc composite oxides. Third, by contrast to industrial emulsion explosives, we analyzed the deflagration reaction mechanics of the unconventional emulsion explosives. Last, layered lithium and zinc nanooxides are successfully collected and characterized by XRD, TEM and FTIR respectively.

1 INTRODUCTION

A zinc and lithium composite oxide is the subject of growing interest for different applications in electronic components [1-4]. Especially, G.Ceder regarded that $LiZnO_2$ compound has a higher voltage than that of $LiCoO_2$ [5]. More recently, it was reported that these oxides nanomaterials have generated tremendous interests in both the scientific and engineering community, which has visibly led to rapid and intense growth in research focus [6-13].

Jianjun Liu et al [14] thought that the shock-induced chemical reactions leading to synthesis of compounds in powder mixtures occurred under conditions of the microsecond -scale duration of the high pressure, stress, strain- rate, and temperature states. Such high-rate chemical reactions can be advantageously utilized to synthesize materials with novel phases and unique microstructures, or to generate radically modified materials with physically interesting or technologically useful properties.

I.J. Davidson [15] reported that using solid-state reactions method, usually, the powder preparation route is also quite complicated, for example, several times calcinations and subsequent physical grindings. Moreover, its electrochemical properties are greatly dependent on its crystalline particle size [16].

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ROLE OF RESIDUAL STRESS ON INTEGRITY OF STRUCTURES

D. J. Smith *

Residual stresses occur in most engineering structures usually as a result of the manufacturing and fabrication processes. This paper examines residual stresses at different length scales and their impact on structural integrity particularly in the context of cracked components.

INTRODUCTION

Residual stresses materialize in most engineering structures as an outcome of their manufacture and fabrication. Residual stresses can be classed as either those which have been deliberately introduced or those which are a by-product of the manufacturing process. Consequently, all stages of the manufacture of a component introduce locked-in or residual stress into the materials of the component or structures. Material failure mechanisms, including environmentally assisted cracking, fatigue, creep and fracture, are all sensitive to residual stress, microstructure and environmental factors occurring over a range of length scales. Consequently, the extent to which these locked-in stresses influence the performance of the components and structures depends on the nature of the mechanisms of failure and the length scale over which the failure mechanism occurs.

While some recognize that residual stress on balance can contribute to failure there is an opposing view (outlined by Boyles, [1]) suggesting that residual stresses are not damaging. Examples of conditions where residual stresses are not damaging include relief of residual stresses through cracking and plasticity before onset of complete failure. Nevertheless, there is a comprehensive number of well documented practical examples where it is evident that residual stress has contributed to failure and in some instances dominates conditions for structural failure, [1, 2, 3]. Recently, Coleman et al [3] demonstrated that creep crack initiation and growth was driven by the presence of residual stress alone in regions adjacent to welds in steel operating at high temperature. Furthermore, there is now substantial evidence from laboratory tests [4, 5] indicating that residual stress provide either the main driving force for failure or combine with stresses generated by external forces. The concern that residual stresses are a contributing factor is reflected in their inclusion in standards for fitness for purpose or assessments for structural integrity, [6, 7, 8]. By necessity these documents provide cautious advice and imply that the presence of residual has a greater effect than often might otherwise occur.

The purpose of this paper is to provide insight to the role of residual stress on structural

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integrity. In particular there is a need to understand the interrelationship between residual stresses and failure mechanism at different length scales. For example, in microstructural modelling it is important to determine the residual stresses at the microscale, and to understand how they influence, for example, the behaviour of short fatigue cracks and the onset of inter and transgranular fracture. On the other hand, the structural assessment of long cracks requires information on the spatial distribution and the magnitude of macroscale stresses.

INFLUENCE OF RESIDUAL STRESS IN MEASUREMENT OF APPARENT FRACTURE TOUGHNESS

S. J. Lewis*, D. J. Smith*, J. D. Booker* and C. E. Truman*[§],

The measurement of fracture toughness, K_{1C}, in laboratory specimens is commonly made under the assumption that there is no influence of residual stresses on the measured values. In other words, it is assumed that the extraction of test specimens from the sample of interest totally relaxes any residual stresses present. Due to the large degree of scatter commonly observed in experimental fracture testing, particularly when the principal failure mechanism is cleavage fracture, it is often difficult to distinguish between an erroneous value caused by the retention of residual stress in the test specimen and one near the limits of the statistical distribution characterising the expected scatter. By means of a simple statistical study considering the representative case of cleavage fracture in A533B ferritic steel, this paper aims to quantify the levels of residual stress needed to produce a statistically significant shift in toughness. In the example considered, it was found that a relatively high magnitude of residual stress, approximately one third of the room temperature yield stress, was required to cause a statistically measurable shift in apparent fracture toughness.

INTRODUCTION

In modern day failure assessments the drive is to increase accuracy in order to reduce unnecessary conservatism. A key requirement of this is an accurate statistical model of the material ‘strength’, be it yield stress, fracture toughness or indeed any other applicable measure. Perhaps the most commonly used model for the distribution of material strength is the model proposed by Weibull.

$$P_f = 1 - \exp\left[-\left(\frac{\sigma_w}{\sigma_0} \right)^m \right], \quad (1)$$

where σ_w is a characteristic stress measure and σ_0 and m are fitted constants, often assumed to be material properties [1]

The Weibull model is based on a 'weakest link' assumption for overall failure and as such is generally well suited to cleavage fracture where component failure is often traceable to a single carbide or other nucleation site. The two parameter distribution above is often modified [2] to include a threshold stress σ_m, below which failure will not occur. In the context of fracture mechanics, stress is often replaced with the crack tip stress intensity factor (SIF), K_I [3],

$$P_f = 1 - \exp\left[-\left(\frac{K_I - K_m}{K_0 - K_m} \right)^m \right]. \quad (2)$$

By ranking fracture data in terms of failure probability P_f, and using linear rectification of equation (2), the three required constants m, K_m and K_0 can be fitted using linear regression. It is not of course uncommon for two sets of data from the same parent population to produce different fitted values, simply due to the statistical scatter present within the parent population (i.e. the measured fracture toughness), however, it is important to be able to distinguish between such cases and instances where there is a meaningful shift in the distribution within the parent population.

THE INFLUENCE OF SURFACE OXIDE ON THE MEASUREMENT OF STRESSES IN FERRITIC STEEL COMPONENTS

G. Hilson[*], M.C.J. Parsley[*], D.J. Smith[†], and P.E.J. Flewitt[*,‡]

To assess the integrity of engineering components, it is necessary to have knowledge of both the system and residual stresses. In practice, many components fabricated from ferritic steel have a covering of surface oxide. X-ray diffraction is a non-destructive method for measuring surface stresses.

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It is usual to remove oxide from the surface prior to measuring the stresses using a combination of grinding, mechanical and electropolishing. In this paper we investigate the ability to measure by X-ray diffraction stresses in a ferritic steel (A533B) without the removal of surface oxide. Stresses have been measured on a plate into which a known stress distribution has been introduced and X-ray diffraction measurements made with and without oxide removal. The results demonstrate that it is feasible to measure stresses in the metal substrate by X-ray diffraction when the oxide is less than a limiting thickness. An application to the measurement of stresses in a ferritic steel pipe containing a butt weld is also presented.

INTRODUCTION

An essential input to the structural integrity of components and structures is a knowledge of both the primary and secondary stresses [1]. There are a range of physical and mechanical techniques that can be used to measure secondary macrostresses [2]. Of these, X-ray diffraction has the advantage that it is non-destructive and offers the potential for evaluating the stresses present in the near surface layers to a depth of up to about 10μm depending upon the wavelength of the X-radiation selected. To undertake these measurements on samples or indeed service plant it is usual to remove any surface oxide and prepare the surface mechanically and by electropolishing. The latter removes any induced mechanical preparation damage [3]. In this paper in Section 3 we describe the preparation of an A533B steel plate with a known induced residual stress profile and the measurement of these stresses using X-ray diffraction. However, a comparison is made both with and without the thin surface oxide arising from the prior thermal treatment. In addition, results are described for measurements made on a weldment in a P91 pipe in the unstresss-relieved condition. Again, measurements are made with and without oxide removal. The measurements are supported by calculation of the X-ray penetration depth into iron in the presence of surface oxide of various thicknesses. Concluding comments are made in Section 4.

STRESS CORROSION CRACKING OF OIL AND GAS PIPELINES IN NEAR-NEUTRAL PH ENVIRONMENT: A REVIEW OF RECENT RESEARCH RESULTS

Wenyue Zheng*

Since the first discovery of transgranular stress corrosion cracking (SCC) on a Canadian gas transmission line in 1985, a great deal of research has been conducted in the past 20 years. Findings of the effects of operating conditions, metallurgical factors and the soil environment have been very useful in preventing and mitigating uncontrolled failures. Several overview summaries of the progresses in this area can be found in the open literature and this review is an effort to update the research results on this subject matter produced in the past five to six years.

Fuxiang*, Wang Weibin, Tong Wenqiang, Feng Qingshan, Wang Yuqin, Liu Zhe

Corrosion and pitting defects of pipes are major problems in the oil, chemical, and other industries. These defects probably occur at the outer or inner surface of the pipes and lead to a serious loss of pipe wall thickness. Ultrasonic guided waves testing is introduced as a new non-destructive pipe inspection method for its rapid, long distance inspection and applied to special pipes which are inaccessible to other conventional NDT methods. Ultrasonic guided waves technology can detect the defects such as the wall thinning, wear, corrosion, crack, weld line, and so on. The attenuation variation of guided wave propagating in the pipes is slow, which are suitable to long distance, large range, non-contact, and quick inspection of defects in pipes. The proper wave mode selected can improve the sensitivity of defect inspection in work.

INTRODUCTION

Long distance pipelines are often used to transport different kinds of fluid corrosive substances in the oil, chemical and other industries. However, defects, such as

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corrosions, notches and cracks etc, usually reduce operating life of pipes in service [1]. Many parts of these lines and the station pipes cannot be inspected with smart pigs. Furthermore, a high proportion of these industrial pipelines are insulated, so that even external corrosion cannot readily be detected without the removal of the insulation, which is very expensive in most cases. Traditional NDT methods analyze the entire structures point by point, they are consumed and expensive [1]. There is an urgent need for the development of a quick and reliable method for the detection of corrosion under insulation. Obviously, ultrasonic guided waves are suitable for detecting the defects in pipes because of their capability of long range propagation with low attenuation [2]. The pipelines, which are hundreds of meters long or are buried in solid media, can be inspected easily by using guided waves.

Long range ultrasonic guided wave testing was commercially introduced in early 1998 for in-service monitoring of pipes and pipelines [3]. The oil, gas and chemical process industries now uses it for detection of corrosion and other metal loss defects, and it has acceptance as a valid means of assessing the condition of pipes and pipelines where inspection preparation or access is difficult or expensive. The rise of the technology is especially significant in view of the recent United States government emphasis on pipeline integrity assessment and the lack of a proven technique to inspect the pipelines that cannot be evaluated with smart pigs. The technique has now been extensively used in the field for evaluating the condition of pipes in the range of 2 to 60 inches in diameter and has performed well in identifying corrosion in pipes in a variety of situations including buried and aboveground pipeline sections as well as plant process piping.

INTEGRITY TECHNOLOGY ENSURING INHERENT SAFETY OF PIPELINES

Qingshan Feng[1,2], Zupei Yang[2], Muyang Ai[2], Guangwen Liu[2], Hongsheng Cui[3], Xueli Wang[2]

Pipeline integrity technology, no accident philosophy, aims at “no defeat and maintaining the function of pipeline system”. Based on defeat detective technology, risk assessment technology, integrity technology, repair & maintenance technology and performance audit technology, using integrity technology in pipeline management ensures the safety of pipeline system. Data collection and integrity technology also should be used to improve the assessment and management. This paper focuses on establishing logical model

of integrity technology of pipeline system, and points out the crucial research field that shall be studied in future.Click here for first heading.

INTRODUCTION

Safety is the basic requirement in pipeline industry. No death, no property loss, and no environment pollution, are the main objective of pipeline companies. But in service pipeline is aging and new constructing pipeline of high press give us more challenge to operation, it now knows that it must change its operational practices to ensure continuing safety. New practices, Pipeline Integrity Management systems (PIMS), and new code are being introduced to our industry to help operators improve their management to prevent failure. These methods are centered on integrity technology, but are difficulty to apply, and need more technology research.

How can we change, to keep the integrity of pipeline, in other words, to prevent our pipeline failing in the future? We are reactive industry when it comes to safety. This has been the failing in the pipeline industry, with resulting regulations. The reactive and archaic approach to pipeline safety is a passive method for pipeline failure, not to find the defeat before it failure. [1] But the new approach aim to find the defect before it failure and make the pipeline condition under control by integrity technology, seeks to ensure that pipelines stay fit for purpose – safe and operational – under all circumstances.. The core of success is integrity technology, and new approach requires the base integrity technology are: Data gathering and integrity; HCA assessment; Risk assessment; Integrity assessment; Maintenance and repair and Performance assessment technology. The development and implementation of those specific technical tend to be emphasized as key measures required to ensure the integrity of pipeline systems. These activities are clearly of vital importance

PROBABILISTIC SAFETY ASSESSMENT FOR A PRESSURE PIPE WITH CIRCUMFERENTIAL SURFACE FLAW

Y. Zhou*, Q.P. Zhong, Z. Zhang

Due to the random of flaw size, applied loads and material properties, a probabilistic safety assessment on a pressure pipe with circumferential surface flaw is adopted with the failure probability calculated, applying Mento Carlo (MC) simulation. An analysis of p (L_r, Kr), the joint probability density function for (L_r, Kr), is performed together with single sample Kolmogorov-Smirnov (K-S) goodness-of-fit hypothesis tests on L_r and K_r. It is found that contours of p (L_r, Kr) are supposed to be series of ellipses

approximately; the distributions of Lr and K_r fit the lognormal distribution well. Sensitivity of the failure probability to stochastic parameters is performed using an interval method, instead of the calculus of differences.

1. INTRODUCTION

Flaws initiate during the manufacturing, installation and operation of the piping system, then could propagate further under specific mechanical and natural environmental conditions, ultimately it could lead to local or global damages. Usually the major failure modes in pipelines are unstable fracture and plastic collapse. Dowling and Townley [1] presented a two-criteria failure assessment diagram (FAD) to correlate this two failure modes. British Standards Institution (BSI) published *BS7910: Guide on methods for assessing the acceptability of flaws in metallic structures* in 1999. The assessment is based on fracture mechanics, and is carried out by FAD. In this study the random of assessing parameters are considered, and it is of certain reference to calculate the structure failure probability, using probabilistic method during the assessment.

THE DEVELOPMENT OF HIGH PRESSURE PIPELINE MONITORING SYSTEMS FOR THIRD-PARTY DAMAGE.

Sang Yup Jang* · Jae Pil Koh * · Shin Kyu Oh* ·Young Geun Kim*

Natural gas has been established as main energy sources of the industry and household in Korea. The higher the level of life, the more energy sources is inevitable. Pipeline is considered as the safe and effective method for mass supply of natural gas. Considering the safe and effective land value, pipeline is constructed at underground. But, buried pipeline is exposed to damage such as corrosion, third-party impact, ground movement and etc. Because unexpected damage could cause the interrupt of supply and economic loss, pipeline monitoring system is developed and improved through the field test to prevent the pipeline accident in this study. New developed system is composed of sever-client equipment connected with data communication line and acceleration sensor. Acquired signals from acceleration sensor parts were analyzed by programmed algorithm and compared to other site equipment. Finally, the signals gathered at client systems are transmitted to server computer and then server computer do a synthetic judgment totally.

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INTRODUCTION

The safe security regarding a high pressure gas pipeline is the field which has a many interest from our company and it invests a many expense and efforts. Especially due to restricted country area, construction or maintenance actions are often performed near the already buried high pressure pipeline and naturally occurrence of the accident have the tendency of increase. That kind of direct shock (Third-Party Damage) caused by excavating equipment while constructing near the pipeline area is more frequent compared to being caused by pressure change or the corrosion of the pipe inside. Because mis-operation of the system might bring about the tremendous disaster, it is essential that the ensuring the reliability for third party damage monitoring system of buried gas pipeline. In order to ensuring the reliability, third party damage source, the changes of physical property, measurement technique, analysis technique, system integration technique are demanded.

This research shows the example of facilities management system to adapt more scientific and efficient method using the improved information technique

THE APPLICATION OF STRUCTURAL INTEGRITY TECHNOLOGY IN THE OIL-GAS STORAGE AND TRANSPORTATION SYSTEM'S INTEGRITY MANAGEMENT

Xue Zhenkui* Feng Bin* Li Daquan

After several decades developed of structural integrity technology, a lot of theories of structural integrity have formed. These theories are widely used in the industrial fields of nuclear industry, construction, machinery and equipment manufacturing, but in the field of the safety assessment of the oil-gas storage and transportation system is still in the stage which has just started. This paper present some prospects which the application of structural integrity technology in the safety assessment of the oil-gas storage and transportation systems: Pipeline Integrity Management, safety assessment of a large storage tank, compressor reliability analysis of high-pressure gas pipeline, Evaluate the structural stability of large Pipe Bridge, Evaluate the safety of offshore pipeline. And explore the application steps of reliability and stochastic finite element analysis theory in the design, maintenance, monitoring, and other aspects. The research directions of the structural integrity assessment of oil-gas pipeline systems have been pointed out. Use

structural integrity technology to promote the safe evaluation method of oil-gas storage and transportation system developed in the direction of quantitative. And to reduce subjectivity of the current methods of semi-quantitative assessment, with the greatest possible to avoid human subjectivity; Meanwhile constructing new safety assessment system of oil-gas storage and transportation system, will improve the level of oil-gas storage and transportation system's integrity management.

I. INTRODUCTION

The structure safety assessment is an important part of pipeline integrity management. Whether to make an accurate and objective evaluation about the security condition of structure, it will direct impact on the measures taken in the integrity management process are reliable and reasonable or not. If integrity management programs and measures are improper, maybe leading to a waste of resources, poor efficiency, Else maybe have caused some casualties, property losses, and have a great adverse impact on society.

With the continuous development and improvement of reliability engineering and probabilistic fracture mechanics, structural integrity assessment technology has being used in the more and more field of industrial technology. This article will introduce the applications of structural integrity assessment technology in the field of oil-gas storage and transportation systems integrity management, in order to put forward some new ideas about the oil-gas storage and transportation system's Integrity Management Technology.

RISK ASSESSMENT FOR THE URBAN BURIED GAS PIPELINE BASED ON FUZZY COMPREHENSIVE EVALUATION METHOD

Wenhe WANG, Shiming SHEN

With the increasing popularization of the urban buried gas pipeline, accidents as the fire and explosion and so on are occurred usually. Once the pipeline failed in operation, it can produce leakage serious consequence, and the consequence involves security of resident life and property loss, and affects the social stability, therefore the safe operation of urban buried gas pipeline is extremely important. The factors effected failure of pipeline are complicated, varied and fuzzy because of complicated underground environment in city, meanwhile, the factors caused failure consequence are uncertain because of

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various states on ground. Article takes risk study on buried gas pipeline in service as an example, the failure possibility and consequence of pipeline are expressed and evaluated with fuzzy language and comprehensive assessment method, and illustrated the risk grade of pipeline with risk matrix according to API, and obtained risk grades of element of pipeline, some measures are adopted to perfect integrality management, and to decrease the operation risk, and to ensure operation safely of the buried gas pipeline.

INTRODUCTION

The buried gas pipeline undertakes the task of transporting flammable and explosive gas, once the pipeline failed in operation; it can produce leakage serious consequence as the fire and explosion and so on. The consequence involves security of resident life and property loss, and affects the social stability, Meanwhile because the gas pipeline is buried deeply under the ground, the failure factors are various, and most of them have getting fuzzy. Fuzzy comprehensive evaluation method can analyze failure possibility and failure consequence of the buried gas pipeline, the risk grade of different element pipeline can be signified by risk matrix, can confirm the order of risk for each of pipe, these can instruct the pipeline in using and maintaining, reduce the pipeline risk, ensure the safe operation of the urban buried gas pipeline [1-3].

Leak Monitoring - an Important Part of Monitoring the Integrity of Pipeline

Qin Xianyong* Zhang Laibin Wang Zhaohui Liang Wei

Pipeline transportation is used comprehensively in many aspects of life because of its particular advantages. Monitoring the integrity of pipeline is crucial for ensuring the safety of pipeline transportation. As an important part of pipeline monitoring, leak monitoring is absolutely necessary, because pipeline leak not only make the loss of wealth but also make environment and human lives threatened. Research indicates that the beast opportunities to mitigate pipeline accidents and subsequent leaks are through prevention measures such as aggressive controller training and strict enforcement of safety and maintenance programs. Nowadays, most pipelines are equipped with well-developed SCADA system, so the leak monitoring system must not only ensure the key attributes of leak methods but also be compatible with SCADA system. Leak monitoring system is introduced, and the application of which on

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West Products Pipeline shows it is a reliable leak monitoring system.

INTRODUCTION

Pipeline transport nearly all of the natural gas and nearly two-thirds of the crude oil and refined oil products in china. Although pipelines have a better safety record that other modes of freight transportation, their cargo is dangerous and leaks or ruptures can have serious consequences, including facilities destroyed, harm to the environment, and property damage. With increasing public awareness and concern for the environment, more stringent statutory regulations are introduced.

Recently, various pipeline leak detection methodologies and leak monitoring system were mentioned. Leak detection technologies can be categorized based on a variety of criteria. One such criterion used in the past was to classify methods based on where measurements were made. Internal methods examine flow in the pipeline while external methods look to detect fluids that have exited the pipe. Rather that using this criterion, this study has divided leak detection methods based on the methods that use sensors available in normal oil & gas operations (pressure, temperature, and flow rate) and those that require special sensors.

THE RELATIONSHIP BETWEEN MATERIAL PROPERTY OF LINE PIPE STEEL AND THE HYDROGEN-INTRODUCED CRACKS

XU Xue-Dong ， GU Bao-Lan

The hydrogen introduced cracking (HIC) of pipeline steel is a common problem caused by H2S in oil and gas. The purpose of this study is to investigate the effect of the material of pipeline steel on HIC resistance. The HIC susceptibility was expressed using the following parameters, defined in relation to crack susceptibility ratio (CSR), crack length ratio (CLR), crack thickness ratio (CTR). The microstructures of the section observed using OM and SEM. The results indicate that samples with either large banded structure or inhomogeneous structure showed high susceptibility to HIC, but the cracks propagated paths and the failure mechanisms are different. Also in this study,

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the susceptibility of this grade of pipeline steel to HIC is irrelative with the grain's sizes.

INTRODUCTION

In the system of long distance transportation of oil and nature gas, the safety of pipeline operation is threatened by the corrosion phenomenon, especially in sour environments containing H_2S. Hydrogen induced cracking (HIC) is a common H_2S corrosion cracking problem for pipeline steel. The presence of HIC has potential hazard, under the external pressure, the crack along with the shearing stress direction which perpendicular to the tensile stress, apt to propagate and joint each other form a stage-wise cracks penetrating the thickness, those cracks cause the drop of load-carrying capacity of the component, the potential danger will charge to the disaster at any time.

Many researches have performed to study the factors which affect the HIC resistance of pipeline steel. The HIC resistant behavior dose depends not only on steel chemical composition but also on microstructure. So far most work concern the effect of microstructure on HIC resistance. In this work, the materials used are domestic pipeline steels 15CrMoR, the laboratory test of HIC are carried out according to the NACE TM0284-2003 standard, the objective are to evaluate the HIC resistant behaviors of the different microstructure and study the effect of microstructure to the pipeline steels HIC resistance.

THE COLLAPSE LOAD OF CIRCULAR ARCH PIPE WITH 3D DEFECTS

Huimin Zhang [a,b] Jiazhen Pan [a]

The paper examines the nonlinear elastic-plastic response of internally pressurized circular arch pipeline. The pipe has different shape, direction and size of 3D defects. The collapse load is calculated by nonlinear finite element method. The paper also presents a parametric study, aimed at investigating the effects of defect depth-to-thickness, defect length-to-width and radius of curvature. The collapse loads of circular arch pipe are compared with that of straight pipe. The numerical results and failure mode are validated by burst tests. The result shows that the axial defects have more influence on the collapse load.

INTRODUCTION

Curved pipe or curved pipe segments are widely used in industrial piping and pipelines. Because of their ability to sustain significant deformation, they can accommodate thermal expansions and absorb other externally-induced loads (e.g., seismic ground motions). In the long transmission buried pipeline, the circular arch pipe is often used in piping system crossing the small river and canal. Because of the condition changing from the buried segments of pipe to suspended segments, suspended segments of pipe near the buried segments are easy to cause corrosion pit. Hence it is necessary to know the corrosion pitting defects take a role to evaluate the safety of pipe.

APPLICATION OF ROUGH SET THEORTY ON INTEGRITY ASSESSMENT TO BURIED GAS PIPELINES

YANG Linjuan, SHEN Shiming

With natural gas being more widely used in industry and people's daily life, the reconstruction of gas pipelines and its integrity assessment are becoming very important. Soil and atmospheric corrosion for the outside of buried pipelines are the main factors that influence the integrity of buried pipelines. However, due to ignoring management of gas pipelines in long term, the information and data about the buried gas pipelines is incomplete and imprecise, therefore, it is difficult to assess the integrity of the buried pipelines according to interrelated criterion. Rough Set Theory is a new mathematical tool for data analysis and for reasoning from imprecise and ambiguous data. This paper introduces the concepts of Rough Sets Theory, then an approach of Importance Analysis of basic events in the Fault Tree by Rough Sets Theory is put forward, and an example of Importance Analysis on outside corrosion fault tree of gas pipelines is given. As the result, it is found that there are many factors affecting external corrosion of the buried natural gas pipeline and the order of Importance of theses factors is as follows: coating condition, cathode protection, and soil causticity.

INTRODUCTION

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With natural gas being more widely used in industry and daily life, the reconstruction of gas pipelines and its integrity assessment are becoming very important. External interference, construction defect/material failure, corrosion are main influence factors on the integrity of buried pipelines. Furthermore, of all corrosion incidents 79% were caused by external corrosion, therefore external corrosion is one of main influence factors on the integrity of buried pipelines. However, due to ignoring the management to gas pipelines for long time, information about gas pipelines were lacking, incomplete and imprecise, thus it is difficult to assess the integrity of buried pipelines according to correlative criterion. Rough Set Theory is a new mathematical tool dealing with incompletion, vagueness and uncertainty. This paper introduces the concepts of Rough Sets Theory, then an analysis approach of Importance of basic events in the Fault Tree by Rough Sets Theory is put forward, and an example of importance analysis on external corrosion fault tree of gas pipelines is given.

RESEARCH AND APPLICATIONS FOR INTEGRATED ULTRASONIC TECHNOLOGY OF PHASED ARRAY AND TOFD FOR PIPELINES

Wenqiang Tong[1],Weibin Wang[1],Yuqin Wang[1],Jianping Zhu[2],Jinyu Yang[3]

The fundamental principle and key technology of the ultrasonic phased array and the ultrasonic time of flight diffraction (TOFD) are presented in detail. The phased array pulsing and receiving method can inspect various kinds of defects with good precision whereas the TOFD method can enhance the precision of detection with a dead zone on the pipeline surface. However, if the two methods are used together, the system will not only gain the best precision but also boost the inspection efficiency, avoiding the dead zone of the TOFD method. It is found that the inspection results can be affected by the coupling liquid. The inspecting procedure may be influenced by the relative position of probes and coding machine. In general, the ultrasonic phased array and TOFD technology are professional in inspecting welds and will be put into service extensively in future.

1 INTRODUCTION

Inspection is of much importance for the safety of pipelines. As the welding automatization and the welds inspection requirement develops, the conventional inspection techniques are not satisfying. Therefore, the research and development of effective equipments are urgent.

The ultrasonic phased array is one of the latest nondestructive techniques. In early years, it was applied to medical treatment fields, now it has been applied to industry fields [1]. The ultrasonic TOFD is also one of the latest inspection technology[2], which can detect the depth of defects precisely. When the two technique are integrated to complement each other effectively, the areas under inspection will be scanned completely and located exactly. The rate of detection will be upgraded too.

CASING PIPE DAMAGE DETECTION METHOD BASED ON ELASTIC WAVE

PEI Qiang[1,2], GUO Xun[3], Wang Guixuan[2]

The elastic wave reflections which take place at the fixed or free end of uniform medium may be considered as special cases of the general reflection and refraction phenomena occurring at any discontinuity in the medium properties. In this paper, the medium is a long steel casing pipe connected with many short pipes. On the basis of elastic wave reflection and refraction theory in well-proportioned medium, identifying the time difference of the acceleration waveforms in the steel pipes recorded damage location can be detected.

INTRODUCTION

Casing pipe damage in the heavy oil field is the problem that concerned by us, and it will result in enormous economic lost. Casing damage mechanism has been an important issue for the last three decades. But quantificational study of casing damage is little, and increasing trend of casing damage is not always kept with limit in domestic and overseas oil field. For example, in china Daqing oil field, the amount of casing damage well is always increased. In 1997, there are 576 wells with damaged casing, the number of which has increased to 700 up by 2001, and the total number of casing damage well in all the daqing oil fields added up to 8000. Oil field invests a great deal of fund to repair the well with casing damage every year. In order to make sure whether a damaged oil well is to repair or not, the damage location and damage degree must be prior to know. Conventional non-destructive detection instrument is difficult to detect damage which located in oil well in one thousand meters depth. Vibration-based damage detection method possess many advantages, the damage location and damage degree in oil well casing can be identified only by analyzing the vibrational signal obtained from the mouth of an oil well.

LAN-CHENG-YU PIPELINE RISK ASSESSMENT PRACTICE

Zheng Honglong* Du Yanping* Zhang Huabing* Gao Xiguang*

The pipeline risk assessment is an important task of pipeline integrity management. By assessing the risk of Lan-Cheng-Yu pipeline segment (from Neijiang to Chongqing), this paper illuminates the affecting factors and the size of risk, which provides the theoretical basis for pipeline management.

1 INTRODUCTION

The methods and theories of risk assessment origin from the insurance industry. From the last century 30's, the insurance companies started to provide the insurance service for customers, to undertake various kinds of risk and charge a certain fee as a commission, however, how much fee to be charged was determined by the size of risk undertaken. So, there was a problem of how to weight risk extent, the process for weighting the risk was the risk assessment engaged in by US Insurance Association at that time [1].

Since its birth, the risk assessment has obtained widespread applications in various trades and occupations. By estimating the likelihood and consequences of possibly occurred events, the possible risk value can be obtained and all kinds of disadvantageous events can pointedly be prevented and controlled, achieving the goal of risk reduction. The introduction of the assessment methods into the pipeline industry has played a vital role in the safe operation of pipelines. By distinguishing various kinds of harm factors along the pipeline routes, the risk of the pipeline can be calculated through the probability calculation and consequence assessment for each accident. W.Kent Muhlbauer[2] has made a good summary to the pipeline risk assessment in the book 《Pipeline Risk Management Manual》. According to the different quantification extents, the risk assessment can be divided into three types: the qualitative, the quantitative and semi-quantitative risk assessment.

CONTACT BEHAVIOR BETWEEN VESSEL SHELL AND REINFORCEMENT PAD

Li Lei*, Benhua Wu, Zhifu Sang

In the analysis of the cylindrical pressure vessels with reinforced pad using thin shell theory, no contact between the pad and vessel is often assumed. It has no enough evidences to verify this hypothesis. Contact behavior between the reinforcement pad and shell under internal pressure, transverse, longitudinal moment separately was simulated by nonlinear finite element technology provided by the software of ANSYS. A comparison of the finite element results with those from experiments shows that the finite element method with contact assumption can predict the stress distribution well. The effect of the gap between the pad and vessel, as well as the effect of the variety of d/D to the contact were also investigated.

INTRODUCTION

The reinforcement pad is often used in the pressure vessel and pipe connection structures based on the equal area-reinforcement principle[1]. The structures are divided into three parts—nozzle, pad and shell according to thin-shell theory. The deformation and force equations are established in the joints to solve the displacements and stresses. It is always considered that there is no relative rotation and displacement between pad and shell in the process solving displacements and stresses. And their contact is ignored either. But it is not accorded with the fact.

With the progress of FEM, solving this problem is becoming possible. Wilson and Parson[2] studied FEM about planar, elastic, non-friction problems firstly. The experiment and finite element analyse were carried out when the nozzle is subjected to axial thrust, transverse and longitudinal moments separately in order to present the results of local stresses in the region of opening-reinforcement pad[3]-[4]. Junker, A.T[5] analyzed the limit load of a nozzle in a cylindrical vessel due to in-plane and out-of-plane moments by FEM. The contact behavior between vessel shell and reinforcement pad under pressure was simulated by three dimensional FEM, and the comparative analysis study between the experimental and FEM results was carried out[6]. Contact property between reinforcement pad and vessel shell due to transverse moment on nozzle was analyzed[7]. Contact behavior between the reinforcement pad and shell under internal pressure, transverse and longitudinal moments separately was simulated by nonlinear finite element technology provided by the software of ANSYS in this paper. The effect of contact behavior on the maximum stress of the whole structure and the distribution of contact pressure were carried out. The effect of the gap between the pad and vessel, as well as the effect of the different d/D ratio on the contact pressure were also investigated.

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THE EFFECT OF GRAIN SIZE ON FATIGUE CRACK INITIATION IN PIPELINE STEELS

B. Chen* S. J. Wu*†

The fatigue crack initiation was studied in both ultrafine-grained (UFG) and coarser-grained (CG) pipeline steels under three point bending (3PB) fatigue test at stress ratio, R, of 0.1. Emphasis was placed on investigating the crack initiation life and site of the UFG and CG steels. The UFG materials investigated possess a higher resistance to crack initiation. This was explained by the fact that the microhardness value of ferrite phases in UFG materials has been enhanced compared with that of ferrite phases in CG materials. This was also attributed to the lower value of incompatible internal stress between the ferrite phase and the pearlite phase. An attempt was made to provide information about the improvement of fatigue life for further application of these steels to various industries.

INTRODUCTION

Among the several strengthening mechanisms, grain refinement is the only mechanism improving strength and toughness simultaneously. In the last thirty years or so, studies about UFG steels have been so widespread that many different processing techniques have been created, and mechanisms of producing UFG steels have been researched deeply. Prior to the implementation of these high strength steels into the industries, several areas require further investigation, which involve a method for economically processing these materials and a greater understanding of the fatigue properties that may be expected in service [1].

There have only been a limited number of studies on the fatigue behavior of ultrafine grained steels [1,2]. D.H.Shin et al [2] investigated the fatigue properties of UFG low carbon steel and ascribed the deterioration of the fatigue crack growth resistance to the less tortuous growth path and the larger reverse crack tip plastic zone size compared with the CG steels. In the high cycle fatigue regime, however, the reports about the fatigue properties were lacking and the mechanism of the crack initiation was unclear. In view of the application of these steels into industrial area, these investigations are of necessity and great value.

The aim of this study is to develop a better understanding of the fatigue crack initiation in UFG steels. A carefully designed experimental procedure investigates the microstructure of the UFG steels, microhardness, fatigue crack initiation life and site.

APPLICATION OF GB/T 19426-2004 "SAFETY ASSESSMENT FOR IN-SERVICE PRESSURE VESSELS CONTAINING DEFECTS" TO THE LONG-DISTANCE OIL PIPELINE

ZHAO Zihua[1], XUE GuoXing, Lv LianZhong, ZHOU Yu, ZHANG Zheng, ZHONG Qunpeng

Annex H "Safety assessment method for straight pressure pipeline with local thinning area" of "Safety assessment for in-service pressure vessels containing defects" (GB/T 19426-2004) was briefly introduced. Maximum allowable hanging length of straight pressure pipeline with local thinning area (LTA) was acquired by using this assessment method. It was the first time that the assessment method was applied to the long-distance oil pipeline. As a typical case, we analyzed a length of straight pressure pipeline with LTA and gave the relationship of maximum allowable hanging length, operating pressure and the depth of LTA.

The national standard, i.e. Safety assessment for in-service pressure vessels containing defects (GB/T 19426-2004), was formulated based on the latest research achievements and engineering experience in the domain of safety assessment for pressure vessel and pressure pipe in China. [1][2]

Annex H "Safety assessment method for straight pressure pipeline with local thinning area" of GB/T 19426-2004 adopted the innovative research achievement of state key research project in the period of ninth five-year-plan, i.e. "engineering assessment method of plastic limit loads for LTA pressure piping".

ANALYSIS OF STRESS INTENSITY FACTOR FOR THE CRACKED FILM-SUBSTRATE CONFIGURATION

Baoliang Liu*, Xianshun Bi and Longhai Yan

This study gives the two problems of a crack in the film oriented perpendicular to the film-substrate interface with the crack tip fully within the film and the crack tip fully within the film. Based on Beuth's theory, three-dimensional

model is simplified to plane strain problems, which obtains fracture mechanisms of a cracked film-substrate system by applying the boundary element method, and applies it to evaluate the cracked film-substrate system. It shows that the stress intensity factor(SIF) is affected by the different elastic mismatches and the thickness ratio of the film and the substrate. What's more, this paper studies the special condition of the film-substrate system, which is the analysis of the fracture of the absence of any elastic mismatch between the film and the substrate.

INTRODUCTION

Thin bonded films have numerous diverse applications. The last decade has seen enormous progress in the area of integrated circuits and micro-machined devices. These engineering systems typically consist of thin films of dissimilar materials joined together on a substrate. In film processes, the thermal stress exists due to the difference among the thermal expansion coefficients of the film and substrate (Xia [1], Beuth[2]). Thus, the reliability of these systems often depends on the fracture behavior of the films comprising the device. This study gives the two problems of a crack in the film oriented perpendicular to the film-substrate interface with the crack tip fully within the film and the crack tip fully within the film. (Fig.1).

THE FUTURE OF NUCLEAR POWER: FROM AGEING PLANT TO NEW REACTORS

Brian Tomkins

INTRODUCTION

Civil nuclear power is not new. The first nuclear power station at Calder Hall opened in 1956 and operated successfully until its closure in 2003; a lifetime approximately 50 years. Throughout the 1960's and 70's there was a rapid expansion of nuclear power in the developed world with an increasing number of reactors, of increasing capacity from the 60mw per reactor at Calder Hall to over 1000 mw per reactor. However, this rapid expansion, leading to around 200 reactors either built or under construction by the late 1970's was brought to a instant halt in the United States by an accident to a 900 mw reactor at the Three Mile Island Plant in Pennsylvania in 1979. This arrest in new US orders was compounded worldwide in 1986 following a second major accident at the Chernobyl nuclear power plant in the Soviet Union. The Three Mile Island accident, following a shortage of cooling water to the core of this pressurised water reactor (PWR) resulted in partial meltdown of the cove, but there

was no significant release of radioactive material to the outside. This was in contrast to the Chernobyl accident where operational errors resulted in a runaway nuclear reaction in the core of the RBMK reactor which blew the top off the reactor, resulting in a widespread release and distribution of radioactive material. Neither accident was the result of structural/material failure and in fact the PWR accident demonstrated the high integrity of the core pressure boundary.

INVESTIGATION ON THE SEAMLESS CONNECTION BETWEEN THE SAFETY ASSESSMENT AND RISK ASSESSMENT OF PRESSURE VESSELS AND PIPING CONTAINING DEFECTS

Zhong Qunpeng[1]* Luo Hongyun[1] Zhang Zheng[1] Zuo Shangzhi[2] You yiliang[1]

This article first put forward the key elements of risk assessment from the concept of risk management. Then Comprehensive analysis and comparison of the qualitative, quantitative or semi-quantitative assessing methods of assessing techniques and methods of structural failure probability for pressure vessels and piping containing defects, including the reserve factors, the second level, Monte Carlo methods to explore for its safety assessment and risk assessment methods provide a seamless connection ideas. This paper will be valuable for the natural transition from safety assessment to risk assessment of the pressure vessels and piping containing defects.

INTRODUCTION

Risk is a measure of harmful incidents and the possibility of the consequences of the accident integrated [1]. Risk assessment is the qualitative or quantitative analysis for a risk, obtain the probability of incidents or probability (P) and the loss after the accident occurred (L), determine its risk rating, so the risk R,

EXPERIMENTAL STUDY ON FATIGUE LIFE OF THICK-WALL CYLINDER WITH INNER SURFACE CRACK SUBJECTED TO SUPER HIGH PRESSURE

Huang Jianwen, Lu Yan, Li Guicai, Ren Zening, Hu Jun, Tian Yujiang

A model used to analyze the fatigue life of thick-wall simulation tubes was set up in this paper and experiments on measuring fatigue life of thick-wall cylinders with inner surface crack subjected to super high pressure were carried out.The results show that the fatigue life of simulation tubers analyzed by this paper's fatigue crack growth rate achieved through striation delineating and hydraulic pressure cyclic experiment agreed well with the practical results of hydraulic pressure cyclic experiment. With the method of this paper, quantitative problem that has ever been existing in the analysis of fatigue life of thick-wall cylinder can be resolved.

INTRODUCTION

Thick-wall cylinder components subjected to super pressure are widely used in engineerings, such as high pressure vessels and pipes in petrochemical industry, gun barrel in weapon, reactor in nuclear industry. The components operate under high pressure, high temprature and corrosive environment which always cause minute cracks at the place where stress concentrate like scratch trace, corrosion hole etc. Under inner cyclic pressure, these minute cracks propagate continuously and finally lead components to fracture and fatigue failure.

INTEGRITY OF WELDED JOINTS - SELECTED CURRENT RESEARCH THEMES

Geoff Booth*

There is now a long history of structural engineering design and consequently assuring structural integrity may be considered a mature discipline. Nevertheless, new industry and society drivers require continuous improvement to meet the challenges of the 21st century. The paper highlights selected areas of current research to indicate how these challenges are being addressed.

INTRODUCTION

The premature failure of a structure or component may lead to catastrophic loss of life or very large financial losses. Maintaining structural integrity is therefore of vital importance as even loss of public confidence, let alone actual failure, has very serious societal implications.

Engineers now have a thoroughly documented history of well over a century of successful (and unsuccessful) structures on which to base their new designs. This history would initially imply that ensuring structural integrity is a mature discipline. Whilst this is largely the case, there remains a great deal of development to be achieved to satisfy the demands of the 21st century.

NUMERICAL ANALYSIS OF BEARING CAPACITY OF SUCTION BUCKET FOUNDATION UNDER COMBINED LOADS

Ke Wu[*], Mao-tian Luan[※], Qing-lai Fan[*], Zhi-yun Wang[*]

The response of suction caisson foundation subjected to combined loads is therefore of significant importance for the design and construction of offshore foundation. Three dimensional finite element numerical analyses are performed by utilizing the general-purpose FEM package ABAQUS/Standard to define the stability or failure envelopes and collapse and working mechanism of suction bucket foundation founded in the non-homogeneous soil strata under undrained conditions is discussed.

INTRODUCTION

Engineers are often required to evaluate the behavior of offshore foundations subject to inclined and eccentric loads (i.e. horizontal loads, H, and moments, M, in addition to central vertical loads, V). This is especially true in the offshore industry, where, during a storm, environmental wind and wave forces impose significant horizontal loads and overturning moments on offshore foundations, as well as alter the vertical load (Cassidy[1]). Many recent researchers seek to characterize a failure envelope in V-H-M loading space to describe the foundation response transformation from safe condition to failure state. Tan[2], Houlsby and Martin[3], Butterfield and Gottardi[4] have analyzed the combined loading response of foundations using plasticity methods based on an assumed yielding envelope. However, the failure envelopes of deep foundation under combined loads on non-homogeneous soft clay are lacking a systemic research.

STUDY OF ELASTIC STRENGTH FOR CYLINDRICAL VESSELS WITH LATERAL UNDER INTERNAL PRESSURE

Nan Li, Wei Guo-hong, Sang Zhi-fu

The objective of this work is to study the elastic stress distribution, deformation characteristic, stress concentration and stress concentration factor of three full scale vessels with different structure dimension and lateral angel θ （θ =30°，45°，60°） under internal pressure by both experimental and three dimensional nonlinear finite element methods. The results of experiment and three-dimensional nonlinear finite element method are in good agreement. Distinct stress concentration occurs. The intersection region shrinks in the longitudinal section of cylinder, while bulge appears in the transverse section. The maximum stress of the structure occurs at acute side of nozzle-cylinder intersection in the longitudinal section of cylinder. When *d/D, D/T, t/T* radios of the structure are fixed, stress concentration factor at the most dangerous point of the structure decreases with the incensement of lateral angel θ.

INTRODUCTION

Lateral connection configurations are widely used in the pressured vessels and piping industries. Because of their unique geometry of the structures, a distinct stress concentration occurs at the intersection area of the cylinder and nozzle (or main pipe and branch pipe). The previously studies were mostly focused on the structures with 45 degree Lateral nozzles. Quite a long time has passed since Mershon presented the problem of lateral nozzle firstly [1]. Many scholars [2]-[3] have studied on the lateral connections in the past. All the literatures [4]-[5] indicated that, it is effective to make use of Finite Element Analysis.

EXPERIMENTAL STUDY ON FATIGUE GROWTH OF SURFACE CRACKS ON WELD OVERLAY IN COMPOSITE STRUCTURE

SHEN Shiming*, DING Guoquan

The vessels with composite structure were widely used to refining oil and petrochemical devices such as hydrogenation reactor with a hot wall, which is made from 2.25Cr1Mo as a base material and austenitic stainless steel 309L+347L as overlay. The hydrogenation reactor services at severe conditions of high temperature, high pressure, hydrogen environment. A stripping and surface crack on overlay induced hydrogen is usually created on

overlay, which damages to the structure integrity of hydrogenation reactor. The fatigue growth of surface cracks on overlay of hydrogenation reactor was attracted attention of engineering fields. In this paper, the experimental study on fatigue growth of surface crack on overlay was carried out. The patterns of surface crack growth showed that surface crack on overlay could penetrate through the interface of overlay and base material under the fatigue load, when overlay and base material were combined better each other. The fatigue propagation rate of surface crack on overlay was obtained from the experimental results.

INTRODUCTION

The vessels with composite structure were widely used to refining oil and petrochemical devices such as hydrogenation reactor with a hot wall, which is made from 2.25Cr1Mo as a base material and austenitic stainless steel 309L+347L as overlay. The Hydrogenation reactor services at severe conditions of high temperature (350～480℃), high pressure (0～17.5MPa) and environment with hydrogen. A stripping and surface crack on overlay induced hydrogen is usually created in hydrogenation reactor, which damages to the structure integrity of hydrogenation reactor. The fatigue growth of surface crack on overlay in hydrogenation reactor was attracted attention of engineering fields[1]. So it is very necessary for the safety operation of hydrogenation reactor that studying fatigue growth of surface crack on overlay experimentally.

REVIEW AND PROSPECT ON RISK ASSESSMENT APPLICATION IN PRESSURE VESSELS INSPECTION IN JIANGSU

Qian Xiayi*, Miao Chunsheng, Ma Xin

5 typical cases of Risk-based Inspection (RBI) technology application in Jiangsu province were summarized and reviewed. Some problems which special attention should be paid to during publicizing and applying RBI technology in china were put forward based on experiences from risk assessment conducted for 10 years, and emphasis is put on the management of equipment integrity, qualification requirement for organization conducting RBI and safe employing pressure equipments. Responses to requirement of Chinese petrochemical enterprises are suggested to be divided into three categories and the combination of excellent RBI software and well-organized RBI team is pointed out as essentials to conduct RBI work in china successfully, and sinicized and localized database of materials and chemicals is suggested to be built progressively as well.

INTRODUCTION

RBI is a new technology tendency of inspection and management of pressure equipments in large petrochemical plant. with detailed analysis on potential damage mechanism, failure mode, probability of failure, consequences of failure and risk rank attained further of pressure equipments to be assessed, RBI technology can identify major problems and weak links, establish a reasonable inspection plan, reduce certain level of expectation risk through implementation of inspection and risk mitigation measures, ensure essential safety of pressure equipments, reduce operating costs and optimize inspection strategy.

A STUDY ON PLASTIC INSTABILITY OF STRUCTURES IN PLANE STRESS UNDER PROPORTIONAL LOADING

Yang Chun DENG*, Liang SUN**, Tong XU**,Gang CHEN**

In this paper, plastic instability of several structures in plane stress under proportional loading is studied. For materials with stress-strain relationship of Swift type, strain at instability can be deduced to be considered as a failure criterion. Meanwhile, the strength of the structure can be calculated according to the stress-strain relationship. Finite element analysis and bursting experiments are performed to six thin shell cylindrical vessels with varies materials and dimensions respectively. The results of calculations and experiments demonstrate that it is accurate and reasonable to adopt instability strain as a failure criterion.

INTRODUCTION

In order to exert the material capacity of pressure endurance and to use materials safer and more reasonable, we need to identify a failure criterion for structure with plastic deformation. Although it is difficult to determine the plastic failure criterion for general structures, more precise theoretical deduction can be made to derive plastic failure criterion for some simple structures in plane stress under proportional loading.

FATIGUE TEST AND CRACK GROWTH ANALYSIS OF RETIRED MILITARY AIRCRAFT WING

CHEN Yueliang TAN Xiaoming JIN Ping

The right wing of a retired military aircraft was tested under measured load spectra, which had serviced for more than twenty years in a coastal airport located at high temperature, high humidity and high salt fog place, and the remainder fatigue life was obtained. The test result showed that the crack in fatigue critical part (the second hole of main beam flange of aircraft wing) initiated earlier and crack growth rate increased greatly than the full-scale fatigue test result of new aircraft, as a result of corrosive environment and service load. Based on comparing crack growth rate da/dN, crack growth coefficient increased 5.9 times, provided that the crack growth exponent was constant. The macro- and micro-fatigue fracture characteristics of main spar were observed by use of scanning electron microscope. And fatigue crack growth life was retro-estimated through fracture quantity analysis; also the test result was analyzed.

INTRODUCTION

There is qualitative analysis and quantitative analysis in fracture quantity. The former includes structure failure mode analysis and failure cause analysis, only can the failure type be gotten; and the latter gives emphasis to predict the magnitude of failure cause, such as failure stress, fatigue domain area, crack length, flaw dimension and fatigue life[1]. Based on the fracture information, the fatigue fracture quantity analysis involves element analysis, stress analysis and so on; it plays an important role in fracture analysis, especially fatigue life retro-estimation.

RESEARCH ON IN-PLANE INSTABILITY OF U-SHAPED BELLOWS SUBJECTED TO INTERNAL PRESSURE AND AXIAL DEFORMATION

CHEN Ye *, GU Boqin*

Stress and strain distributions in the U-shaped bellows acted by interna1 pressure-axial compression were investigated by nonlinear finite element analysis method (FEM). The calculation results indicated that the bellows' in-plane instability rests with the plastic region expansion in bellows. The

criterion for in-plane instability is defined that the plastic hinge line is formed in roots and the plastic region emerges in annular plates of bellows. The results obtained by theoretical analysis are in good agreement with experimental data. Considering the effect of strain accumulation on the critical load of the bellows acted by cyclic axial displacement, the in-plane instability critical loads curve can be illustrated in the internal pressure-axial compression coordinate system.

IN-PLANE INSTABILITY MECHANISM OF U-SHAPED BELLOWS UNDER INTERNAL PRESSURE-AXIAL COMPRESSION

In-plane instability is a plastic failure of non-reinforced U-shaped bellows. The design formula for avoiding the in-plane instability has been presented in EJMA (Expansion Joints Manufacturer Association of American) standard [1], but the effect of axial displacement loads on the instability has not been taken into consideration.

A RESEARCH ON THE RELIABILITY CALCULATION AND SAFETY ASSESSMENT METHODS OF SPHERICAL TANK WITH DEFECTS

Shuo Pan Jianping Zhao*

In the process of spherical tank fabrication, there were lots of defects such as edge offset and angular distortion appearing by the reason of cylinder prebending, assembling and mistakenly welding. It was dangerous during the spherical tank with these defects was operated, so calculation of the failure probability and safe assessment were especially important. Assessment procedures based on probabilistic fracture mechanics doesn't only analyze the uncertain factors of traditional safe assessment method and process and fully consider the randomness and actual variance of different parameters, but also analyzes the effect of vary of sorts of parameters and factors controlling fracture failure to confidence level and fracture failure probability. According to stress-strength interference theory, limit state function was established, failure probability model was developed and some parameters in this model were considered as stochastic variable. Then the failure probability of spherical tanks is calculated by First-Order Second Moment method and Monte-Carlo method.

INTRODUCTION

In the chemical & petrochemical industry, spherical tank were mostly used in storing up liquefied petroleum gas, liquefied natural gas, liquid hydrocarbon, ethylene, propylene as well as oxygen, nitrogen, hydrogen and so on. These are always flammable, explosive and virulent liquid and gas medium. Once accident happened, not only spherical tank itself is destructed, but also can bring the disastrous consequence, therefore guaranteed their security and reliability are very important.

INVESTIGATION OF ACOUSTIC EMISSION (AE) TECHNIQUE APPLICATION TO INTEGRITY ASSESSMENT OF CRANE METAL STRUCTURE

Zhanwen Wu1, Gongtian Shen2, Shaomei Wang1, Chunxu Pan3

In this paper the acoustic emission (AE) technique was used to the main beam in bridge crane for nondestructive test and integrity assessment. The attenuation curve and linear location of the AE signals on the box beam were investigated. The parameter of AE signals with load were acquired and analyzed. The results indicate that the linear location method can be used well in AE source location in the box beam with thin walled. The investigation is a success in application of AE technique on crane. It provides significant data for the integrity assessment of the crane metal structures.

INTRODUCTION

Today, the high performance of modern crane is developed in bigness, modularization, and high parameters. Once the failure of the metal structure happened, it may bring huge losing of economy and the injured of people. Acoustic emissions (AE) [1] are high frequent, transient sound waves emitted when rapid local stress redistributions occur in a material. The stress redistributions are normally caused by the generation of structural changes in a material under a general loading condition. Examples of structural changes are crack growth, phase transformations, corrosion, wear and so on.

FINITE ELEMENT ANALYSIS OF CREEP DAMAGE FOR WELDED JOINT OF HIGH TEMPERATURE COMPONENT

ZHANG Guodong, ZHOU Changyu

By the finite element analysis code ABAQUS and the function of coupling process between heat and stress, the welding residual stress of welded joint for Cr5Mo furnace tube was analyzed firstly, and the distribution of welding residual stress of welded joint was obtained. Then according to the theory of damage mechanics, ABAQUS user subroutine of the modified Kachanov-Rabotnov (K-R) constitutive equation was developed. Creep damage of welded joint was simulated by the user subroutine on consideration of the welding residual stress of welded joint for the tube. The distribution of creep stress and damage was obtained after the tube was in service for different hours. The results indicate that the hoop welding residual stress of welded joint for the tube is highest. Although the welding residual stress is relaxation at initial stage rapidly, the initial stress accumulative damage has much effect on the welded joint. The distribution trend of damage is similar to that of initial welding residual stress, and which shows that the welding residual stress has a great influence on the creep damage of welded joint.

INTRODUCTION

In oil refining and petrochemical facility, high-temperature equipment is the key facility of device system. The weldment used at elevated temperature is one of the most important unit in the device system. But, in a lot of equipment accidents, the failure examples of welded joint are common occurrences (Viswanathan [1], Lundin, [2]). At present, more and more scholars investigate the creep damage on the high temperature components. Storesund and Tu (Storesund, [3]) analyzed the creep stress redistribution of welded joint test sample for 1Cr0.5Mo steel. The results showed that stress in the heat affect zone (HAZ) release to welding line. Gong J. M. (Gong, [4]) has investigated welding effect on creep damage of high temperature furnace tubes. He concluded that the weldment might be come the weak link in HK-40 furnace tubes. Hyde T.H. (Hyde, [5]) made lots of research on creep damage and life prediction for power plant high temperature pipeline. He had calculated the creep damage state of parent material (PM) and weld metal (WM) for the pipelines (Hyde, [6], [7]).

EFFECT OF WELD DEFECT ON THE PERFORMANCE OF STEEL PIPE PILES WITH A WELDED JOINT SUBJECTED TO IMPACT LOADING

Gab-Chul Jang*, Kyong-Ho Chang**, Chin-Hyung Lee***

Most of steel structures, such as steel pipe piles, etc., are joined by welding. During welding, various weld defects such as cracks, undercuts, misalignments, etc, are caused due to the incomplete fusion and the imperfect shape in welds. It is therefore necessary to investigate the effect of undercuts and welding residual stress on the behavior of steel structures. In this paper, the effect of weld defect(undercut) on the performance of steel pipe piles with a welded joint under impact loading was investigated by three-dimensional elastic-plastic finite element analysis. It is seen from analysis results that maximum load carrying capacity of steel piles undercut decreases due to influence of undercuts.

INTRODUCTION

Most of steel structures, such as steel pipe piles, etc., are joined by welding. During welding process, various weld defects such as cracks, undercuts, misalignments, etc, are caused by the incomplete fusion and the imperfect shape in welds. Undercut can be defined as a surface depression along the interface between weld and base metal. Undercut can be formed in fully mechanized welding of long fillet welds in the horizontal and vertical position with large heat input.

RISK ASSESSMENT AND ITS DEVELOPMENT IN CHINA

ZHONG Qunpeng* ZHANG Zheng* SUN Yongqing* ZUO Shangzhi**

Risk assessment is an effective method to improve the resource utility. The risk assessment starts from analysis and classification of the accident data of pipeline. Three kinds of risk assessment methods, qualitative method, semi-quantitative method, and quantitative method, are established. In 1990’s, the risk assessment concept and method were imported into China. The risk assessment on pipelines are paid more attention, it makes a great progress in the development, application and research of risk assessment in China. But the hazard evaluation and risk assessment technology for gas pipeline in China is still at the starting phase. Some problems to the risk assessment of pipelines in China should be solved in the future.

RISK AND RISK ASSESSMENT

When the concept of risk is used in the management of gas pipeline, the traditional safety management is gradually replaced by the risk management, the passive maintenance is replaced by aforehand active maintenance. The buried gas pipelines and attachments with complex structure and different geographic environment are complicated system, so the accidents of pipeline, such as explosion, fire, personal injury and property damage etc., always happen. Therefore, it is necessary that date, location and consequence of accidents could be forecasted. The risk assessment and risk management for gas pipeline are the effective measure to prevent the accidents.

ASSESSMENT STRUCTURAL INTEGRITY OF OPERATED HIGH ENERGY EQUIPMENT AND PIPING OF FOSSIL, NUCLEAR, CHEMICAL AND REFINERY PLANTS BY QUANTATITIVE ACOUSTIC EMISSION NON-DESTRUCTIVE INSPCTION METHOD

Prof. Dr. G. Muravin, Dr. B. Muravin, Dr. L. Lezvinsky*

Increased requirements for the safety and reliability of potentially dangerous equipment and structures stimulated us to create and develop a new AE technology that would also make it possible to reveal, identify and assess the danger level of individual and interacting flaws according to fracture mechanics criteria. We started this work at the beginning of the nineteen eighties and created our technology, entitled "The Quantitative Acoustic Emission Non-Destructive Inspection (QAE NDI) technology". In the following we shall describe results of using it to inspect high energy piping in fossil and nuclear power plants, and in chemical industry.

INTRODUCTION

The situation with thousands of miles of high energy piping of chemical, refinery, fossil and nuclear piping, and high energy reactors is a cause for alarm. This has increased interest in the prospect of securing timely indications of failures in the early stages of their development, and creating rational methods for inspecting and evaluating the condition of structures. Below we shall consider the application of Quantitative Acoustic Emission Non-Destructive Inspection (QAE NDI) techniques to assess risks in high-energy piping in fossil, nuclear and chemical plants.

FATIGUE RELIABILITY UPDATING EVALUATION USING NONDESTRUCTIVE INSPECTIONS FOR EXISTING STEEL BRIDGES

WANG Chun-sheng †*, YU Xin †, LIU Xin †, XU Yue †

Through nondestructive inspection (NDI) techniques, the flaws of structures can be detected earlier in period of use, and the update of fatigue reliability assessment can be realized. The probabilistic fracture mechanics method based on the Bayes theorem using the results of NDI techniques can update the crack growth models and relevant parameters effectively, and evaluate the actual fatigue life and service safety of steel bridges. In current paper, an approach to assess the service safety of existing steel bridge components after nondestructive inspection is developed, and based on the Bayes theorem the fatigue reliability updating models for steel bridge components have been proposed. In the case study for a truss steel bridge, the $\beta - T$ curves of the third suspender of a truss bridge can be calculated using fatigue reliability updating models after fatigue cracks were inspected and updated in this paper. The results prove that the fatigue reliability will increase when no flaws were inspected, decrease when flaws were inspected without flaw length, and has remarkable changes when find crack flaws were inspected.

INTRODUCTION

The safety state of existing steel bridges in China is not optimistic while these bridges are carrying an increasing volume of traffic. So methods for evaluating and updating the actual fatigue life of such structures are urgently required. The development of modern nondestructive inspection (NDI) techniques may facilitate early detection of flaws and allow more economic inspection, strengthening and help to ensure the safe condition and extend the service life of the structure (Wang et al. [1]). Tang [2] developed a method to use the probability detection (POD) curve of NDI to update the distribution of crack size at the time of inspection, given that crack or no crack is detected. Byers et al. [3], Zheng and Ellingwood [4] considered the case of crack detected with size measurement in their work. Madsen [5], Zhao and Haldar [6] developed another method that different limit state functions are defined corresponding to different inspection results, and the failure probability is updated directly based on inspection results. Zhang and Mahadevan [7] extended the method above to NDI-based corrosion fatigue reliability updating. In this paper, an approach to evaluate and updating the fatigue-reliability of existing steel bridges is developed, and the effects of the fatigue failure mechanism, failure models of steel bridge, reliability characterization of NDI technique and the Bayes theorem are included. The

fatigue-updating models using NDI technique have been set to assess the reliability of existing steel bridge components.

DEVELOPING OF PROBABILISTIC SAFETY ASSESSMENT BASED ON THE PROBABILITY FRACTURE MECHANISM IN CHINA

Hongyun Luo*, Sujun Wu, Hongwei Wang, Qunpeng Zhong

This paper reviews the development of the probabilistic safety assessment (PSA) based on the probabilistic fracture mechanics (PFM)applied to pressure vessels and piping in China. Two main aspects were considered. One is the distribution of main variables influencing the probability of failure, such as distributions of defect sizes, detection probability, fracture toughness and yield strength values; the other is the approaches for determining the probability of failure of structural components.

Introduction

Nowadays the deterministic safety assessment (DSA) based on the Linear Elastic Fracture Mechanics (LEFM) or Elastic-Plastic Fracture Mechanics (EPFM) is very popular in the safety assessment in industry. It has been formally required in licensing. However, it does not meet today's requirements in many areas. For example, due to uncertainties in some of the variables included the DSA (for instance, crack size and material properties), a purely deterministic approach provides an incomplete picture of the reality. Therefore, a probability approach seems to be very helpful for practical engineering [1].

A SAMPLING TEST METHOD OF MAXIMUM MAINTENANCE TIME FOR LOGNORMAL DISTRIBUTION PRODUCT

Hong Yanji*, Jin Xing , Xiong Longfei, Wang Guangyu, Zhai Yingmin

The traditional sampling test method is fit for cases that the number of sample is greater than thirty, it is an approximate calculation method. An unbiased estimation statistics is proposed for the sampling test of maximum maintenance time. Based on χ^2 distribution function and normal distribution function, a sampling test method of maximum maintenance time is presented, which the number of sample is allowed less than thirty. The problem of the sampling test

of maximum maintenance time is resolved by the method, which the maintenance time is lognormal distributed.

INTRODUCTION

In the sampling test method of maximum maintenance time for lognormal distribution product, sampling test method is fit for cases that the number of sample is big enough (greater than thirty)[1-2]. It is an approximate calculation method. The research for high precision sampling test method has the practical value in engineering.

EXPERIMENTAL STUDY ON FATIGUE BEHAVIOR OF RC BEAMS STRENGTHENED WITH CARBON FIBER LAMINATES UNDER CYCLIC BENDING LOADS

ZHOU ZHILIN [*, 1], HUANG PEIYAN[*, 2], DENG JUN [3], HAN QIANG[4]

Fiber reinforced polymer (FRP) has been widely used to strengthen concrete structures in civil engineering recently. However there were few studies on the durability and fatigue behavior of reinforced concrete (RC) structures strengthened with FRP. In this paper, fatigue tests under cyclic bending loads at different temperature of 20℃ and 80℃ were carried out to investigate the fatigue behavior of the beams strengthened with carbon fiber laminates (CFLs). The test results show the failure modes of the strengthened beams under cyclic bending loads include concrete crush, CFLs debonded and steel bar broken. S-N curves of strengthened beams were developed according to the test results. The fatigue limit and Load–mid-span deflection curves of strengthened beams were obtained as well. The fatigue lives of the strengthened beams are not significantly influenced by the ambient temperatures when the peak loads equal 25.0kN, 27.5kN or 30.0kN. However, when the peak load equals 32.5kN, the fatigue lives decreased significantly with the temperature.

INTRODUTION

The fatigue behavior and durability of reinforced concrete (RC) members strengthened with fiber reinforced polymer (FRP) are one of the major concerns in civil engineering (Theriault[1], Huang PY[2], Gheorghiu[3]). Shahawy and Beitelman [4] conducted fatigue tests on RC beams strengthened with carbon fiber reinforced polymer (CFRP) laminates. Their experiment results showed that the fatigue lives of RC beams were enhanced remarkably, and the fatigue lives also increased with the

number of CFRP laminate layers. Barnes and Mays [5], Pakakonstantinou, et al. [6], Heffernan and Erki [7] and Aidoo et al. [8] indicated that the fatigue behavior of RC beams strengthened with FRP were mainly associated with the stress level applied onto the main reinforcements. Niu Peng-zhi and Huang Pei-yan et al. [9] developed a new method to predict the fatigue life of RC beam strengthened with carbon fiber laminates (CFLs) according to the relationship between mid-span deflection and fatigue life. Moreover, Niu Peng-zhi and Huang Pei-yan et al. [10] found that the flexural stiffness was independent of the peak load. The previous studies show that FRP can effectively improve the fatigue performance of RC beam. However, only one specimen was tested for each peak load in all the experimental studies [1-8] except Niu Peng-zhi and Huang Pei-yan et al. [9, 10]. It is well known that at least five or six specimens need be tested for each fatigue peak load. Therefore, the derived results in the previous studies are suspectable.

PRACTICAL APPLICATION OF DAMAGE TOLERANCE TO THE ASSESSMENT OF ROTORCRAFT STRUCTURAL INTEGRITY

Liu Wenlin*, Mu Zhitao, Hou Zhiqiang

The crack growth behavior in typical metallic material used in naval helicopters under actual load spectra was studied. The effect of the fatigue crack-growth threshold, ΔK_{th} on crack growth from a corner crack under the helicopter load spectra, the sensitivity of the crack-growth threshold to the initial crack length and the effect of the NASGRO crack growth model parameters c, n, p, q to the crack growth life were evaluated. The results showed that for the typical material a stress reduction of about 23% from the baseline stress value was required to achieve an acceptable minimum crack growth time to failure of 1000 flight hours. The fracture toughness K_c and the three parameters c, p, q have little effect on the crack growth life but the parameter n has a significant effect that a 0.01 fraction increase leads to crack growth life more than 0.19 decrease.

INTRODUCTION

Damage tolerance concept is widely used in fixed-wing aircraft to ensure flight safety and to enhance the fatigue life of aircraft components beyond the original design life. However the employment of damage tolerance is not always practical in rotorcraft

dynamic components where crack growth times can be relatively short due to the high frequency loading environment [1].

The crack growth behaviors in several typical metallic materials used in helicopter under helicopter and fixed-wing load spectra were compared [2]. The parent differences in life management between dynamic components and fixed-wing aircraft, the crack growth characteristics for dynamic components (HCF), and the applicability of damage tolerance analysis is demonstrated via a main rotor yoke [3].The evaluation presented in this paper was undertaken to evaluate the effect of the crack growth model and the stress intensity threshold, ΔK_{th}, on crack growth from a corner crack under the helicopter load spectra. The impact of increased loads and the sensitivity of the crack-growth threshold to the initial crack length were also addressed.

ASSESSING AT CRACK TOLERANCE OF TC17 ALLOY'S EB-JOINTS BY CTOD CURVE

By Wu bing*, Li jinwei*, Suo hongbo* and Zhang yanhua#

This report, according to the welding structure integrity request, both in 20℃ and 400℃ temperature, carried network analysis on the Crack Tip Opening Displacement (CTOD) and the fracture toughness of the TC17 alloy's electron beam joints. Based on the CTOD test, crack tolerance of EB-joints has been studied. Through researching, we got the following conclusions. No matter what temperature it is , normal (20℃)or high temperature（400℃）, the average CTOD value of the materials is higher than that of the joints, and the average CTOD value of the joints is low, easy to be fractured. The result of calculating the crack tolerance shows, under the same stress level, the crack tolerance of the metal holds higher than that of the joint, and when the stress level increase, the difference decreases.

INTRODUCTION

Until now, there are two norms to evaluate the defect structure integrity. One is the method basing on the COD designs curve, the other is the criterion basing on J IC testing. The COD design curve establishes the relational expression among working stress, crack size and fracture tenacity on the basis of elastic-plasticity fracture mechanics, and it is an effectual method, has been using extensively.COD (Crack Opening Displacement) is known as CTOD (Crack Tip Opening Displacement) at present [1]. CTOD is a very important parameter, which is used to evaluate the resisting brittle fracture characteristics of the materials and the joints. Comparing with

the impact of the traditional V-shaped notch, CTOD can estimate the resisting brittle fracture characteristics more effectively. CTOD tests not just can diagnose the material tenacity, also can offer the experimental basis for evaluating the structure's reliability [2,3].

ANALYSIS ON DROP OF ARCH AXIS OF A CONCRETE-FILLED STEEL TUBULAR ARCH BRIDGE IN NORTH CHINA

Ren Qingxin*, Liu Yanhua† and Li Shunqun‡

Aimed at the problem of a concrete-filled steel tubular (CFST) arch bridge in north China which the jointing heights of east and west arch rib is 0.30 and 0.44 meters lower than the design elevation, respectively, the software ANSYS is adopted to establish the finite element model of the structure and used to analyze the structural internal force under live load. Based on the contrastive analysis of the bridge, some major conclusions are summarized as follows: There is a little influence on support reaction and deflection, axial force, moment, stress of every reference sections owing to the drop of arch axis, and it is ignorable. By analyzing the drop of arch axis of the bridge, the influences of arch axis dropping on the structure are found, and the bridge is considered to be safe. The results obtained are available to the detection and evaluation of the structure in practice.

INTRODUCTION

Up to now more than three hundred CFST arch bridges have been built or are under construction in my country. In general, the half-through arch bridge is the most popular type of CFST arch bridge among these arch bridges.

ESTABLISHMENT OF VEHICLE FRONT AXLE LOAD SPECTRUM AND ITS APPLICATION OF FATIGUE LIFE ESTIMATION

Hongwei Wang， Hongyun Luo*， Qunpeng Zhong， Lifeng Li

The front axle is very important to safety and reliability of the vehicle. To estimate the fatigue life of the vehicle front axle, a simple and quick method is adopted. The vehicle front axle load spectrum was measured when the vehicle

ran on general tar-paved roads, mountainous roads, stones roads, etc. The table of the frequency relationship of the different mean and amplitude load was obtained by using rain-flow counting method of three peaks and valleys. Through a series of tests and calculation, the mathematical model of P-S-N curve of vehicle front axle under the different probabilities was acquired, and the fatigue life of the different mean and amplitude load was obtained. According to the obtained frequency relationship and the fatigue life of the different mean and amplitude load, and with Miner linear accumulated fatigue damage rule, the service life of vehicle front axle under stochastic load was estimated. This method simplifies the calculation of the fatigue life estimation, and these estimated results will be significant for the fatigue design, test, life estimation and the parameters optimizing of the vehicle front axle.

INTRODUCTION

Road load spectrum is very important to estimate fatigue life of vehicle front axle. Fatigue load spectrum is the load-time course of being handled. It describes the statistics nature of load under all kinds of loading conditions, and determines the statistic relation between load and frequency based on the probability statistics. It shows that fatigue load spectrum is important foundation to design fatigue parameters, estimate fatigue life and imitate fatigue tests, calculate and analysis strength, and design the reliability etc. It is well known that the good formulas of fatigue life curves play important role in fatigue life estimation. But fatigue testing is time-consuming and costly. Therefore, effective formula should be adopted to estimate *P-S-N* curves from a limited number of fatigue tests.

THE IMPACT OF NON-UNIFORMITY OF LOADING ON THE STRENGTH OF CASING

Yongshu Jiao [1*], Muhui Fan [1], Zongxi Cai [2]

Crushing of the casing is one of the most important damage mechanisms in oil industry. It is caused by non-uniform loading among the sand, cement and casing. While most of the critical pressure ratings for casing are based on uniformly distributed pressures, it is extremely valuable to have an accurate understanding of the casing behaviors under non-uniform loading. With the help of the powerful capacity for symbol formulating of Mathematica, the authors derived the general solutions of stresses and displacements for the casing subjected to arbitrarily distributed forces, continuously or discontinuously and tangentially or radially. With these solutions the stresses are calculated in the casings under uniform and non-uniform pressures. The results show that the stresses in the casing under uneven loading are much

greater than those under evenly distributed pressure. It is recommended that the impact of non-uniformity of loading on the strength of casing should be taken into considerations in the casing design, especially in special layers such as salt.

INTRODUCTION

onventional analysis for casing design is based on uniform pressures. Many researches have been made on the capacity of casing for resisting external pressures. For example, Issa and Crawferd [1] developed a design equation for casing collapse, considering the effects of geometry imperfections such as ovality, eccentricity and material elastic-plastic behavior. Yukihisa Kuriyama and Toshitaro Mimaki [2], by using of the theory of elasticity and plasticity, derived a formula for elasto-plastic collapse strength of thick-walled casing. Peterson [3] studied the influence of the internal pressure on the collapse loading rating and provided a tri-axial collapse equation. All of the above investigations are based on the fact that the casing is subjected to evenly distributed internal and external pressures

AN EXPERIMENTAL AND MODELLING STUDY OF BRITTLE CLEAVAGE CRACK PROPAGATION IN A TRANSFORMABLE FERRITIC STEEL

GM Hughes,[†] GE Smith,[‡] AG Crocker[‡] and PEJ Flewitt[†,¥]

Flaws that can be present within pressure vessels, pipework and other engineering structures are assessed using the principles of engineering fracture mechanics. It is necessary to support such an approach with an understanding of the underlying fracture mechanisms. Moreover, many of these components are fabricated using transformable steels. In this paper we describe the fracture of an A508-type steel, heat treated to produce a tempered bainitic microstructure, and subsequently impact tested at -196ºC. In particular, focussed ion beam microscopy has been used to produce high resolution fractography, combined with information relating to the underlying microstructure and crystallography. The results of cleavage crack propagation across prior austenite grain, packet and lath boundaries are described and then correlated with predictions from a 3-D geometric model of brittle cleavage fracture in polycrystalline steel. This model includes a consideration of a lath substructure within the grains based upon a Kurdjumov-Sachs orientation relationship with the parent austenite grain.

INTRODUCTION

Structural integrity assurance provides a demonstration that a structure or component meets the required duty and tolerance to flaws safely and economically.[1,2] When diagnosing a particular problem, often a failure or the presence of a flaw, it is essential to understand the underlying mechanism by which the flaw or defect can extend. As a consequence, to achieve the correct structural integrity assessment combined with the required reliability, it is necessary to address the potential failure modes and how well these can be predicted for the various mechanistic models available.[3] In polycrystalline ferritic steels, crack initiation and growth mechanisms change with temperature. This results in the well established variation of Charpy impact energy or fracture toughness with temperature arising from brittle fracture at low temperatures and ductile fracture at higher temperatures.[4] Certainly, there have been advances in the ability to model fracture in polycrystalline materials, including 3D models describing brittle fracture at the micro-scale.[4,5] For ferritic steels at lower temperatures, transgranular cleavage on {100} planes predominates. However, for interfaces such as grain boundaries or sub-boundaries (e.g. twins), it has been demonstrated that significant accommodation is required at the interface to compensate for the mismatch between cleavage planes on either side of the interface.[6]

ANALYSIS AND EXPERIMENTS ON THE PLASTIC LIMIT MOMENTS OF ELBOWS WITH/WITHOUT LOCAL THINNED AREA

DUAN Zhixiang, SHEN Shiming

The plastic limit load of elbows under in-plane closing bending moments is discussed in this paper. In this research finite element analysis (FEA) and experiments have been used. The results of FEA show that the limit load of elbows under in-plane bending moments increases with the increasing wall thickness and increasing bend factor of elbows. By data fitting of FEA, an empirical formula of the limit load for elbows with/without local thinned area in extrados has been obtained. These results have been validated by the experiments.

INTRODUCTION

Elbows are often considered to be the critical components in a piping system. Because of corrosion, erosion, mechanical damage and crack polishing, there are local thinned areas (LTAs) in an elbow. The LTAs reduce the structural integrity and may affect the

safety of the pipeline. For the safety evaluation of an elbow with LTA(s), it is significant to calculate the limit load of an elbow with LTA(s) (HAN, [1]).

STRUCTURAL ANALYSIS OF ANCHORING SYSTEM BASED ON NUMERICAL SIMULATION

Yang licheng*, Fu caiming, Hu Guojun

A stay cable bridge with an inclined tower and its surface is arc line-type one. The cable tower lies in the inner side of the bridge floor slantways. It has two steel cables on the reverse side of the declining direction. To adopt OVM250-211 anchor, each steel cable undergoes the load of 22000kN. The pre-stressed anchor system uses several steel cables, that is, the back cable anchor is fixed in the center of the connective plate (II), then the connective plate (II) and (I) ties together through four tension bars, furthermore, the connective plate (I) is fixed on the anchoring system by four bunch of OVM15-55 pre-stressed steel cables. After the design of the structure, it is necessary to withstand the tension force with 22000kN but does not appear yield phenomenon. The anchoring system with back cables was simulated based on MSC.MARC three-dimensional elasto-plastic finite element method software and advanced contact technology. The finite element model of the structure was established by Lagrange method of three-dimensional FEM. To calculate and analyze equivalent of elastic strain and equivalent of stress for the connective plates and the tension bars, the results indicated that the two connective plates and the tension bars satisfied the request of strength characters, thus the design of the anchoring system was feasible.

INTRODUCTION

The pre-stressed concrete technology develops rapidly in the civil engineering, especially, the technology of pre-stressed anchor system has already been inclined to consummate by the development of a few tens of years. The tensile anchor system with pre-stressed steel wire is one of many kinds of pre-stressed systems with back tensile pre-stress. It regards steel wires as pre-stressed ones. These steel wires pass through the anchor plate with many holes in the end of the structure together. Each steel-wire is clamped by a wedged splint and anchored on the plate, which produces the permanent pre-stress. Because OVM anchor system owes the performance of stable anchor character, even stress, safety and reliability, be suitable for steel wires with many kinds of different specification, it has already used widely to steel structure, bridge, nuclear power station, hydraulic engineering and other pre-stressed concrete structures. The anchor system plays the vital role when the pre-stressed method is widely used in engineering structures. The effect of pre-stress depends on

the maximal load that the anchoring system can withstand. The field of the civil engineering accumulated the certain experience in using the pre-stressed technology aspect, has formed the certain application standard, but it lacked the systemic analysis of theory, especially few in researching for the strength and characteristics of materials. Thus it is essential to research for the strength of the pre-stressed anchor system. However, it is difficult to study internal mechanical behavior of the anchoring system by experimental method. Numerical technology has already become the main analytical tool for solving complex engineering problem based on FEM.

ESTIMATION OF RESIDUAL CONTACT PRESSURE IN HYDRAULICALLY EXPANDED TUBE-TUBESHEET JOINTS OF HEAT EXCHANGERS

Haifeng Wang*, Zhifu Sang*

The connection of the tube to tubesheet is the most critical element of a tubular heat exchanger because its reliability depends on the integrity of many parallel tube-tubesheet joints. The process of hydraulic expansion of tube-tubesheet joints was simulated using finite element method, and the empirical equation based on data from calculations was developed to evaluate residual contact pressure of joints. In order to confirm the credibility of the empirical equation, some specimens were fabricated and joint strength experiments were performed using a MTS testing machine. The latter were found to be in good agreement with the estimated values. This work shows that material property and expansion pressure are the most important factors to determine residual contact pressure, the thickness of tube and the radial clearance between tube outer surface and tubesheet hole have the secondary effect. The thickness of tubesheet is the third important parameter for determining residual contact pressure in hydraulically expanded tube-tubesheet joints.

INTRODUCTION

SHELL-TUBE HEAT EXCHANGERS ARE WIDELY USED IN THE PROCESS, CHEMICAL, REFINERY, AND NUCLEAR INDUSTRIES. ACCORDING TO THE LITERATURE AND PRACTICAL EXPERIENCES, MOST FAILURES OF HEAT

EXCHANGERS OCCUR AT THE TUBE-TO-TUBESHEET JOINTS [1]. THE CONNECTION OF THE TUBE TO TUBESHEET IS THE MOST CRITICAL ELEMENT OF A TUBULAR HEAT EXCHANGER BECAUSE ITS RELIABILITY DEPENDS ON THE INTEGRITY OF MANY PARALLEL TUBE-TO-TUBESHEET JOINTS. CONSEQUENTLY EACH JOINT MUST PROVIDE SUFFICIENT STRENGTH AND TIGHTNESS WHICH ARE DIRECTLY AFFECTED BY THE RESIDUAL CONTACT PRESSURE BETWEEN THE TUBE AND TUBESHEET HOLE. THERE ARE THREE MAIN TECHNIQUES USED FOR TUBE EXPANSION: ROLLING, EXPLOSIVE FORMING AND HYDRAULIC FORMING. COMPARED WITH OTHER TECHNIQUES, HYDRAULIC FORMING CAN BE MORE CONVENIENTLY OPERATED BY MEASURING AND CONTROLLING THE PRESSURE. IT IS THUS OF INTEREST TO PERFORM SOME RESEARCH WORK DEALING WITH THIS TECHNIQUE. NUMERICAL SIMULATION OF FRACTURE BEHAVIORS ON THE FRP-STRENGTHEND REINFORCED CONCRETE STRUCTURES

Ling Li[1], Tang Chun-an[2], Wang Shuhong[1,*], Tang Liexian[1], Tan Zhihong[1]

The technique of bonding Fiber Reinforced Polymer (FRP) composites to the tension face of Reinforced Concrete (RC) beams has become very popular for strengthening purposes. In this paper, RFPA (Realistic Failure Process

Analysis) is used to simulate the fracture behaviors and load carrying capacity of FRP-strengthened RC beams, which mainly focus on the effects of thickness of FRP on fracture behaviors of strengthened RC beams and the load carrying capacity. The simulation results agree well with the experiment observations. The simulation results indicate that RFPA method provide a new method and approach to simulate the failure process and mechanical behavior of reinforced concrete structure.

INTRODUCTION

Reinforcement concrete structures shall gradually deteriorate owing to excessive loading, environment attacks and poor initial design. The degradation or deterioration of structural members shall lead eventually to structural failure. In order to meet the same requirements demanded for structures built today and in the future, the rehabilitation of concrete structures is inevitable, strengthening and rehabilitation of these structures are considered to be more practical method than rebuild them(Garden H N[1]). Of all different types of concrete strengthening methods, the use of FRP materials for tension face strengthening techniques are considered to be the best of all, so it has been used extensively to repair and strengthen RC structures in many parts of the world during the past decade(Zheng Y. et al.[2] and M. Maalej. et al[3]).

FINITE ELEMENT ANALYSIS OF ELASTIC STRESSES FOR CYLINDRICAL SHELL CYLINDER-NOZZLE INTERSECTION UNDER COMBINED LOAD

Qinghui Tang*, Li Lei, Zhifu Sang

Finite element analysis of elastic stress for cylinder-nozzle intersection under internal pressure and in-plane nozzle moment was carried out. The distribution and superposition of elastic stress under combined load were compared with under separate loads. The result indicates that stresses induced by different load do not exist an absolute relation of linear superposition in cylinder-nozzle intersection area. The total stress value under combined load is not completely equal to the total value gotten by mathematically adding the two stress values under separate load. There are differences between the two total values, but the differences are so small, therefore, it will be true to suppose that stresses induced by different load are linearly superposed in cylinder-nozzle intersection area all the same.

INTRODUCTION

ylindrical pressure vessels with nozzle are widely used in petroleum and chemical industries. The stress distribution in the region of nozzle-cylinder intersection is complicated. So, to study this structure more systematically is very important. Early in 1955, Bijlaard[1] put forward a way to evaluate stresses from radial loads and external moments in cylindrical pressure vessels. Furthermore, a large number of studies have been carried out by many other scholars[2]-[5], which provide a lot of valuable results and useful data for designing these pressure vessels. But, most of them are performed under a separate load (internal pressure or nozzle moment), only a few works have done under a combined load[6]. Actually, lots of pressure vessels in use are loaded by both pressure and nozzle moment. Therefore, this paper presents a detail elastic stress distribution, stress superposition and interaction of different loads for the cylindrical shell intersection under combined load.

PRELIMINARY STUDY THE EFFECT OF CORROSION AND FATIGUE INTERACTION ON AIRCRAFT STRUCTURAL INTEGRITY

YU Da-zhao *, CHEN Yue-liang※, YANG Mao-sheng*

Based on initial discontinuity state (IDS) of material, this paper presents a preliminary analytical model which was developed to evaluate the effect of exfoliation corrosion on the residual fatigue life of upper wing skins. A life prediction was then carried out using constant amplitude compression dominated loading for various exfoliation corrosion levels by AFGROW, and the prediction agreed reasonably with the available test data. The result suggest that exfoliation can be treated as a process zone (pit + IDS) located initially at a surface, and then at the base of an evolving general stress concentration representing the loss of material in the exfoliation region. The major effect of the exfoliation corrosion on fatigue life is to cause a dramatic reduction in life with small corrosion depths, and most of the fatigue effect is associated with the introduction of small pits, rather than more general stress concentration associated with the bulk of the exfoliation attack. But the effect of pit on fatigue life is gradually reduced with increasing pit size. A pit with a constant depth can be applied to the model described in this paper for long exposure structure. A preliminary recommendation for the pit depth is about 0.3mm for LY12CZ.

INTRODUCTION

Like corrosion pitting and stress corrosion cracking, exfoliation is commonly found in aircraft structures, especially in the upper wing skins around fastener holes where it originates at the exposed end grains in the countersink and hole bore surface, which can growth beyond the fastener head, resulting in the characteristic ‘bulging’ on the exterior surface.

UNCERTAINTY BASED OPTIMIZATION OF COMPOSITE LAMINATE SUBJECT TO FREQUENCY CONSTRAINTS

Wu Hao*, Yan Ying*

This paper investigates the optimization of composite laminate subject to frequency constraints, while accounting for the uncertainties in material properties. The approach is based on the combined use of structural reliability analysis, composite mechanics and genetic algorithm. The Response Surface Method(RSM) is applied in the probabilistic reliability evaluation. In the uncertainty-based optimization of composite laminate, the mass of the laminate is maximized in terms of the ply number and fiber orientations, subject to frequency constraint. Numerical examples are conducted, the difference between the determined optimization and uncertainty-based optimization is clarified.

INTRODUCTION

Because of the advanced elastic properties and tailoring capability, optimal designs of composites with frequency constraints are useful in dynamic problems of structures, to avoid resonance for space vehicles[1], or to minimize the gap between the lowest bending and torsional frequencies of composite wings to improve the flutter characteristics of an aircraft[2]. However, most of the optimization of composite structures subject to frequencies were under the deterministic conditions. Research and experiments have shown large uncertainties in the mechanical properties of composite materials, as a result of the anisotropic property and the complexity in manufacturing process. Therefore, it is essential to apply probabilistic method such as reliability based optimization to quantify the uncertainties during the optimization process.

FUZZY RELIABILITY OPTIMIZATION OF KEY PARTS OF THERMAL CONTROL SHUTTER MECHANISM ON XX SECONDARY SATELLITE

Lai Yinan*, Cui Sihai*, You bindi*, Dai ye*

The method of Fuzzy reliability was used to the optimal design of thermal shutter key parts. NSGA- II method is brought forth to fully consider the fuzzy nature of the transition intermediary in order to achieve a better balance between the diversity and convergence. The optimization results are obvious, and the volume of corona of worm gear reduced 34.01% compared with the original design, and transmission efficiency increased 10.96%. The results of reliability optimization design have been verified by ANSYS/PDS tool. It has shown that the optimization variables are appropriate and the optimal results are correct.

INTRODUCTION

Thermal control shutter is used to adjust heat exchange of internal and external XX secondary satellite. This paper studies the reliability of worm driving mechanism on thermal control shutter to ensure the success of thermal control task. The process from Safety to Failure is not in sudden change, that is, there exists fuzziness of Failure occurred gradually in designed process [1-2]. Therefore, the reliability of a part is referred as the probability of the fuzzy event $\tilde{A}$.

THE DAMAGE EVOLVEMENT OF FLEXURAL BEHAVIOR OF RC BEAMS STRENGTHENED WITH CARBON FIBER LAMINATE

HAN QIANG[*, 1], HUANG PEIYAN[*, 2]

Fiber reinforced polymer (FRP) materials are used widely in the rehabilitation and reinforcement of civil engineering structures due to their high specific strength and corrosion resistance. To probe the fatigue behavior of FRP strengthened concrete structures, three point bending experiments of carbon fiber laminate (CFL) strengthened RC beams are performed under cyclic load. The fatigue lives, the histories of mid-span deflection and strain in steel bars

are obtained. The concept of coefficient of stiffness is defined to describe the evolvement of structure's rigidity. The process shows three stages of primary quick damage, steady linear fatigue damage and unstable damage to failure at last. According to the Miner cumulative damage theory, a three-stage linear cumulative damage model is proposed to describe the damage and fracture process of strengthened beams. Based on the model, the evolvement of fatigue damage is further simulated to predict the fatigue life of RC beams strengthened with CFL.

INTRODUTION

Fiber reinforced polymer (FRP) composites have been successfully used in new construction and repair and rehabilitation of existing concrete structures. Compared to traditional materials, FRP materials are superior in the areas of resistance to electrochemical corrosion, strength to weight ratio, fatigue resistance, and their versatility of use. Many tests have been conducted investigating the static performance of FRP strengthened structures, relative little is known of the fatigue performance of FRP strengthened members. Meier et al. (1993), Heffernan (1997), Barnes and Mays (1999), Shahawy and Beitelman (1999), Papakonstantinou et al. (2001), Aidoo et al. (2004), Tserpes et al. (2004), Mahmut et al. (2006), above researches have investigated the fatigue behavior of RC beam strengthened with FRP, However, the number of specimens and fatigue load condition is limited in these tests, so these test dates are difficult adopted in engineering actually.

KEY TECHNICAL ISSUES IN SERVICE SAFETY ASSESSMENT FOR ENGINEERING MATERIALS

Dongbai Sun*

Three key technical issues were put forward on the study of engineering materials basing on the entire review on the gap between conventional scientific researches and the real engineering practice in scale, circumstance and time dimensions. National Center for Materials Service Safety, China is in process of design with its aim as providing solutions for these three key technical issues and an open platform for the study on scale dependence, coupling effect of complex environmental factors and equivalent acceleration of materials damage process. Besides of the experimental instruments, a simulation system and a dynamic database and expert system for engineering materials will be established as well.

BACKGROUND

With the rapid progress of China's economy, expending amount of super engineering programs such as Sanxia (Three Gorge) dam project, Qingzang (Qinghai-Tibet) railway project, the construction of Beijing National Stadium etc., have been designed and constructed all over the country. The engineering materials used in these projects possess high performance and in extremely large scale. But, the service circumstance turns to be more complicated and adverse. For instance, the pavement in west area of China are exposed to strong ultraviolet rays, while the pavement serving in northern China is expected to resist low temperature below -40℃ and the influence of freeze-thaw cycle.

STRUCTURAL INTEGRITY ANALYSIS OF POWER PLANT WELDS SUBJECTED TO HIGH TEMPERATURE CREEP

T. H. Hyde[*], W. Sun[*†], A. H. Yaghi[*]

Welds are metallurgically complex, with heterogeneous structures within the weld metal and heat-affected zones. In order to carry out a structural integrity assessment, it is important to have knowledge of the initial metallurgical features and the associated material property variations so that it is possible to accurately model all of the possible failure modes of welds using, for example, numerical techniques. This paper describes some fundamental issues concerning a holistic process for high temperature performance and failure prediction assessment of power plant welds. This includes welding process simulation and residual stress determination, microstructural evolution and the formulation of creep damage mechanics constitutive equations including weld metal anisotropy. Typical examples, for P91 welds, are used to illustrate the application.

INTRODUCTION

Fusion welding in power plant components, such as steel steam pipes induces residual stresses due to heating and cooling cycles as well as heterogeneous microstructure in the weld region causing weld metal bulk anisotropy. The recrystallised weld microstructure is either "equiaxed" or columnar, with varying grain sizes, depending on factors such as weld procedure [e.g. 1]. The nature of the low ductility columnar regions and the relatively ductile coarse and fine grained equiaxed regions, including their boundaries, influence failure modes. The modified 9Cr1Mo (P91) steels have been developed for the creep resistant properties in service under high temperature conditions. Creep damage can lead to intergranular or transgranular cracks which are sensitive to post weld heat treatment and tri-axial

stress states. Using continuum damage mechanics in the finite element (FE) analyses allows for the full creep regimes, including tertiary creep, to be included, in predicting the failure lives of welded components [e.g. 2,3]. In this paper, FE weld modelling and failure prediction methods are briefly described, covering a number of topics such as welding simulation and residual stresses, creep damage mechanics constitutive equations and failure modelling of welds, with reference to typical P91 welds.

EXPERIMENTAL STUDY ON SIMPLIFIED COMPUTATION MODEL OF OBLIQUE SECTION OF MULTI-RIBBED COMPOSITE WALL

ZHANG Jie* YAO Qianfeng XIA Lei ZHANG Hao

The multi-ribbed composite wall structure (MRCWS) is a new seismic structural style. Multi-ribbed composite wall is the main structural member of the MRCWS. On the basis of seismic tests of eight 1/2-scaled models, the paper analyzes seismic performance of multi-ribbed composite wall and composition of shearing resistance. The results of experimental study indicate that the multi-ribbed composite wall has high seismic performance and the shearing resistance capacity is supplied by reinforced concrete of lattice, filled blocks and the interacting combination of them. This paper presents simplified computation model of reinforced concrete lattice as concrete frame and proposes that filled blocks works as a 45° compression bar of equivalent elastic state. The interacting combination is reflected by a coefficient on the basis of the experimental results. At last, a simplified computation model for multi-ribbed composite wall is given.

INTRODUCTION

Adapting to the national policies of wall reform, energy-saving building and industrialization, Multi-ribbed composite wall structure (MRCWS) was developed by Xi'an University of Architecture & Technology in 1990. During the last more than ten years, some achievements have been gained. However, as the main bearing component in MRCWS, the structural performance of multi-ribbed composite wall is related to the division of lattice, the section measure of ribbed column and ribbed beam, the ratio of axial compressive force to axial compressive ultimate capacity, the ratio of shear span to effective dept and the performance of filled material etc. In order to make sure the capacity of oblique section of composite wall reasonably, eight 1/2-scale specimens were experimented on the bearing mechanism, the composition

of shearing resistance capacity and the oblique-compression-bar effect of filled blocks. At last, a simplified computation model of multi-ribbed composite wall is given which can be used in ultimate state.

ASSESSMENT OF THE INFLUENCE OF ANISOTROPY AND INHOMOGENEITY ON THE STABILITY OF UNDERGROUND OPENING USING A MICROMECHANICS MODEL

Shuhong Wang[1,*], Tianhong Yang[1] , Fei Li[1], Chun-an Tang[1, 2]

This paper presents a study of the quantification of the degree to assess the influence of anisotropy and inhomogenetiy on the stability of underground opening using a micromechanics model. The approach builds on the finding that a realistic failure corresponding to a micro seismic event can be established by applying a tensile cracking model and the traditional shear model. In our model, the inhomogeneous characteristics of rock at the microscopic level are included by assuming that the material properties of the constituent elements conform to a Weibull distribution; the anisotropy is incorporated as a transversely isotropic medium; the non-elastic characteristic is simulated via an elastic damage-based constitutive law. A finite element program is employed as the basic stress analysis tool. Finally, the influence of rock anisotropy and excavation shape is modeled using the Realistic Failure Analysis code; the whole fracturing process of initiation, propagation and coalescence of fractures around excavations under a variety of loading conditions are simulated. It is found that this micromechanics model may used as a useful tool to improve the understanding of realistic rock failure process.

INTRODUCTION

In general, underground excavation cause crack initiation and propagation, and Excavation Disturbed/Damaged Zone (EDZ). EDZ will be formed around the cavern. Now in several underground projects, to monitor and control the EDZ is the one of the most important technology for the design. As we know, the theory of classical fracture mechanics was developed to resolve the initiation and propagation of cracks, but it encounters many problems in explaining the coalescence and interaction of cracks in a **D**iscontinuous, **I**nhomogeneous, **A**nisotropic, **N**on-**E**lastic (DIANE) medium. It is useful to consider the inhomogeneity and anisotropy on the mesoscale to investigate the macro mechanics behavior of the whole rock by studying the rock components individually including stronger grains, weaknesses and cavities at the mesoscale. Based on the former works (Hudson, 1997; Tang, et ac 2003; Wang, 2004; Zhu, 2004; Cai, 2005), the numerical code RFPA (Realistic Failure Process Analysis) is used to simulate the progressive failure of inhomogeneous and anisotropic rock specimens composed of two different rock materials with the same dip angles between the rock layer orientation and the loading direction in this investigation.

DEVELOPMENT OF A TEST AND FAILURE ANALYSIS METHODOLOGY FOR ELASTOMERIC SEALS EXPOSED TO RAPID GAS DECOMPRESION IN OILFIELD APPLICATIONS

Z. Major[1,2], K. Lederer[1], T. Schwarz[3] and R.W. Lang[1,2]

While in oilfield engineering applications elastomeric materials are widely used as seals, membranes and flexible hoses in high pressure aggressive gas environments, the rapid gas decompression (RGD) failure is frequently observed. A phenomenon termed rapid gas decompression failure occurs if elastomer components exposed to high gas pressure fail upon the sudden release of the gas pressure in an unstable manner. As the forecasting of every unanticipated process is difficult, and the rapid gas decompression failure is inherently fortuitous, it is of an extraordinary theoretical and practical importance to characterize the potential influence factors on the RGD failure behavior of various elastomers. Hence, experiments were performed on both component level under near service loading conditions and on laboratory test specimen level using various fracture specimen configurations for two model elastomers. The results are summarized as the kinetics of the loading and the material response. Special emphasis was devoted to the observation and the adequate characterization of the crack initiation and crack growth process by fracture mechanics parameters.

INTRODUCTION AND OBJECTIVES

A phenomenon termed rapid gas decompression (RGD) damage occurs if elastomer seals exposed to high gas pressure fail upon the sudden release of the gas pressure in a brittle manner. The rapid gas decompression failure of elastomer seals is an important issue for the oil exploration industry and recently the objective of an intensive theoretical and practical research [1, 2].

As to the characterization of the rapid gas decompression failure behaviour of pressurized elastomer seals, the paper deals with (i) the instrumented autoclave tests of pressurized O-rings and (ii) the crack initiation and crack growth at high deformation rates and under various constraint conditions. The main objectives of this paper are (i) the characterization of the failure process in elastomers by novel non-contact experimental techniques and (ii) the determination of relevant fracture parameters.

THE SIZE EFFECT ON THE CONCENTRATION OF STRESS AND STRAIN IN FINITE THICKNESS ELASTIC PLATE CONTAINING A CIRCULAR HOLE

Zheng Yang[a,*] , Chang-Boo Kim[a], Chongdu Cho[a], Hyeon Gyu Beom[a], Seung Gwan Song[a]

he elastic stress and strain fields of different size plate with a hole subjected to tension are investigated using 3D finite element method. It is found that the stress and strain concentration factor of the finite thickness plate are different even if the plate is in elasticity state. The maximum stress and strain concentration factors do not always occur on the mid plane of the plate. The maximum stress in a finite thickness plate is higher than the one in the plane stress or plane strain states. The differences between maximum and surface value of stress concentration factor increase with thickness and this difference of stress concentration factor is larger than the one of strain concentration factor in the same plate.

INTRODUCTION

Knowledge of the three-dimensional stress concentration factor is a prerequisite for an accurate design of structural components. Exhaustive stress concentration factor figures and tables have been published by Pilkey[1] and Young[2]. However, many of these readily available sources of stress concentration factors consider only a two-dimensional theory of elasticity solution. Bellett et al. [3] showed experimentally that the common 2D methods for fatigue assessments of isotropic-notched bodies might lead to conservative predictions when applied to three-dimensional geometries. It has been confirmed that the stress concentration factor in the interior of the linear elastic isotropic plate with a hole or notch is significantly higher than that on the surface or the corresponding planar solutions [4]. In this paper, the coupled influence of plate width and thickness upon the stress concentration factor, the strain concentration factor and the stress distributions of plate containing a hole subjected to tension are investigated using the finite element method.

MODELING OF CRACK GROWTH ON 16MNR STEEL NOTCHED COMPACT TENSION SPECIMEN

TU Wenfeng[1,2], GAO Zengliang[1,] , and WANG Xiaogui[1]

Fatigue crack growth was modeled for 16MnR steel notched compact tension specimen on the condition of Mode I cyclic loading with different stress ratios. The crack growth rate is determined by material damage during crack initiation at the notch and crack propagation. In the paper, a new cyclic plasticity model was introduced to describe cyclic stress-strain response near the notch properly, and the stress-strain field around the notch was calculated. Crack growth behavior in notch plastic zone was predicted by using a new multi-axial fatigue criterion to evaluate the fatigue initiation damage and growth damage near the notch. The modeling results are agreed with experimental data. The results show that when stress ratio is 0.1, crack growth rate near the notch accelerates monotonically with the increase of crack length. When stress ratio is equal to -1, crack growth rate near the notch decreases initially and then increases with the increase of crack length.

INTRODUCTION

16MnR steel is a kind of typical material widely used for pressure vessels in China. Lots of fatigue crack growth experiments have been made to investigate the basic mechanical properties and fatigue or fracture properties [1-3]. Few experiments and modeling work have been conducted to study notch crack growth behavior for 16MnR steel. Since Elber's work, crack closure concept has often been used to explain notch crack growth [4-5]. However, unfortunately most of present studies are unable to predict notch crack growth behavior explicitly. In the paper, a new approach based on fatigue damage has been used. Modeling of notch crack growth was carried out on the condition of constant amplitude loading. The finite element (FE) method is used to acquire the stress-strain response near the notch with the implementation of a robust cyclic plasticity theory. A new multi-axial fatigue criterion is used to evaluate fatigue damage based on the stress-strain response.

DAMAGE VALUATION OF PRESTRESS-INCLUDED CONVEYING-FLUID VEHICLE'S PIPE UNDER RANDOM-SHOCK LOADS*

Qiang GUO[1,2] Mei ZHAO[1]

In this present paper, damage analysis of the vehicle's conveying-fluid prestress-included pipe induced by complex random shock loads is considered. The outline of this paper is that, firstly, under some reasonable assumption and simpleness, the conveying-fluid prestress-included pipe in vehicle can be studied by a finite straight pipe; then, dynamic analysis is considered by the water hammer effect of fluid and external random-shock load in vehicle pipe, furthermore, Damage analysis of complex random-shock loads that come from vehicle vibration will be obtained in theory; which can be used in industry application.

INTRODUCTION

Many experts [1-4] had studied pipe system from different profiles such as dynamic & reliability analysis, stability of pipe system, linear & non-linear vibration analysis, influence by different supports of pipe system, random shock loads, acoustic analysis of pipe system and so on. While, S.Finnveden [3] created a special finite element analysis method to calculate vibration of straight pipes with flanges. From the above discussion, the reliability of vehicle's conveying-fluid prestress-included pipe, which is an important problem both in reliability theory and in vehicle application, is seldom considered. These conveying-fluid pipe systems in vehicle are always under prestress condition, together with complex condition where there might have some random vibration loads, random shock loads, high thermal stress or other static/transient conditions. So these problems should be studied in detail.

ENVIRONMENTAL FAILURE AND PREVENTION OF MATERIALS

En-Hou Han*, Jianqiu Wang and Wei Ke

The paper reviewed the environmental degradation of mechanical properties of various materials, i.e., magnesium alloy AZ91D, low alloy steel A537 and aluminum alloy LY12CZ. The relative humidity and corrosive environment have much influence on the mechanical properties, including yield strength,

ultimate strength, elongation, fatigue strength, plastic zone in the vicinity of crack tip etc. The loading procedures for corrosion and fatigue also have strong effect on the final fatigue lifetime. Therefore, for mechanical design and failure analysis, the environment conditions should be considered. To separate the material and environment by using coatings, to obtain compact surface film by modifying the surface properties, or to develop the corrosion resistant materials to against environmental failure are very important to improve the lifetime and reliability of engineering structures and components. The possible consideration against environmental damage and materials degradation control methods were proposed.

INTRODUCTION

When people mention the mechanical properties of materials, the properties always mean those obtained in air. However, most materials are used in various environments, such as humid air, solutions, high temperature or low temperature, etc. For example, when relative humidity is higher than 60%, the water film will form on the surface. In this case, the mechanical properties become the properties in water in fact. For the polymer materials, it is known that the humidity has strong influence on the mechanical properties. However, for metallurgical materials, the water, water film or corrosive environment may have much influence on the mechanical properties. In this paper, the materials' properties under different environments were tested, and the humidity and corrosive environment effects were clarified. The possible consideration against environmental damage and materials degradation control methods were proposed.

A STUDY ON FATIGUE AND DAMAGE MECHANICS OF PISTON

Wang Yanxia*, Shi Haiyan, Liu Yongqi

The 1/2 rational 3-dimensional solid model of a piston is introduced to the powerful FEA software ANSYS 8.1 to analyze the thermal and mechanical coupling stress field of the piston. A special method is used to plot girding to a local model and the stress intensity factors (SIF values) of the crack original position of the piston pin seat are calculated. The results show that thermal loads have little effects on stress intensity factors, whereas mechanical loads are the dominant factors. This work can afford a theoretical foundation for the fatigue and reliability analyses of pistons.

INTRORDUCTION

Piston is one of the most important components in engines; it withstands the extremely alternating thermal and mechanical loads simultaneously in the working process. With the enhancement of the power of the engine, piston is requested to have the better thermal stress resistant and anti-mechanic fatigue and damage performances. To date, lots of theoretic and experimental investigations on the piston's fatigue and damage have been conducted by means of the local stress-strain methods [1，2]. However, little attention is paid to systematical discussions on the stress-strength coefficient of the fatigue and damage crack original position. Based on the mechanical fatigue and damage experiments, this study aims to analyze a piston's fatigue and damage using the theory of rupture.

STUDY ON VIBRATION RESPONSE OF AIR COOLED CONDENSER PLATFORM UNDER THE EXCITATION OF LARGE-DIAMETER FANS IN THERMAL POWER PLANTS

ZHU Lihua*, BAI Guoliang, DOU Panqiao

A 1/8 scale air cooled condenser platform model is constructed and tested to study the vibration response under the excitation of large-diameter fans. The structural dynamic properties, the amplitude-frequency curve under different rotation speed and work state of fans, and the dynamic strain of structural members are measured in the experiment. A harmonic response analysis is done with ANSYS®, and the calculation results show agreement with the test results. Some design advice is presented based on the experiment results and FEM analysis.

INTRODUCTION

The exhaust steam is customarily cooled by hyperbolic cooling tower in thermal power plants. But this type of cooling technology always results in the waste of water. In order to save water resource, air cooled technology is widely applied in many thermal power plants. For air-cooled technology, the hot exhaust steam in a closed system is cooled by the flowing air forced by many large-diameter fans.

STUDY ON RISK ASSESSMENT OF BURIED GAS PIPELINE IN CITY

ZHANG Zheng* ZUO Shangzhi** SUN Yongqing* ZHONG Qunpeng*

Risk assessment is an effective method to improve the resource utility. The buried gas pipeline is a key factor to ensure the supply of industrial energy sources and resident life. Therefore, it would be a great benefit to assess the risks of buried gas pipeline. On the basis of investigation, the fault tree of buried gas pipeline in city is established. The evaluation system of failure probability is put forward with the analysis of fuzzy mathematics. Comparing with the different national standards and codes, the evaluation system of consequence, including personal injury, property damage and invisible loss, is demonstrated. The evaluation system of failure probability and consequence is applied and verified in several gas pipes in different cities. Finally, the modified models for different environments and operation conditions are established.

INTRODUCTION

The city gas pipeline is an important part of the city energy supply. It is widely used in transportation of the gaseous fuel to the factories, businesses and residents in city. Along with the development of economy, the pipeline net extends continuously. A city is a region with many people and dense buildings, the accident of city gas pipeline, such as leakage or explosion, will result in severely casualty and huge properties damage. In fact, several explosions of buried transmission pipeline in some cities have already taken place in recent years. The old management technique for the city gas transmission pipeline is not suitable for the huge potential threat to the safety of residents' life and property in city.

BURST PRESSURES OF CROSS SCORED REVERSE BUCKLING RUPTURE DISCS

GAO Guang-fan*, DING Xin-wei†

The non-linear buckling behavior of cross scored reverse type rupture discs, subjected to pressure on convex, is investigated with the finite element method. The tracing of nonlinear paths in the load-displacement response for the buckling and post buckling of reverse rupture discs uses the arc-length orthogonality method. The geometric imperfection is considered as a linear

combination of the first buckling mode by using the method of wave-distributed imperfection. At first, the influence of negative-curvature zone on the buckling behavior of structure is studied. It is found that initial buckling occurs at the zone near the pole when the ratio of hold-down radius to orifice diameter r_u/d is from 1.43×10^{-3} to 9.05×10^{-3}. The influence is negligible in respect that the buckling pressure is nearly fixed. When r_u/d is greater than 9.05×10^{-3}, initial buckling occurs at negative-curvature zone near the periphery. At this time, the buckling pressure decreases as the increase of r_u/d. Then, the correlations between buckling pressure and similarity criterions such as thickness to diameter ratio, dimensionless pre-deflection are explored. Finally, the influence of normalized notch depths s_c/s_0 (s_c is remaining thickness in grooves) on the buckling pressure of rupture discs is studied. It is found that there is a linear relationship between the buckling pressure and s_c/s_0.

INTRODUCTION

Many safety pressure relief devices of the rupture disc type have been developed and used to protect equipments from overpressure or to meet some particular needs in technical processes as quick opening devices. Rupture disc units may be of “normal” or “reverse” type (Brazier [1]). For rupture discs of the reverse buckling type, the fluid pressure is exerted on the convex side of the dome portion of the disc and upon failure the dome portion reverses and then ruptures. Originally, a set of knife blades is disposed below the concave surface of the disc with their cutting edges facing the interior of the dome. Recently, several scores or grooves are notched on a surface of the concave or convex portion thereof creating lines of weakness, so that upon reversal of the disc the dome tears along the scores and opens without fragmentation.

RELATION BETWEEN ENERGY RELEASE RATE AND STRESS INTENSITY FACTOR FOR MODE I CRACK UNDER TRIAXIAL STRESS STATE

Yuting He*, Feng Li, Ronghong Cui, Hongpeng Li, Chaohua Fan

Relation between energy release rate and stress intensity factor for mode I crack under triaxial stress state is analyzed in detail. Firstly the crack-tip fields for mode I crack under axial tension in a three-dimensional (3D) isotropic continuum are derived by aid of the equilibrium and compatibility equations. Then the relation between energy release rate and stress intensity factor for mode I crack under triaxial stress state is obtained in explicit form by recourse to the analytic expressions of the afore-mentioned crack-tip fields. The present

solutions for plane stress and plane strain states coincide very well with the classic elasticity solutions for plane stress and plane strain states respectively. Also the present work can be applied to theoretically calculating the fracture toughness of ductile metals, and the evaluated fracture toughness values have a good agreement with the tested values.

INTRODUCTION

Three-dimensional (3D) effects are of great importance in engineering applications of fracture mechanics[1]. The weaker singularity of stress at the 3D crack border in linear elastic material is shown to be confined to an infinite small zone at the intersection point of the crack front line and the free surface of the cracked body. Therefore the *K*-based linear elastic fracture mechanics theory can be extended to 3D cracked bodies[2]. Also the 3D problems can be simplified to a quasi-planar problem with the triaxial stress constraint T_Z being taken into account, which makes it possible to solve the problem analytically[3]. In this paper, Relation between energy release rate and stress intensity factor for mode I crack under triaxial stress state is analyzed by virtue of triaxial stress constraint T_Z and analyses of stress-strain fields at crack tip.

ANALYSIS FOR FRACTURE TOUGHNESS OF 2205 DUPLEX STAINLESS STEEL PIPE

LI Wei-wei

Being a relatively new type of material to most people, 2205 duplex stainless steel (DSS) posses favorable mechanical property and good corrosion resistance at the same time, and applied wildly in transport, oil and natural gas, ocean and chemistry industry, etc. One natural gas headstream project maximum operation pressure is 13.3MPa and minimum operation temperature is at -30℃, and so put forward very high toughness requirements for the pipe. The Charpy-V Notch Impact Toughness(CVN) test, Drop-weight Tear Test(DWTT) and Crack-tip Opening Displacement（CTOD）test of 2205 duplex stainless steel pipe used for the high pressure nature gas transmission has been done, the fracture toughness has been investigated. The results show that this pipe material has very high Charpy impact absorbed energy, very low ductility to brittleness translation temperature (FATT) and very high CTOD value, that is said this pipe material has good fracture toughness and good safety performance for high pressure natural gas pipeline.

INTRODUCTION

Duplex stainless steels also referred to as ferritic-austenitic steels, combine many of the beneficial properties of ferrite and austenitic steel. Being a relatively new type of material to most people, 2205 duplex stainless steel (DSS) is one of modern duplex steel. 2205DSS posses favorable mechanical property and good corrosion resistance at the same time, and applied wildly in transport, oil and natural gas, ocean and chemistry industry etc［1-2］.

MECHANICS CHARACTERISTICS AND FAILURE CRITERIA OF CONCRETE UNDER TRIAXIAL COMPRESSION AFTER FREEZE-THAW CYCLING

Likun Qin[1,a], Yujie Wang [2] Jiawei Yao[1]

Most buildings at cold (northern) region such as concrete structures and dams are badly effected by freeze-thaw cycling. According to the fact, 0, 25, 50 and 75 cycles of freeze-thaw cycling are made to normal concrete, and triaxial compressive experiments on strength and deformation of normal concrete using the large static-dynamic triaxial test system for concrete in the State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology. Design stress radios are 0.1：0.25：1、0.1：0.5：1、0.1：0.75：1和0.1：1：1. The strength and deformation of concrete is measured through normal and real triaxial test respectively, the effect of freeze-thaw cycling and stress ratios on concrete strength and deformation under normal and real triaxial states is analyzed based on experimental results. Study on the experiment indicates that the triaxial compressive strength of concrete is decreased with the increasing of freeze-thaw cycles, and the compressive strength is greater than uniaxial compressive strength because of the effect of stress ratio when concrete endured the same cycles of freeze-thaw cycling. Failure criteria of concrete under triaxial compressive stress after freeze-thaw cycles are established in Octahedral stress space. The study result provides structural assign and analysis foundation for structures at cold (northern) region such as dams、concrete bridges and ect., which work in triaxial compressive stress condition. This study is the first step in the field of mechanical characteristic of concrete under triaxial stress after freeze-thaw cycling.

INTRODUCTION

Structures at cold region, such as roads, bridges, marine concrete structures, industrial and civil structures are often subjected to the action of freeze-thaw cycles. The cycle of freezing and thawing will influence the concrete's property badly. So it is necessary to analyze the mechanics properties of the structure under complex stress state after subjected freeze-thaw cycles. So far, the research references about the mechanics properties of concrete structure subjected to freeze-thaw cycles are rare, and most of them are about the concrete structure in uniaxial stress state. Triaxial test consists normal and real triaxial test. In this paper, the concrete strength and deformation property under normal and real triaxial compressive state influenced by two factors of stress ratio and freeze-thaw cycles are analyzed. On the basis of the tests, the failure criterion of concrete subjected to triaxial compressive stress after suffering freeze-thaw cycles is established in the Octahedral stress space .

STUDY ON TENSILE STRENGTH OF SHORT-FIBER-REINFORCED ELASTOMER MATRIX COMPOSITES

ZHU Dasheng*, GU Boqin**, CHEN Ye

The tensile strength of short-fiber-reinforced elastomer matrix composites (SFREs) was studied. A new model for predicting the tensile strength of SFREs was put forward based on the mixture law. The influences of the volume content and mechanical performances of main components, short fiber critical aspect ratio, short fiber length and orientation distributions on the tensile strength of composites were investigated. The tensile strengths predicted by the model in this paper are in good agreement with experimental data. Furthermore, the mechanism of tensile fracture of SFRE was discussed. It is found that the tensile fracture of the composites depends largely on the bonding strength of fiber-matrix interface and the length of reinforcing short fibers.

INTRODUCTION

Short-fiber-reinforced elastomer matrix composite (SFRE) is one kind of common-used sealing material, and its tensile strength is one of important technical indexes for evaluating combination property of sealing composites. The tensile strength of SFREs depends largely on the volume content and mechanical performances of the main components and microstructural parameters, such as short fiber critical aspect ratio, fiber length and orientation distributions. Many researches

were carried out on short-fiber-reinforced metal and polymer matrix composites (Arbelaiz [1], Shao [2], Huang [3], Shanju [4]). However, the work in elastomer matrix composites was rarely reported. In this paper, a new mixture law was put forward, the tensile strength of SFREs was predicted, and the influences of the mechanical performances of the main components and microstructural parameters on the tensile strength of composites were also investigated. Furthermore, the mechanism of tensile fracture of SFREs was discussed.

The Experimental Study for Fatigue Behavior of Weld Line by Third TIG-Dressing

LI DongXia[1], LI Shen[2], FENG PengCheng[3], JIA BaoChun[4]

In this paper, the third TIG-dressing technology is used for the weld-line after secondary TIG-dressing and its fatigue life is higher in high stress region. But the fatigue life after third TIG-dressing is decreased in low stress region. The effects of third repairing weld and TIG-dressing on the fatigue property of high strength steel weld joints used in platform have been investigated. The life estimating formula is obtained after third repairing weld and TIG-dressing. The S-N curve and the equation after third TIG-dressing are given.

INTRODUCTION

The ocean platform is very important structures for ocean oil industry. Welding techniques are adopted in the platform design and manufacture. The legs of platform undergo a tremendous themselves weight and various environmental loads. Due to the alternate loads, fatigue cracks inevitably appeared in its welded parts during service period. Some cracks are over one meter long. Therefore the platforms of the cracks emerged in legs have to stop operating and is carried to repair welding and TIG-dressing in dockyard so that the platform is used safely. The TIG-dressing has an optical effect on the formal purpose. It is specially noticed for its simple technology, convenient use methods, obvious more effects and also low price. As a result, it is pressed for that third repairing weld and TIG-dressing and improving fatigue strength of weld line.

STUDY OF MATERIALS CORROSION RESISTANCE CHARACTERISTIC DURING ACETATE PRODUCTION

LIU Wen-bin *,WANG Jun, QIU Qi-hao, LI Wen-zhong, MA Xin-peng

The corrosion resistance behavior of 304, 316L stainless steel and Nicrofer Ni-Cr-Mo alloys was investigated in the simulation media of butyl acetate production. The results showed that 316L, alloy-31 and alloy-59 worked well under low-temperature process (< 95 ºC), and had no obviously corrosive evidence, whereas the corrosion rate accelerated dramatically at high-temperature (> 105 ºC), especially in the media of H_2SO_4-HAc, and the metal surfaces appeared black except alloy-59. The corrosion rate of 316L, alloy-31 and alloy-59 was 1.162, 0.1471, 0.0512 mm/a, respectively, in the the media consists of 1.0%wt. H_2SO_4, 60% HAc, 30% butyl acetate and 10% H_2O at 105 ºC for 12 h. SEM analysis showed that 304, 316L was etched with obvious localized corrosion sites in the form of pits. Alloy 31 exhibited much slighter localized corrosion sites than 304, 316L, and alloy 59 was observed with almost no localized corrosion sites. This indicates that the localized corrosion resisitance of alloy-59 is superior to other alloys, and is a potential candidate to be applied to heat exchanger and other equipments during acetate production.

INTRODUCTION

Acetate, such as ethyl acetate or butyl acetate, is an important raw material for many applications in chemical industry including coatings, adhesives, varnishes, ink and perfumes (Wu and Chen [1]). Mineral acids such as sulfuric acid, and organic acids such as p-toluenesulphonic acid (PSTA), are examples for the homogeneous acid catalyst in the production of acetate. These catalysts are of high catalytic activity, but were shown to induce severe corrosion to the process equipments made by 304 or 316L stainless steel in the industrial scale process, and results in increased maintenance costs and downtime (Qi and Lester[2] and Turnbull [3]). Hence, it is highly desirable to find an alternative alloy with improved corrosive resistance to substitute the classical 304, 316L stainless steels.

EFFECT OF HEAT TREATMENT ON THE SUSCEPTIBILITY OF ENVIRONMENTAL CRACKING FOR SPV50Q STEEL WELDMENT

Jian-Qun Tang, Jian-Ming Gong*, Jie Tang, Yong Jiang

SPV50Q steel is often used to fabricate spherical tanks for holding liquefied petroleum gas (LPG) and those tanks are designed to free post weld heat treatment (PWHT) for avoiding the possible reduction in strength. However, the welded parts, especially the heat-affected zone, are found to be susceptible to sulfide stress corrosion cracking (SSCC) in LPG environment contaminated accidentally by wet H_2S. The failure analysis showed, besides the presence of wet H_2S, the existence of welding residual stress in weldment plays a major role in the occurrence of SSCC. Therefore, in order to explore the effect of PWHT on SSCC susceptibility of SPV50Q steel weldment, some experiments were performed for the cross-welded specimens which are heat treated at 590 ℃ for one or multiple times. The susceptibility to environmental cracking were evaluated by slow strain rate testing (SSRT) in H_2S-containing solution. The feature of fracture and the morphologies of cracks were observed by scanning electrode microscope and optical microscope. The results indicate that the susceptibility of environmental cracking for the specimens with heat treatment is decreased as compared with specimens without heat treatment, which can provides technology support for the remanufacturing of the LPG spherical tanks having suffered from SSCC.

INTRODUCTION

As one of high strength low alloy steels, SPV50Q steel is often used to fabricate spherical tanks for holding liquefied petroleum gas (LPG) for its excellent resistance to corrosion and mechanical properties. However, during the service process, H2S content in LPG held in tanks may surpass the allowance due to insufficient desulphurization or H2S run off accidentally from refining units into store system, which will lead to the formation of wet H2S environment. In such environment, the welded parts, especially the heat-affected zone (HAZ), are found to be susceptible to sulfide stress corrosion cracking (SSCC) (Tsai [1] and Tang [2]). The failure analysis showed, besides the presence of wet H2S in LPG, the existence of welding residual stress in weldment plays a major role in the occurrence of SSCC. However, for LPG tanks fabricated with SPV50Q steel, they were designed to free post weld heat treatment (PWHT) for avoiding the possible reduction in strength before it put into service. Then, welding residual stress will be inevitably present in the welded parts, which has been testified by using Barkhausen noise technique or X-ray method [2].

FATIGUE CRACK GROWTH CHARACTERISTICS OF 4130X STEEL IN DIFFERENT H_2S ENVIRONMENTS

ZHANG Yiliang*, MIAO Wei, WANG Jing

The fatigue crack growth rate of 4130X steel used in compressed natural gas vessel in H_2S environment was investigated in this paper. Considering working environment and stress status of the vessel, modified WOL specimens were used in experiments, the frequency of experiments was 0.0067Hz, and the environments of experiments were saturated H_2S environment, moderate concentration and laboratory air. The relations between FCGR-da/dN and the increment of fracture toughness ΔK were determined through data fit based on Paris method. A correlation study between the microscopic features of the crack growth's three stages and the tendency of stress intensity factor (K) to the test samples has been carried out. Then the quantitative results of K of the three stages in different environments were concluded. The results show that: the da/dN in H_2S environment is 20 times more than that in air environment; but the value of da/dN doesn't increase when the H_2S density reaches to a certain limit, the H_2S corrosion medium accelerates the fatigue failure.

INTRODUCTION

In the safety evaluation and life-time estimation of compressed natural gas (CNG) vessels which bear flaws, there are two factors that could determine the allowable crack sizes of different service period: 1) the critical crack sizes determined by K1SCC experiment; 2) the fatigue crack increments within a service period determined by the fatigue crack growth rate (FCGR). And the difference value of critical crack size and crack increment is the allowable crack size of the service period.

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MULTIAXIAL RATCHETING-FATIGUE INTERACTION OF SS304 STAINLESS STEEL

Yujie Liu*, Guozheng Kang*☆, Qing Gao*

The ratcheting behavior and fatigue failure of SS304 stainless steel were investigated by multiaxial cyclic stressing tests with two kinds of loading paths. The multiaxial ratcheting deformation and low cycle fatigue (LCF) properties, as well as their interaction were discussed. It is shown that progressive multiaxial ratcheting deformation can induce the decrease of fatigue life for SS304 stainless steel, and the ratcheting behavior and fatigue life of the material are depended on mean stress, stress amplitude and the shape of loading path.

INTRODUCTION

The ratcheting-fatigue interaction has been investigated for a low carbon steel En3, low alloy steel En19 [1], ASTM A-516Gr.70 [2], SS304 stainless steel [3], and 42CrMo steel [4] by some researchers respectively and some useful conclusions have been obtained. It is shown that the ratcheting deformation significantly influences the fatigue life in cyclic stressing, and it is proved that the modified failure model can

provide more accurate predictions, which account for the effect of ratcheting. However, most of known literatures focus on the cases in uniaxial cyclic loading. The study of ratcheting-fatigue interaction in multiaxial cyclic stressing is still insufficient. Thus, it is necessary to carry out LCF experiments under multiaxial stress-controlled loading, and to examine the ratcheting-fatigue interaction of engineering materials in such complex conditions.

In this work, a series of symmetrical and asymmetrical tests were conducted for SS304 stainless steel with two kinds of multiaxial cyclic stress paths at room temperature. The loading paths were rhombic and circular paths. The ratcheting behaviors and LCF failure, as well as their interaction under non-proportionally multiaxial loading were observed. Some significant results are obtained, which are useful to construct a LCF model considering ratcheting effect.

LAMELLAR TEARING AND HIC OF THE THICK LOW-CARBON STEEL PLATES

L.W. Cao[*], Sujun Wu[†*], Yongjian Yang[*]

The phenomenon of the formation of the lamellar tearing in banded low-carbon steel plates has been studied. In this study, the specimens were divided into two parts by the technique of NDT (Non-destructive Testing), which was called NDT-UQ and NDT-Q. To determine the probability of HIC with respect to the direction of banding, hydrogen charging of the NDT-Q specimens in a H_2S saturated saline solution was performed. After the specimens had been charged for 96h, a detailed micro-structural investigation assisted by the OM and SEM technique was used for checking the morphologies and propagation paths of HIC. Compared with the research of the NDT-UQ specimens, the results show that the hydrogen is not the chief factor which leads to the lamellar tearing of the banded low carbon steel.

INTRODUCTION

The thermomechanically controlled processing (TMCP) method has been widely used in the industry production, and the mechanical properties of the plate steel produced by the TMCP are largely improved, especially the strength and toughness. However, some type of the plate steels are detected there are some lamination-cracks. As we know, some of these plate steels frequently work in harsh environments, such as ocean, oil etc., where the risk of failure by hydrogen embrittlement is probably greater. A substantial body of evidence indicates that there are some relations between lamellar tearing and hydrogen embrittlement[1-3]. For those steels the microstructure consist of predominantly ferrite and pearlite, and banding is the most important characteristic of the unqualified plate steels.

INFLUENCE OF CONCRETE'S MINERALOGICAL COMPONENTS ON FRACTURE COMPRESSIVE AND TRACTIVE

*Mary Patricia Morales Alfaro; **Fathi Aref Ibrahim Darwish

This is an approach to study the fracture behavior in concretes of standard, medium and high compressive strength, tested under compressive and tensile loads. Tensile loading was carried out by diametrical compression and also in a direct way using notched short rod cylindrical specimens. The study was focused on analyzing crack initiation and propagation in light of the water-cement ratio as well as the physical characteristics of the aggregates used. The compressive strength tested at 45 days, for standard and medium level of compressive strength's concrete by ratios water-cement 0,5 and 0,6. For high strength concrete was used 0,36. Each group of concretes tested had three different geological coarse aggregate so its physical and mineralogical influence on the concrete's microstructure could be analyzed by scanning electronic microscopy of the surfaces failure by compressive and tensile tests. The conclusions obtained for standard concretes did`nt show an important influence of the mineralogical aggregate's composition in the 0,5 or 0,6 ratio's water-cement on compressive, tensile and fracture toughness strength. On medium compressive strength's concretes an increase on fracture toughness to increase the ratio water-cement 0,5 to 0,6 and a significant influence of the mineralogical composition of the aggregates in compressive and tensile strengths, were observed. About the high strength concrete the strong matrix composed by additive and silica fume are the principals influenced in highest results of compressive, tensile and fracture toughness proprieties.

THE DEVELOPMENT OF AN IMPACT-SLIDING WEAR TEST MACHINE

Chu Shengli, Fan Jianchun and Zhang Laibin

A new test machine was developed to simulate the impact-sliding wear conditions between the casing and the tool-joint in drilling fluid during the deep or ultra-deep well drilling. At first, a tribo-system model for the deep section of the drilling-pipe and casing is presented and the lateral vibration of the drilling-pipe is taken into account. Then the framework of the test machine is introduced based on the system model. The on-line detection measures of the

tribological parameters such as wear, fraction torque, and temperature are described. Finally, some test results obtaining by this test machine are shown which present a good corresponding relationships with the practical casing wear monitoring results.

INTRODUCTION

In the western oilfields of China, casing wear in the deep or ultra-deep well drilling occurs frequently, and has been considered as one of the pivotal factors leading to great drilling costs. The prevention of casing wear presents as one of the most important problems in the drilling process. It is necessary to realize the casing wear mechanism for the solution of the problem[1]. Now it is well known that the rotation of drilling pipe mainly cause the casing wear and there are higher lateral loads on the casing with large dog-leg severities, which can cause severe casing wear[1]-[4].

Different from the wear occurring in a common straight well, the severe casing wear in the deeper well drilling usually takes place in the deep of well where the lateral pressure on the casing inner surface seems to be lower, sometimes even the dog-leg severity was very small. Current casing wear theory based on common straight well drilling engineering cannot only explain this phenomenon but also give proper guidelines to the prevention of casing wear. It is noticed that the lateral vibration of the drilling-pipe in the deep section can cause a great dynamic load on the casing which may lead to severe casing wear. It is necessary to develop a new test machine representing the impact-sliding wear conditions in order to realize the casing wear mechanism.

DISTORTION TENDENCIES IN WELDED STEEL LATTICE BEAMS

Yusuf Ozcatalbas[1)], Mehmet Turker[1)] and H. Ibrahim Vural[2)]

The aim of this study is to determinate the distortion tendencies which were formed by various welding sequences (WS) in the welded lattice beams. Distortion tendencies in the beams were determined by means of distortion forces. Distortion forces created by different applications of WS in the lattice beam were transferred to data-logger and then to a personal computer. The relationship between WS and distortion forces was analyzed. Effects of three different combinations of WS on distortion forces in the lattice beam were determined. It was found that minimum distortion tendencies were observed for WS includes homogenous heat gradient and welding joint points arranged far from to each other on the lattice beam.

INTRODUCTION

Residual stress and welding distortion are very important problems in vehicles that have a lattice frame and lattice beam chassis. Welding distortion in large structures is usually caused by buckling due to the residual stress [1]. Buckling causes loss of structural integrity, dimension control and increased production costs [2]. Due to the tight dimensional tolerances of chassis components the quality requirements on the welding process are high [3]. Occurring of different distortions in a bus chassis with lattice structure causes inharmoniousness in joining of further equipments or members. Therefore, welding distortions and residual stress must be minimized to control them according to respective requirements. There are several methods, including heat treatment, hammering, pre-heating, vibration stress relieving, and welding sequence to reduce the residual stresses attributed to welding, in these methods, to choose an available welding sequence is more simple and efficient for reduction residual stress and distortion [3-5].

THE REISSNER-SAGOCI PROBLEM FOR FUNCTIONALLY GRADED MATERIALS WITH ARBITARY SPATIAL VARIATIONS OF MATERIAL PROPERTIES

Tie-Jun Liu *, Yue-Sheng Wang

The paper examines the elastostatic problem related to the axisymmetric rotation of a rigid circular punch which is bonded to the surface of a functionally graded half-space with arbitrarily varying shear modulus. The linear multi-layered model is used to model the functionally graded materials. With use of the transfer matrix method and Hankel transform technique; the pro and torblem is reduced to a singular integral equation. The stresses, displacementque are calculated by solving the equation numerically. The results show that the stress, displacement and torque are great effect by the gradient of the coating.

INTRODUCTION

Functional graded materials (FGMs) are a new kind of nonhomogeneous composite materials. Through control of gradients in mechanical properties offers opportunities for the design of surfaces with resistance tom contact deformation and da age that cannot be realized in conventional homogeneous materials [1]. Reissner and Sagoci [2] first consider the problem of torsion of a semi-infinite, isotropic, homogeneous, elwastic solid hen a circular cylinder is welded to its plane boundary and it is forced to rotate about its axis. The extension of the Reissner-Sagoci problem to include

effects of material non-homogeneity is of interest to geomechanicas and to non-destructive materials testing. Gladwell [3] give a complete and informative account of the torsional indention problem.

EFFECT OF BIAXIAL LOADING ON FRACTURE TOUGHNESS OF RPV STEEL

Milan Brumovsky*, Dana Lauerova*, Jiri Palyza*

Reactor pressure vessels under some special regimes (i.e.pressurized thermal shock) are loaded by a strongly biaxial tensile stresses that ratio can reach even an opposite value in comparison with normal operating conditions.Special biaxial tests on cruciform type specimens with thickness up to 90 mm were tested in NRI Rez - special testing equipment and testing methods including measurements have been developed and realized. Testing equipment with maximum loading up to 1.5 MN allows to reach different biaxial loading ratios between 0 and 2. In Nuclear Research Institute in Řež comparative experimental tests on cruciform and beam specimens were performed. The aim of these tests was to examine the effect of crack depth and biaxial loading on fracture toughness for reactor pressure vessel material 15Kh2MFA. For evaluating the tests, the FEM (program SYSTUS) was used. The performed tests confirm shallow crack effect, i.e. increase of fracture toughness for shallow cracks compared to that one of deep cracks. Quantitatively, this increase was 53 - 93 %. Further, the performed experiments show decrease in fracture toughness of shallow cracks loaded biaxially compared to uniaxial loading of shallow cracks. Quantitatively, the fracture toughness decrease was about 20 %.

INTRODUCTION

Investigation of biaxial loading effect on fracture toughness is motivated by the fact that loading conditions in reactor pressure vessel (RPV) produce biaxial stress fields in the RPV wall both under normal operation and pressurized-thermal-shock accident conditions. These biaxial stress fields have a significant positive stress component aligned parallel to the postulated crack front oriented in either the longitudinal or the circumferential direction. The biaxial loading effect applies in association with shallow crack effect. The stress component parallel to the crack front as well as shallow crack effect are not represented in standard specimens testing (uniaxial loading, deep cracks).

MODEL TEST FOR FATIGUE PERFORMANCE OF ANCHORAGE IN CABLE-STAYED BRIDGE WITH STEEL BOX GIRDER

Wei Xing*, Li Jun, Qiang Shizhong

Cable-girder anchorage in anchor-plate form is adopted to connect cable with steel box girder in Zhanjiang Bay Bridge. Its mechanic behavior is very complicated and fatigue performance of anchorage system under service live-loads needs special attention. The application of anchor-plate anchorage structure in long span cable-stayed bridge is introduced. The characteristics of anchor-plate anchorage structure are investigated and fatigue test of a full-scale model of the anchorage zone is introduced. Combining theoretical analysis with the result get from fatigue test, stress contribution of the anchorage system under cyclic load and static load is analyzed in detail and fatigue performance of the anchorage system under cyclic loads is assessed.

CABLE-GIRDER ANCHORAGE IN ZHANJIANG BAY BRIDGE

Large cable force acts concentrically on the cable anchor points in cable-stayed bridge. Cable anchorage structure must transfer the cable force smoothly throughout the main girder. During the process of force transferring, there is stress concentration near the anchor points, consequently, the reliability of anchor zone is the key of the whole bridge safety. It is important to master the mechanism of force transferring and the stress distribution on cable-girder anchorage. “Various types of anchorage structures are adopted in many modern cable-stayed bridges, the representative types include Spray-saddle plus Anchor-girder type, Steel-pipe type, Anchor-box type, Gusset type, Tensile Anchor Plate type and so on(Guomin Y[1])”.Tensile Anchor Plate type (Fig.1) is adopted in Zhanjiang Gulf Bridge.

ENVIRONMENT ASSISTED CRACKING ASSESSMENT METHODS: THE BEHAVIOUR OF SHALLOW CRACKS

C. M. Holtam*, D. P. Baxter*

TWI Ltd has an ongoing research program aimed at validating and improving Fitness-for-Service assessment procedures for Environment Assisted Cracking. Initial studies have focused on the shallow crack phenomena and this paper

reviews current assessment procedures, highlighting one area where further experimental work is required.

INTRODUCTION

Setting conditions for the avoidance of in-service crack growth in aggressive corroding environments has long been a major challenge due to the number of variables that have a significant effect on material behaviour. It is therefore imperative that service conditions are properly characterised and the mechanism of environmental damage fully understood. Under static loading conditions, shallow stress corrosion cracks may grow faster or slower than deeper cracks, depending on the material-environment system. There are several reasons why shallow cracks might behave differently to deep cracks. For example, a crack's size relative to microstructural features, environmental effects within the crack and the size of the crack tip plastic zone can all influence behavior, Jones and Simonen [10].

ELECTRICITY-MECHANICS ANALOGY IN THE WHOLE FRACTURING PROCESS OF GRAPHITE CONCRETE

Xian Wu[1,2], Zhiqiang Zhou[1], Qiang Xiao[1] & Qi Liu[2]

Conductible concrete possesses the property of stress and temperature sensitivity. It can be used as functional material in nondestructive self diagnostics of concrete structures (such as bridges and dams), measurement of gravity and speed of motor vehicles, electromagnetic screen, heating, snow melting, and so on. To study the mechanical and electrical behavior of graphite concrete, three aspects of the mechanism and analogue are discussed. First, find out the reason of the consistency of deformation modulus-strain and electrical conductivity-strain. Second, find out that the analogue between electricity and mechanics can be done even in the status of damage. Third, regard electrical conductivity as a damage variable.

INTRODUCTION

Concrete can be conductible when graphite is added to it, and this concrete can monitor the damage. The distribution of the stress field can be obtained by analogy. The classical numerical 'fuse' network model has been studied to analogize the proceeding of material failure under loading, both brittle and ductile (Arcangelis[1] to Zapperi et al[5]). The basic reason for using electrical field to analogize mechanical field is that the failure process can not been given out by mechanics. In recent years, researchers have studied the mechanism of failure (Petri et al[6] to Herrmann et

al[17]). But when the method of analogy was used, there is no real experiment positively, and only numerical simulation was adopted.

FATIGUE CRACKS INITIATION AND PROPAGATION BEHAVIOR IN WELDED JOINTS OF TITANIUM ALLOY

LIU Chang-kui*, ZHANG Wei-fang, LIU Xin-ling, TAO Chun-hu

In this article, in-situ observation upon the dynamic extension of low cyclic fatigue cracks in weld fuse zone(FZ) and heat affected zone(HAZ) for TA15 titanium alloy were carried out. The results show that there are both two stages(stage I and stage II) during the process of fatigue crack propagation in FZ and HAZ. Slips at the tip of the cracks in FZ are very clear in the whole crack growth process and slip lines are much longer than those in HAZ which can only be found in fast expanded area. The fatigue cracks in HAZ are more deviated and bifurcate than those in FZ during the process of fatigue cracks propagation. And more secondary cracks are also found near the main crack at the surface of HAZ. Furthermore, the crack growth rates in FZ are larger than those in HAZ. It is concluded that the different fatigue crack growth behaviors between HZ and HAZ are related to different microstructures.

INTRODUCTION

Titanium alloys are attractive structure materials for aerospace and marine application because of their high specific strength, stiffness, inherently good corrosion resistance and weldability[1]. Weld of titanium alloys not only lightens engineering structure but also improves engineering structure integrity. With the increased applications of TA15 titanium alloy in China, some fields such as mechanical properties, microstructure and defects of welded joints have attracted much attention[2,3]. But the mechanism of fatigue crack initiation and propagation of welded joints has not been addressed[4]. Therefore, the present work focuses on fatigue cracks initiation and propagation mechanism of welded joints of TA15 titanium alloy by means of SEM in-situ testing.

PREDICTION OF MULTIAXIAL CREEP DUCTILITY FOR A USC STEAM TURBINE ROTOR STEEL AT 600℃

Huatang Yao, *Fu-Zhen Xuan, Shufang Shen,
Zhengdong Wang and Shan-Tung Tu

Prediction of multiaxial creep ductility is conducted on the newly developed 1Cr10NiMoW2VNbN steel for Ultra Supercritical (USC) steam turbine rotors. Creep rupture tests are carried out in use of the smooth specimens under four stress levels at 600℃. An approach for multiaxial creep ductility prediction is proposed on the basis of cavity growth theory. The FE calculations are performed by implementing the proposed model in the user-defined subroutine of ABAQUS software. Numerical simulations for three types of notched bar specimens show that the proposed method can predict well creep performance of the rotor steel under multiaxial stress states.

INTRODUCTION

In China, More than 90% of coal-fired power plants are operated at or below sub-critical conditions and thus lead to a low efficiency. So a research and development (R&D) program has been launched by China in 2000 to develop Ultra Super Critical (USC) power plants so as to improve the efficiency. With the increase of operating temperature, the main concern for design of components is focused on the creep damage under multiaxial stress states (Goodall et al. [1]). In this work, predictions of multiaxial creep behaviour are studied on the newly developed rotor steel for USC power plants.

STRESS CORROSION CRACKING SUSCEPTIBILITY INDEX, I_{SCC}, OF S2205 DUPLEX STAINLESS STEEL IN MARINE ENVIRONMENT

Michael Adegbite*

The 22%Cr - 5%Ni, ferritic-austenitic duplex stainless steels (DSS) have potential to offer trouble free service in a variety of corrosive media, which, combined with their high strength-to-mass ratio, allows for savings to be made both in terms of structural weight and maintenance costs. However, a number of service failures have been reported, and there remains a cloud over the mechanism of stress corrosion cracking (SCC), which is the most prominent

form of failure in offshore applications. In this study, the mechanism of stress corrosion cracking of S2205 duplex stainless steel was investigated in neutral artificial 33.33 %wt sea-salt solution at strain rate of 1.5 x 10^{-6} s^{-1}, between the ambient temperature and 80^{o}C. Slow strain rate tests were carried out at open circuit potential and applied austenite-passive potentials at respective temperatures. The fractured surfaces were examined and the test data were analyzed to verify the susceptibility, as well as understanding the mechanism of stress corrosion cracking. Fractographical examination revealed that pitting corrosion assisted the initiation and selective dissolution was involved in the propagation of SCC of cold-drawn S2205 DSS in solution temperatures above 50^{o}C.

INTRODUCTION

Duplex stainless steel (DSS), which has a two - phase, ferrite - austenite microstructure, has attracted great interest in the past few years with its cost saving combination of high strength and improved resistance to general and localized corrosion, stress corrosion cracking, abrasion and wear. Duplex Stainless steels have a microstructure consisting of about 1:1 mixture of austenite and ferrite and combine the near-immunity to Stress Corrosion Cracking (SCC) in seawater of the ferritic stainless steels with the toughness and the ease of practical application of the austenitic types. Duplex stainless steels are available both as wrought and cast products, resulting in a number of applications including gate valves, pumps shafts, cast propellers, seawater piping, seawater-inert gas scrubber systems and critical seal components of nuclear submarines.

PHASE FIELD SIMULATION OF MICROSTRUCTURE EVOLUTION IN THERMAL AGING OF CAST AUSTENITIC STAINLESS STEELS

Shuxiao Li[1,3], Xitao Wang[1], Yanli Wang[1], Guogang Shu[2], Guoliang Chen[1]

The spinodal decomposition of the ferritic Fe-Cr solid solution leads to a fluctuation of the Cr concentration corresponding to the formation of an interconnected sponge-like network of the Cr-enriched α'domain. In the present work, the morphological evolution during spinodal decomposition in Fe-Cr ferritic solution was studied. A Fourier transformation method was used to solve the Cahn-Hilliard diffusion equation. We demonstrated the effect of the aging time and temperature on morphological change during the microstructure evolution.

1. INTRODUCTION

Many metal materials are used under service conditions in which they are metastable or unstable against some form of phase separation on the atomic scale . An important example is the duplex stainless steels used for primary cooling circuits in pressure water reactor (PWR) nuclear power plants . Under working reactor conditions ,the ferrite phase undergoes spinodal decomposition which generates an ultra-fine two-phase microstructure consisting of Fe-rich α and Cr-rich α',with a characterstic scale of several nms[1]. As the phase separation proceeds ,there is an increase of hardness which may lead to embrittlement over several years[2,3] . So it is necessary to explore systematically the time and temperature dependence of the spinodal decomposition in order to predict the long behaviour of these materials.

NEUTRON IRRADIATION OF MATERIALS AND ITS EFFECT ON STRUCTURAL INTEGRITY

R.G. Faulkner

This paper describes the Neutron Radiation Damage issues that have an impact on structural integrity in current nuclear plant. Emphasis is given to two major problems of current importance: irradiation- assisted inter-granular cracking (IASCC) in austenitic steels; and ductile to brittle transition temperature shift (DBTT) in reactor pressure vessel steels. The approach used will be to survey modelling techniques that have been applied to the phenomena and to evaluate the best models to describe materials degradation in circumstances appropriate to IASCC and DBTT shift. The model predictions are compared with plant in-service observations. The result is a mechanistic interpretation of these two important structural integrity-related effects which can be used to help to design future plant with greater confidence.

INTRODUCTION

The effects of neutron irradiation on materials property degradation are well-known but there remains still much to be done in order to control the materials degradation to within acceptable limits for the safe and prolonged operation of future nuclear power plant. The major phenomena that are experienced by core materials such as fuel cladding or reactor pressure vessels are matrix embrittlement, void swelling, irradiation creep, irradiation assisted stress corrosion cracking (IASCC), and He bubble embrittlement.

MASTER CURVE APPLICATION TO WWER REACTOR PRESSURE VESSELS INTEGRITY

Milan Brumovsky*

Lifetime of reactor pressure vessels is practically determined by their resistance against potential brittle/non-ductile failure. This resistance is then governs by the damaging effect of neutron embrittlement.

Integrity assessment of reactor pressure vessels has been changed and improved during past several decades but still it contains some parameters that were introduced historically and still are being used. Representative of such parameters is Charpy notch impact testing and resulting transition temperature determination. Even though this test has technological origin, it is still used in material acceptance tests and also practically in most of surveillance specimens programmes for determination of radiation damage level.

Vast application of fracture mechanics to reactor pressure vessels integrity assessment have brought also a tendency for finding a correlation between results of Charpy notch impact tests and fracture mechanics parameters - results are usually called „design fracture toughness curves“. Contraversion between Charpy impact tests and fracture mechanics use for RPV integrity assessment can be overrun by direct use of static fracture toughness data obtained from surveillance, e.g. using a specimen reconstitution technique.

AN EXPERIMENTAL INVESTIGATION ON THE FATIGUE CRACK GROWTH OF NICKEL-BASED SUPERALLOY ELECTRON BEAM WELDING JOINTS

Qin Xin*, Xiong Linyu and Zhang Yanhua

Nickel-based supperalloy and its welded structures have been widely used in aeronautics and astronautics engines, turbine axes. This material are usually working in high temperate. So it is of great importance to investigate the fatigue crack growth to predict nickel-based superalloy’s fatigue life. In this paper, an experimental study on the fatigue crack growth specimens of nickel-based supperalloy electron beam welding joints has been carried out.

The temperature of fatigue crack tests is 650℃. The objectives of the present study are to evaluate fatigue crack growth rate and to make better understanding for the effect of fatigue crack growth rate, initial crack length, critical crack on fatigue crack growth behavior of nickel-based supperalloy. The obtained results were compared with the data of base metal.

INTRODUCTION

In recent years, considerable attention is focused on the development and application of nickel-based supperalloy, because nickel-based supperalloy and its welded structures have been widely used in aeronautics and astronautics engines, turbine axes.[1] This material are usually working in high temperate and subjected to a high level of fatigue loads. However, studies on the mechanical properties, in particular, the fatigue properties of nickel-based supperalloy are very limited[2-4]. So it is of great importance to investigate the fatigue crack growth to predict nickel-based superalloy's fatigue life.

FATIGUE LIFE PREDICTION FOR COMPOSITE MATERIALS UNDER MULTI-LEVEL LOAD

Qi Hongyu*, Wang Yamei, Yang Xiaoguang

In order to improve the strength and reduce weight of structure in aero and astro industry, the advanced materials have been widely adopted such as CFR composite materials. The T300/KH304 is one of the advanced materials and will be used for important structure in the future. The fatigue proprieties of materials need to be investigated because of high reliability and integrity for aerospace structure under cyclic load. Firstly the static properties were obtained. The fatigue experiments were carried out under constant amplitude fatigue. Based on the fatigue data and a significant reduction of modulus of composite materials, the fatigue damage was divided into two stages. The fatigue damage model was set up including the strain and stiffness degradation. The static and fatigue failure has been detected by X-ray radiograph and the failure mode under different loads has been analyzed. The fatigue tension-tension tests were observed under multi-level load. Finally, the residual life of the composite material was predicted using the fatigue damage model and the relative error is 3.1%.

INTRODUCTION

The T300/KH304 composite has the many advantages, such as high strength and stiffness ratio. So this composite material can improve the propulsion and reduce the

weight of areo-engine. It has been designed and manufactured for areo-engine in our country.

SERVICE LIFE PREDICTION OF COMPOSITE STRUCTURES OF AIRCRAFTS

Yuting HE [1, *], Wenjun SHU [1], Chaohua FAN [1], Hongpeng LI [1] and Ronghong CUI [1]

The most important problem for composite structures of aircrafts is to ensure reliability for long-time operation. Actually all aircrafts are operated under various fatigue loads and various aging environmental conditions. In order to consider the combined effects of fatigue loads and aging environment, new concepts of Life Vector, Life Envelope Curve and Life Envelope Surface of Composite Structures of Aircrafts are introduced to illustrate the life characteristics of composite structures of aircrafts. The sketch and establishment methods under different operational conditions are presented later. Then the linear damage accumulation rule is recommended to predict the residual fatigue life and calendric life of composite structures of aircrafts in different operational conditions.

INTRODUCTION

The increasingly widespread application of composite materials to principal structural elements of airframe promotes performance and structural effectiveness of aircrafts. While composite structures of aircrafts (CSA) are quite different from the metal structures in terms of damage mechanism and environmental sensitivity. There comes the problem how to scientifically predict and supervise the service life of CSA and ensure their safety in long-time operation. The main operational conditions affecting the actual service life of CSA are: (i) Load conditions which can be described by load spectra. (ii) Aging environmental conditions which can be expressed by aging environmental spectra. The elevated temperature, relative humidity and ultraviolet radiation are commonly considered as the principal environmental factors affecting the fatigue performance of CSA. (iii) Flight intensity which indicates the flight time of CSA in per unit of calendric time.

SHAAN-JING GAS PIPELINE INTEGRITY MANAGEMENT& TECHNOLOGY DEVELOPMENT AND PRACTICE

Dong Shaohua* Wei Zhenhong Fan Fei

Pipeline integrity management is essential for today's operators to operate their pipelines safety and cost effectively. The latest developments of pipeline integrity management around the world are involved with change of regulation, industry standard and innovation of technology. Beijing Huayou Gas Company (BHGC) is a pioneer of China industry on implementation of pipeline integrity management by using latest developed technologies such as in-line inspection, GIS, Risk assessment and advanced repair technologies. With smart pigging inspection and implementation of GIS and EAM (Enterprise Assets Management) system on one thousand of kilometers of Shaanxi-Beijing gas pipeline BHGC is able to manage pipeline integrity in five areas which include pipe materials safety, nature and geotechnical hazards management, coating and corrosion protection, stationing and associated facilities maintenance, and underground gas storage integrity. This paper presents latest achievement of BHGC in their pipeline integrity programs.

1. INTRODUCTION

Beijing Huayou Gas Company (BHGC) is a pioneer of China oil & gas industry on implementation of pipeline integrity management by using latest developed technologies such as in-line inspection, GIS, Risk assessment and advanced repair technologies. Since integrity center was found in 2001 BHGC has inspected whole system 1200kms of pipeline using high resolution MFL which provides basis for integrity assessment. Thereafter BHGC conduct risk and safety assessment on whole system and establish a set of integrity assessment procedures and methodology. This paper presents latest achievement of BHGC in their pipeline integrity programs.

RELIABILITY ANALYSIS OF MULTIPLE SITE DAMAGE STRUCTURE

Zhao Libin[*], Zhang Jianyu[**], Long Liping[**] and Fei Binjun[**]

The problem of multiple site damage (MSD) has got more attention in ageing structures. Cracks caused by MSD are extremely difficult to detect and greatly

reduce the residual strength, fatigue life and overall structural integrity of aircraft panels. The aim of this paper is: establishing an analysis method to evaluate the reliability of the structure occurring MSD. Analysis shows that the structural reliability level is the probability dominating the multi-dimension random variable of crack growth, which fall into the space surrounded by the equal-surface and the coordinate surface. That's the integral of the probability density function of multi-dimension random variable in the space. Different reliability analysis models, such as completed integral reliability model, simply series reliability model and modified simply series reliability model, were presented and applied aiming at different problems. An example has been provided to illustrate the reliability analysis applied on the structure and verifies the correctness of the presented models. The example shows that the reliability of MSD structure degrades very fast relative to time.

INTRODUCTION

Multiple site damage refers to multiple cracks of arbitrary length, commonly occurring along rows of fastener holes in the fuselages and wings of aircrafts. Cracks caused by MSD are extremely difficult to detect and greatly reduce the residual strength, fatigue life and overall structural integrity of aircraft panels. Nowadays, most of the researches about the structure with MSD are focused on the deterministic analysis, including the fracture mechanics[2], the computational mechanics[3], and experimental investigation under special conditions[4]. Since the variability of fatigue crack growth[5], introducing the probability fracture mechanics to analyze the multiple cracks problem is imperative. It is necessary to present MSD cracks growth model and reliability analysis model for MSD structures. MSD cracks growth model and reliability analysis models are presented. One example has been provided to illustrate the reliability analysis applied on the MSD structure.

RESEARCH ON THREE DIMENSIONAL INDUSTRIAL CT METHOD FOR NDT/E OF AEROENGINE TURBINE BLADES

FU JIAN*, WEI DONGBO*, SHAO JUNMING*, LI BIN*

Implementing the standards on aeroengine structural integrity can improve the reliability and wearability of aeroengines. Non-destructive testing and evaluation (NDT/E) has been one of the research directions of aeroengine structural integrity assessment. Three dimensional industrial X-ray computed tomography(3D-ICT) can provide the internal structure information of objects with digital images and play an important role for NDT/E of aeroengines. However, the 3D-ICT image quality of turbine blades is greatly degraded by

the scatter and the beam hardening caused by the high-density materials and the irregular shape of turbine blades. In order to apply 3D-ICT to NDT/E of turbine blade, this paper made some researches to improve the image quality. Firstly the properties of scatter were analyzed and a correction method based on the dyadic wavelet transform was researched. Then the physics features of beam hardening were summarized and a correction method based on the projections was presented. Finally a wall-thickness measurement method based on CT images was developed. The measurement results were presented and the accuracy reached 0.1mm. Based on these research results, a 3D-ICT system was developed for a Chinese aeroengine company and satisfied NDT/E requirements of turbine blades.

INTRODUCTION

During the stages of the design, manufacturing and maintenance of aeroengines, implementing the standard on aeroengine structural integrity can improve the reliability and wearability of aeroengines(Chen [1]). Many standards on aeroengine structural integrity have been issued, for example MIL-STD-1783 in USA and GJB/Z101-97 in China. Perfect results have been produced.

TENTATIVE STUDY ON ACCELERATED DEGRADATION TESTING OF SPACE-USED FOG

Wu Ge[1] Jiang Tongmin[1] Li Xiaoyang[1]

In view of the characteristics that the space-used FOG has long life and high reliability, accelerated degradation testing (ADT) was utilized to evaluate their reliability and life. Firstly, key technologies which are accelerated model and estimation were proposed. Then, SLD was confirmed as the weak point according to the field failure information. Therefore, system accelerated degradation testing was converted to part level. Finally, the scheme of the ADT which adopted step temperature stress was given. The methodology in this paper was demonstrated and validated by degradation trend of the light power during the test.

INTRODUCTION

The fiber optic gyroscopes (FOGS) are newly solid inertia measure units based on Sagnac effect [1]. Compared with the traditional mechanical gyro and the laser gyro, FOG has no mechanical moving parts, thus it has short startup time and wide dynamic

range, therefore, it has high reliability and long life. As a very pivotal part for posture control, the reliability of the optic gyroscope is critical. Therefore, it is important to estimate its life.

SIMULATION DATA MANAGEMENT AND PROCESS CONTROL IN THE PRODUCT DESIGN AND ANALYSIS PROCESS

Miao Jianquan*, Wang Chunjie

In this paper a method is proposed, that is used in Simulation Data Management and Simulation Process Control related to mechanical product design and analysis process. Based on the MSC.SimManager developing environment, the database schema and general data model between the product design and analysis process is designed according to the requirement of the product design and analysis; the Simulation Process Control is achieved through the integrating the CAD redevelopment with CAE redevelopment and the XML technology, the results and interface data between design and analysis software is also managed efficiently. Meanwhile, the multi-user interactive collaborative design environment is implemented by taking advantage of the LAN technology.

INTRODUCTION

In this paper a method is proposed, that is used in Simulation Data Management and Simulation Process Control related to mechanical product design and analysis process. Based on the MSC.SimManager developing environment, the method that creates a general data model, integrates the CAD with CAE to a platform, manages the data and process between CAD and CAE efficiently is aimed at the developing process of the maturity product. The Software Integrated Platform makes the data flow during the process of design, analysis and simulation of the product more common and more efficiently, it also makes the design time shorter, avoids losing the data between the CAD and CAE process, and assures of the veracity of the result of analysis.

PREDICTION AND ANALYSIS OF SULFURED NBR AGING IN GLYCOL BASED ON ARTIFICIAL NEURAL NETWORKS

Zhu Liqun*, Gu An, Huang Huijie

High temperature accelerated aging was adopted to investigate mechanical properties changes of sulfured nitrile-butadiene rubber (NBR) in glycol at 70 ℃, 90℃, 110℃. Based on the experimental data, a BP neural network model for predicting the aging of NBR was developed by using time and temperature as the input variables and the properties as output variables. The predicted data, which is in good agreement with the test one, is used for creating 3D surface plots and contour plots. This paper discussed the change rules of the properties through analyzing these plots. By compared with the change of the cross-section microstructure, it was found that the rules were well in accordance with the actual situation.

INTRODUCTION

Nitrile-butadiene rubber (NBR) is a widely used sealing material with high performance. But its unsaturated bonds will lead to aging. The glycol is essential component of the anti-freeze fluid which will affect the aging of the NBR seal parts of a car. So it is significant to research the aging rules of NBR in glycol. But the aging of NBR is a complicated process and hardly be expressed by a formula. The widespread methods not only ignore the effect of the complex environment but also waste time. Artificial neural networks (ANNs) are powerful tools for prediction of nonlinearities. With their remarkable advantages such as the ability to derive meaning from complicated or imprecise data, adaptive learning, self-organization and fault tolerance via redundant information coding, etc. (Simon Haykin [1]), ANNs could be used to solve the problems in rubber and other diverse areas with high performance(Fang Qinghong et al. [2] [3]). In this paper ANNs are used to research the aging of NBR in glycol and extract useful information from samples.

CONNECTING PINS RELIABILITY ANALYSIS WITH CONTACT PROBLEM IN THE CUT SYSTEM

Xing Chen-guang[1], Zhang Jian-guo[2], Wang Shi-qing, Li Qiang

The contact problem of connecting pins is the key techniques in the cutting system, which is also the weakness of reliability analysis. First, establishing connecting pins model as the input of deterministic analysis which simulates contact problem with Msc.Marc, then using ARES to establish reliability analysis model and calculate reliability based on deterministic results, third, comparing efficiency and precision of value resulted from different reliability methods, at last, improving different design parameters based on different sensitivities and important level to enhance reliability. Paper discussed the engineering method to settle mechanism and structure with contact problem from deterministic analysis to reliability analysis, which is a useful research for reliability analysis simulation in mechanism and structure.

The cut system is the most important system in cut machine and two vital systems are connected with connecting pins, which contact with base and piston pole; on the same time considering the special work condition, connecting pins should have high intensity and rigidity and high reliability. All mentioned above need reliability simulation analysis about connecting pins.

EVOLVING CELLULAR AUTOMATA(ECA) AND ITS APPLICATION TO MODEL THE BRITTLE ROCK FAILURE

WANG Shi-min[1], ZHU He-hua[1], FENG Xia-ting[2], WANG Yong-jia[3]

Based on the theory of cellular automata, the evolving cellular automata(ECA) model is proposed in the paper. In the ECA system, the triangular cell and the node cell are taken as the neighborhoods with respect to each other and evolve according to the local interaction rules. And the strain-stress relations of the brittle rock are considered to be consistent with the perfect elastic constitutive law in mesocosmic view. The tensile failure and shear fracture are taken into account by the triangular cell's evolvement based on the modified Mohr-Coulomb criteria. The heterogeneity of the brittle rock, the brittle rock failure mechanism and the end effect of the brittle rock failure are discussed by the numerical simulation. Some numerical experiments about the brittle rock under uniaxial compression tests are carried out using ECA numerical method. And some primary conclusions have been drawn out.

0 INTRODUCTION

The rock deformation and failure process is the core content of rock mechanics research. It is imperative to the stability of tunnel project, slop failure and so on. Sine G..W. Cook brought forward the concept of whole rock's stress-strain process curve in 1965 [1], along with the advent of the rigid or servo-control test machine, the researchers had a brand-new knowledge of the mechanism of rock deformation and failure process. Rock material will still have certain remnant support capability after its limit load. This concept made the researchers think about a new form of the rock constitutive relation and gave the concepts of rock strength and failure a new content. The process of rock losing its support capability is gradual and continuous and is called the rock fracture process.

NEW APPROACH TO ESTIMATING THE CONSTANT-STRESS ACCELERATED LIFE TEST

Wan Bo[1], Yao Jun[1]

The least square method has been widely used in fitting accelerated model when estimating the constant-stress accelerated life test, but it could perhaps bring a great error in model fitting and extrapolation. A new derivative fitting and extrapolation method was used to fit both the test data and its derivative well and the development trend of the model curve could be well described. Therefore, a reasonable prediction would be given to improve the precision of life estimation.

INTRODUCTION AND LEMMA

The derivative fitting and extrapolating approach being presented aims at the low precision of the life estimation in constant-stress accelerated life testing when the accelerated model fitted by the normal least square method in engineering field. It can result high precision in life estimation in some degree. The necessary assumption and lemma list as follows:

STRESS ANALYSIS OF 2.5D BRAIDED FIBER REINFORCED COMPOSITES

Zhang Cao[1], Yue Zhang[1,] , Chunjun Liu[1], Dahai Zhang[2], Zhongping Li[2]

A new model of representative volume elements of 2.5D braided fiber reinforced composites was proposed, which can represent the braided manner and coincides with the actual configuration. The finite element software ANSYS was adopted to analyze the stress distributions in this model. Through applying loads and finite element calculation, the stress field of this 2.5D braided composites in tension was obtained. The finite element calculation results fit well with the experimental data, which demonstrates the validity of this model. In addition, the influence of braiding parameters on the mechanical properties was investigated.

INTRODUCTION

2.5D braided fiber reinforced composites is special textile composites, in which performs are made by applying the weaving or braiding technique. It has better integrative mechanical properties, which makes up effectively with the insufficiency of the 3D fabrics in producing abnormal structure textile composites. To make better full use of in industry, it is necessary to understand the effects of textile structure and its parameters on mechanical properties. Some models based on the textile structure have been established. Ishikawa and Chou [1] proposed a microcell approach for predicting the in-plane elastic properties for 3D angle interlock composites using lamination theory, but curvature effect of tows was ignored in the model. Yan and Cheng [2] and Yang et al. [3] took this curvature characteristic of fiber into account in their elasticity of 3D woven composites. In their models, fiber tows were viewed as curved laminate, and the whole elastic properties of this composite were obtained by integrating stiffness constants along crimple tows and then averaging. Cox et al. [4] and Xu et al. [5] developed a finite element model, referred to a binary model, to predict the mechanical properties of 3D angle interlock composites. In the approach of Barbero etal. [6], a finite element model of plain weave fabrics based on geometrical measurements from photographs was developed to determine the damage evolution using a meso-mechanical continuum damage formulation under tensile loading. But up to now, limited attention has been focused on understanding the stress analysis of 2.5D braided composites [7, 8 and 9].

THE EXPERIMENTS STUDY ON INTEGRITY ASSESSMENT OF DUCTILE IRON MODIFIED BY LASER WITH SPACE ARRAY

Ba* Fahai*[1] Wu Wei[2] Yu Gang[2]

Pulsed laser beams with two-dimensional array distribution was used to modify surface processing for ductile iron. France IQL-10YAG pulse LASER with 1.3 mm×1.3 mm spotbeam was applied to these experiments. In which pulse width 24ms, pulse repeat frequency 4Hz, and single pulse were adopted. In this paper integrity assessing methods of modified effect were studied and discussed by experiments including case depth, microhardness distribution and wearing test method. Of which a statistical method of microhardness distribution was adopted to evaluate reasonably the microhardness distribution character and further used to evaluate the case depth. On the other hand, a suitable method for wearing test was analyzed. And that was a integrity assessment method for wearing test by establishing the curve of loss weight vs depth at a given time and load in the whole depth of modified layer.

INTRODUCTION

Surface modification by laser was one of the most effective methods to enhance the synthetically mechanical properties and extend the service life of materials. One main object of laser modification was to obtain deeper case depth and enough wearing resistance. Therefore, it was very important to find integrity method to evaluate the case depth, microhardness distribution and wearing resistance of modified area in order to optimize the laser processing technology and objectively evaluate modification effects. Up to now there had been large numbers of experiments about it and some of which was involved in evaluation technology [J.Ruiz, V.Lopez [1], J.C.Ion, H.R.Shercliff and M.F.ashby[2], S.L.Chen and D.Shen[3]]. However in fact there was only few practical method involved in evaluate the modified result, especially for ductile iron, due to no uniformly microstructure distribution [Ba Fahai,Gan Cuihua andYu Gang[4], Ba Fahai, Gan Cuihua and Yu Gang[5], Ba Fahai,Yan Guoqiang[6]]. In this paper, pulsed laser beams with two-dimensional array (3×3) distribution was used to modify surface processing for ductile iron. And the integrity assessing methods of modified effects were analyzed and discussed by experiments including case depth, microhardness distribution and wearing test method.

EXPERIMENTAL INVESTIGATION ON FRACTURE TOUGHNESS OF INERTIA FRICTION WELDED NICKEL-BASED SUPERALLOY

Xiong Linyu* Fang Yonggang Wang Wenchao Qin Xin Zhang Yanhua

In the present study, the fracture toughness in terms of crack tip opening displacement (CTOD) of inertia friction welded superalloy has been evaluated. The CTOD testing of base metal and weld metal were conducted using single-edge notched bending specimens at room temperature (22℃) and elevated temperature (650℃) respectively. Critical CTOD values were calculated from the corresponding load-CMOD curves. The fracture toughness properties of different regions at different temperatures were evaluated. Fundamental data are provided as references for engineering research and application.

INTRODUCTION

Driven by the aim of developing high performance and low cost aeroengine, various structures, new materials and advanced technologies have been introduced to key components of aeroengines [1]. The thermal efficiency of engine is mainly influenced by the turbine inlet temperature. Thus nickel-based superalloys are widely used in the manufacture of aeroengines by their excellent high temperature properties [2]. However, these alloys are very difficult to be joined by fusion welding and are prone to micro-cracking as solidification takes place during welding [3]. Inertia friction welding is the expected process suitable to join nickel-based superalloys. It is a solid-state joining process, one of the workpieces is connected to a flywheel, and the other is restrained from rotating [4]. The process have advantages over high quality, high efficiency, stability, easy control and reproduction, therefore it won the favor of aero industry immediately after its invention [1]. Although some successes have already been achieved in inertia friction welding of superalloys, there is not much fracture property data of their weldments. The objective of this paper is to provide the information for structural integrity assessment, research and application.

SOME ENGINEERING CALCULATION METHODS OF STRUCTURAL VIBRATION FATIGUE LIFE

Yao Jun[1]

Structural vibration fatigue is one of most important factors in influencing structural integrity. Currently, the static strength design and dynamic strength checking method is used in astronautics field, which means the structural fatigue life is calculated using static fatigue strength method when designing the product. The probable vibration damage is commonly checked by the vibration test with the static fatigue design, but without the vibration fatigue design. So, if the vibration test failed, redesign must be taken, which is blindness. In this paper we present the engineering calculation methods of the structural vibration fatigue life. Including a method for common random vibration fatigue analysis based on the sine resonance S-N curves and a method for the random vibration fatigue damage calculation by the sonic fatigue analysis method.

INTRODUCTION

The reference [1] provided the basic concept and definition of structural vibration fatigue, including the calculation approach of structural vibration fatigue life under the period vibration. It can see that the calculation approach of vibration fatigue life is completely different from the static fatigue life. The new “Military airplane structure strength specification: Vibration and Aero acoustic durability” demanded that some important structure of airplane have to calculate the structural vibration fatigue life. This paper, based on sound fatigue method, presents calculation approach of structural vibration fatigue life to implement the need of specification.

RESEARCH ON APPLICATION OF FLAME SPRAYING OVERLAY TECHNOLOGY ON INCREASING SERVICE LIFETIME OF SLURRY VALVE

Deliang Ren[1]， Lianhai Hu[1], Fangjuan Qi[1],Fuyi Kang[2] ,Bo Liao[1]

Slurry valve is one of the important valves transporting slag in steel factories and power plants. The working conditions of slurry valve are extremely harsh, which bears not only the great flush of slag transported using the high pressure

water, but also the corrosion of the sulphur, phosphorus. Therefore it is in great need of a sort of high corrosion resistance and wash resistance of the slurry valve. In contrast to other methods, flame spraying overlay has excellent characteristics. Thus, flame spraying overlay technology is determined to improve the service lifetime of slurry valves in this study. The choice of alloying powder is analyzed. Through the research on the effect of spraying process on the quality of overlay, the method to improve the spraying quality is proposed. Optical microphotoes are fully analyzed. Research shows that the combination strength of overlaying coatings and base metal is very high and the spraying overlay technology will increase its service lifetime in more than 10 times. So it is of great value to promote the method of manufacturing valves.

1 INTRODUCTION

Slurry valve is one of the important valves transporting slag in steel factories and power plants. Z43H-10 type slurry valve structure is shown in figure 1. During working process, the valve base and valve plate are strongly washed by slag transported using the high pressure water. Therefore a high wash resistance of the slurry valve is required. Because the slag contains some corrosive substance such as sulfur, phosphorus etc, a certain corrosion resistance of valve is needed. At first ductile iron is used to manufacture the valve. But after one more week, a 20×15 (mm) trench at the joint of the valve base and valve plate is eroded so that the valve is unable to be used. Then the valve made of wear-resistant cast iron and stainless steel plate can improve the wash resistance and corrosion resistance. But wear-resistant cast iron is so brittle that it may be easy to crack in the process of manufacture, transport and running and results in uselessness of the workpiece. And if the valve is totally made of stainless steel plate, the cost turns too high.

REMAINING LIFE EVALUATION OF POWER PLANT COMPONENTS FROM CREEP STRAIN-RATE, TEMPERATURE AND PRESSURE DATA

C. F. Matt*; H. C. Furtado[*]; R. O. Rocha[*]; V. G. Guedes[*];
M. A. Michalski[*]; B. R. Cardoso[*]; F. F. Santos[*]; and L. Felippe[‡]

Methodology developed to evaluate the remaining life of a power plant reheater based on creep strain-rate estimate, and temperature and pressure measurements, is described. It uses well-known concepts from the literature on creep and is flexible to account for the cyclic operation of Brazilian power plants. The results computed for remaining life are compared with those obtained from the Larson-Miller approach, which does not take into account creep strain rate in the components subject to high temperature and internal pressure. The discrepancies verified between the two methodologies justify

further research of on-line creep strain rate monitoring in order to assess the accuracy of the proposed methodology.

INTRODUCTION

During the last twenty years, failure analysis, and accurate estimates of cumulative damage and remaining life of power plants have been recognized as extremely important, since the assurance of safe operation, reduction of unnecessary shutdowns for inspection and maintenance, and reduction of costs associated with life extension have been a world-wide trend. During the last fifteen years, the materials engineering team at CEPEL has developed methods for the evaluation of remaining life of power plant components based on field inspection and metallurgical tests. At the same period, the mechanical engineering team at CEPEL has gained expertise in hydroelectric turbine monitoring and diagnosis. The two groups have combined their experience in a project for the needs of the Brazilian electric companies for an automated monitoring system. The goal is to evaluate remaining life in power plant components based on pressure and temperature measurements collected by the monitoring system.

AN ANALYSIS OF DOME REVERSAL IN METAL BEVERAGE CANTAINER BASED ON FINITE ELEMENT METHODS

Muddasar Khan [*] Afzaal M. Malik [*] Shahab Khushnood [**] Khalid Orakzai [***]

Metal beverage containers are used in packaging foods and chemical industries. The beverage container industry is struggling to reduce the amount of material in each container, while meeting the three structural performance standards which have been established to access the adequacy of the container design. These are axial column load, drop resistance and internal pressure. This paper relates to the internal pressure standard which states that container must withstand at least 90-100psi or more internal pressure without buckling (reversal of dome). The purpose of this research is to minimize the weight of an aluminum beverage container as well as fulfilling the entire remaining design parameters such as applied loads, maximum stresses at critical locations and keeping in view all other constraints. A number of alternative solutions are analyzed at a very low cost, using simple FE analysis. Based on these results, promising designs are further analyzed using more complex but accurate FE techniques. A series of different designs are developed, analyzed and an optimum design is considered. The Crown Cork and Seal.890B design is used. The linear analysis is done using COSMOS, SOLIDWORKS and ANSYS. The results are validated using available experimental and numerical data.

INTRODUCTION

The profile of the bottom of a beverage can is generally defined by a series of intersecting arcs and lines. Dimensional parameters can be derived based on the size of the intersecting arcs and lines and their positions relative to one another. The dimensional parameters include such things as the radii of arcs, the degree of slant of lines and the height and length of certain intersection points relative to a fixed reference. The performance properties evaluated are often those of dome reversal pressure and response to axial loading. Dome reversal pressure is the amount of internal pressure required for the dome at the bottom of the can to be reversed in direction from concave to convex and depends largely on the geometrical features inside the bottom rim or stand. Corona E. [1] studied the dome reversal of metal beverage container. Nardini et at. [2] presented a method for development of can bottom profile and a can with a domed bottom structure. J. Han, R. Itoh. [3] worked at shape optimization of the two-piece aluminum beverage bottle bottoms structures.

EFFECTS OF MANUFACTURING-INDUCED RESIDUAL STRESSES AND STRAINS ON HYDROGEN EMBRITTLEMENT OF COLD DRAWN STEEL

J. Toribio*, M. Lorenzo**, D. Vergara** and V. Kharin**

Hydrogen embrittlement (HE) plays a relevant role in the performance of prestressing steel wires. In this framework, the knowledge of residual stresses and plastic strains in wires due to cold-drawing (manufacturing-induced residual stresses), as well as of wires hydrogenation from harsh environments are the keys to successful predictions of wire lives. This paper advances previous analyses of HE in cold-drawn prestressing wires via numerical modelling, first, of the cold-drawing process to gain the distributions of residual stresses and plastic strains, and next, of the stress-strain assisted hydrogen diffusion in wires towards creation the conditions for HE nucleation. Generated results prove the relevant role of residual stress-and-strain field in hydrogen diffusion in the wires, as well as their possible consequences for HE.

INTRODUCTION

Prestressing wires are susceptible to surface cracking, in particular of the stress corrosion origin. Environmentally assisted fracture of prestressing steels has been the subject of extensive studies on the importance of hydrogen embrittlement (HE) in

material damage (Toribio and Elices [1]). With regard to manufacturing factors affecting the strength and life of prestressing wires, apart of the properties of material *per se*, the issue of residual stresses is essential [1]. The pioneering work [1] established an important milestone by establishing a quantitative relationship between the *level* of near-surface residual stresses, represented by *hypothetical* stress distributions, and HE of prestressing steel wires. However, due to lack of necessary data, the influence of *realistic* residual stress profiles or the effects of plastic strain on HE have not been elucidated yet. This paper goes further in the analysis, so the earlier developed model [1] is advanced to analyze the influence of the residual stress-*and*-strain profiles on hydrogenation of cold drawn prestressing steel wires.

FAILURE ANALYSIS ON ELBOW TUBE IN PETRO-CHEMICAL PLANT

*Hafizal Yazid, Mohd B. Harun, Zaiton Selamat, Shariff Sattar and Muhamad Jalil

The elbow tube was found to have leakage. The immediate action was to cover the leakage region with black tar material and clamped metal sheet to protect the liquid flowing out from the leakage. However, after long period of operation the leakage still occurs. It was dismantled from the plant on 10 December 2005. The leakage pipe was sent to MINT Material Laboratory for investigation on 13 Mac 2006. When the clamp metal sheet and black tar material was removed, it was found a large hole on the tube. This paper describes the results of investigation that was performed to determine the cause of the failure.

INTRODUCTION

Plant shut down necessitates immediate repair and maintenance acitivities that cause delay in the production process and considerable financial losses [1]. Statistical surveys revealed that 48-60% of failures were caused by overheating and 15-20% were caused by various mode of corrosion [2]. Frequently, both mechanisms are related to one another and present to accelerate the failures. The objective of this paper is to establish the most probable cause that lead to the failure of elbow tube.

The approach adopted was to assess the failure sample by three modes of investigation, namely visual examination, chemical composition analysis and microstructural examination. Visual examination is carried out to have an overall and close-up view of the failed sample. Overall view is achieved by digital camera.

Close-up examination is carried out using stereomicroscope. Chemical composition is obtained by spark emission spectrometry. Microstructural examination is carried out by optical and scanning electron microscope. The etchant used was Glyceria.

GLOBAL VS. LOCAL CHARACTERIZATION OF CRACK GROWTH IN BIAXIALLY STRETCHED PLATES

V.P. Naumenko[1], S.V. Lenzion[1], and A.G. Atkins[2].

The results of global and local characterization of plane stress tearing resistance at widely different in-plane constraint states are compared in an effort to demonstrate a need for comprehensive and unified description of crack profiles in variously stiffened specimens.

INTRODUCTION

A wide consensus exists in the fracture mechanics community that a single-parameter characterization of self-similar crack growth is conceptually possible. So there are good reasons to quantify the material resistance to Steady State Tearing (SST) solely by a constant value ψ_t of the Crack Tip Opening Angle (CTOA) (Schwalbe et al. [1]). Now, it is of scientific and practical interest to measure CTOA-ψ_t for SST cracks growing at widely different constraint states. In this respect, hydraulic bulging offers a suitable basis for characterization of resistance to SST in thin-sheet metals. This type of biaxial tests simplifies measurements of the local fracture parameter (ψ_t) together with the global ones, namely, with the Crack Mouth Opening Angle (CMOA-η), Crack Opening Angle (COA–γ), and Steady State Tearing Angle (SSTA-α), which were introduced by Naumenko and Atkins [2], Naumenko [3], and Naumenko and Lenzion [4].

A PARAMETRIC STUDY OF MULTI-STAGE AUTOFRETTAGE IN METAL TUBES

Muddasar Khan[*] Afzaal M. Malik[*] Shahab Khushnood[**] Musarrat Khan[***]

Thick-walled cylindrical pressure vessels are commonly used in power, nuclear, chemical, armament and food industries as boilers, nuclear reactor vessels, high-pressure containers, and gun barrels. The autofrettage process can be applied to such cylindrical pressure vessels in order to induce favorable residual compressive stresses at the inner surface of cylindrical vessel to

increase its load-bearing capacity. A process for enhancing the strength of thick-walled cylinders has been in service, and is referred to as "autofrettage". It extends the service life of the cylinder. The autofrettage is achieved by increasing elastic strength of a cylinder with various methods such as hydraulic pressurization, mechanical swaging, or by utilizing the pressure of a powder gas. This research work deals with the swage or mechanical autofrettage of metal tubes. The objective is to attain an enhanced strength of metal tubes through mechanical autofrettage. Two metal tubes are taken randomly for analysis purpose. The experimental data for five metal tubes is obtained to analyze the behavior of different parameters used during, before, and after mechanical autofrettage. For this research, two-stage autofrettage is taken into consideration. The modeling of the metal tube is carried out in Autodesk inventer5 and for analysis purpose, finite element software COSMOS WORKS and ANSYS7 are used. The graphical analysis of swage autofrettage is carried using MATLAB7. The experimental data is tabulated both for swage autofrettage of metal tubes, A mathematical model is developed including Bauschinger effect and the appropriate failure criteria. Numerical simulation of the mathematical model has been carried out using finite element method. And results are validated using available experimental and numerical data.

INTRODUCTION

Autofrettage is an effective technique of increasing the strength of thick-walled cylinders. This process has a vast application in automobiles industry of HDI (high diesel injection diesel engines, common rail system distributions (ramps, spheres) and conductors), aircraft industry, arm industry and nuclear fields. Malik [1] has outlined the salient features of swage-autofrettage process on a thick-walled cylinder. Generally the work reported in literature is based on steady-state autofrettage analysis. There have been very few time-dependent analyses attempts [2, 3, and 4]. Malik M.A., Khan Muddasar [5, 6, 7 and 8] has done experimental and numerical work related to mechanical autofrettage process.

ANISOTROPIC FRACTURE PERFORMANCE OF COLD DRAWN WIRES

J. Toribio* and F.J. Ayaso**

The work studies the anisotropic fracture behavior of cold drawn prestressing steels that exhibit exfoliation fracture consisting of oriented and enlarged cleavage, its orientation being parallel to the cold drawing axis and with river patterns in such a direction. Using computer-assisted image analysis, a geometric relationship was found between this special cleavage and the

conventional cleavage surface, which indicates that the fracture micromechanisms in both cases are also similar and allows a definition of the critical fracture unit in the drawn material as the pearlite colony more than the prior austenite grain. Thus the slender pearlitic colonies become the actual microstructural fracture units and determine the size of the enlarged cleavage facets characteristics of exfoliation fracture in cold drawn steels.

INTRODUCTION

Cold drawing is used to produce prestressing steel wires for prestressed concrete used in civil engineering. This manufacturing technique affects the steel microstructure in the form of microstructural orientation in the cold drawing direction (Embury and Fisher [1], Langford [2], Toribio and Ovejero [3]) thus leading to crack deflection and anisotropic fracture behavior (Cherry and Price [4], Sarafianos [5], Toribio and Lancha [6]).

A FATIGUE CRACK GROWTH OF ALUMINUM ALLOY BY SURFACE HARDENING

Tae Hoon Song*, Man Bae Lim**, Sun Chul Huh**, Won Jo Park†

This study is to investigate the effect of compressive residual stress on the fatigue crack growth characteristics. [1] Additionally we found the optimum shot peening condition. Shot peening was performed on velocity of 40 m/s, 50 m/s and 70 m/s. Compact tension specimen are Al7075-T6 and Al6061-T651. Fatigue crack growth rate ware expressed at crack tip as stress intensity factor range that is da/dN and ΔK. Frequency was 10 Hz and used sinusoidal. The result show that the fatigue characteristics was improved by shot peening. Also the optimum shot velocity condition was 50 m/s at Al7075-T6 and 40 m/s at Al6061-T651.

INTRODUCTION

Nowadays, many components used in machine industry are required light weight design and high strength. The high strength materials have the problem which the propagation rate is fast when the crack exists. Shot peening is an effective method to improve the fatigue characteristics of metal. The compressive residual stress generated by shot peening. Hammand and Meguid report that compress residual stress delay the fatigue crack growth at initial crack growth so shot peening effective the fatigue crack growth. [2] In this study, peening and un-peening materials were used to investigate on fatigue characteristics by fatigue test(MTS-810).

MICROSCOPIC MATERIAL CHARACTERISTICS GOVERNING THE MACROSCOPIC FATIGUE PERFORMANCE OF COLD DRAWN WIRES

J. Toribio*, B. González**, J.C. Matos** and F.J. Ayaso**

This paper analyzes how the cold drawing process influences the fatigue behaviour of eutectoid steel, with special emphasis on the role of microstructural changes induced during such a manufacturing process. Fatigue cracks are transcollonial and exhibit a preference for fracturing pearlitic lamellae, with non-uniform crack opening displacement values, micro-discontinuities, branchings, bifurcations and frequent local deflections that create microstructural roughness. The net fatigue surface increases with cold drawing due to the higher angle of crack deflections.

INTRODUCTION

High-strength prestressing steel wires are one of the two constituents of prestressed concrete structures and frequently subjected to fatigue loading. To obtain high strength, this materials are manufactured from a previously hot rolled bar with pearlitic microstructure which is heavily cold drawn in several passes to obtain the commercial prestressing steel wire with increased yield stress and ultimate tensile strength as a consequence of a strain-hardening mechanism. Thus, the final product has undergone strong plastic deformations which modify drastically its microstructure at the two basic microstructural levels, namely the pearlite colony and the pearlitic lamellae (Embury and Fisher [1]. Langford [2], Toribio and Ovejero [3-6]) in the form of progressive slenderizing and orientation of the colonies quasi-parallel to wire axis or cold drawing direction [3,4] as well as increasingly closed packing and orientation of the lamellae also in the drawing direction [5,6].

FATIGUE ASSESSMENT OF WELDED TUBULAR STEEL STRUCTURES DETAILS BY USING FEM

RM Natal Jorge*, MPL Parente*, AA Fernandes*(1)

Fatigue failures typically begin at high stress concentration locations, at weld terminations of specific structural details. Welded steel structures design can involve very complex details. Due to the complexity of the details, the simplified methodologies of codes cannot be used directly in the fatigue design

and Finite Element Method analyses have to be used.. The limitations of the classical S-N fatigue analysis used in current codes of practice and in particular the uncertainty in the characterization of the loading on the structure are discussed.

INTRODUCTION

Fatigue and fracture are at the root of more than 80% of the failures in steel structures. Brittle and ductile failures subsequent to fatigue cracking can occur in welded steel structures, mainly because specific details have a lower fatigue resistance than foreseen at design stage. Once the design of a structure is finished, there is little room for improvement of the fatigue life, during the fabrication process. Thus to obtain an optimal cost design, the total costs should be considered, including not only the fabrication costs but also costs associated to inspection during construction and in-service inspection, assuming that the consequential costs due to structural collapse are not acceptable. It is well documented that the costs due to changes of design parameters, carried out at the beginning of a project, are a fraction of the costs incurred if defects are detected during fabrication or if fatigue and/or fracture cracks develop in-service. Thus fatigue reliability evaluation is of crucial importance for the design and management of steel structures. Fatigue failures typically begin at high stress concentration locations, at weld terminations of specific structural details such as stiffeners, reinforcements, attachments, secondary brackets, due to the presence of secondary stresses or out of plane bending, and less frequently by the presence of large internal defects in the welded joints. Welded steel structures design can involve very complex details, specially when aesthetic factors rather than functionality dictate the design of the structure. In this context, steel tubular hollow sections are being used by designers as structural elements. The concept design adopted uses very complex nodes with a high number of intersecting members, thus creating very complex stress fields and high stress concentration spots. Due to the complexity of the details, the simplified methodologies of codes such as Eurocode 3 [1] or BS5400 [2] and others such as IIW [3], cannot be used directly in the fatigue design and more refined 3D Finite Element Method analyses have to be used to calculate the structural hot spot stress range at the weld toe [4].

THE EFFECT OF WELD'S GEOMETRY IN FRACTURE OF WELDED FLANGE PLATE CONNECTION IN I.R. IRAN

Tahuni SH.[1]; Nouri H.[2]

Failure of the CJP groove weld at the top and bottom plates in welded flange plate (WFP) connection is the main cause of the observed damages in Iranian steel structure. In steel skeleton sites, welding of top and bottom plates is

always encountered with some problems. Sometimes, due to lack of awareness of contractors of the importance of CJP groove weld the preparations of the plates are not performed properly in construction. In addition, the inspectors ignore to check the welds because of the height. These are the main cause of not having a perfectly penetrated weld in CJP groove weld. Moreover, when the inspection is done and the flaws are observed, instead of grinding the welds, they are strengthened by fillet weld. In some cases, the fillet weld is used. In this paper, by the means of static and dynamic tests on specimens of top and bottom plates, different method of welding are compared and discussed.

INTRODUCTION:

Pre Northridge, California Earthquake, more than 100 steel buildings with welded moment-resisting frames were found to have experienced beam-to-column connection fractures. [1] Traditionally, these connections were designed based on the hypothesis that the moment in the connection is transferred to column by a force couple through the flanges, and the shear through the web. This hypothesis cannot show the distribution of stress in the connection, therefore, the performance of connecting elements, and specifically the CJP groove welds, is not predicted.[2] These connections utilize plates to connect the beam flanges to the column flange, without any direct connection of the beam flange to the column flange. The flange-plate-to-column-flange joint is a complete joint penetration groove weld. The flange plates are fillet welded to the top and bottom of the beam top and bottom flanges, respectively. FIGURE 1 provides a typical detail for this type of connection. The WFP connection was tested at the University of California at Berkeley. The connection has similarities to both the cover plated connection, which has been extensively used, and to the WUF-W connection. Its performance is comparable to that of the WUF-W. This connection, rather than the cover-plated connection commonly used from 1994 until publication of FEMA-267A, has been recommended for use in new buildings, because the welding of a single thickness of plate is considered to be more reliable than the welding of the combination of the beam flange and a cover-plate. [3]

INFLUENCE OF STRUCTURAL DEFECTS ON THE BENEFICIARY EFFECT OF AUTOFRETTAGE

S. Hadidi-Moud[1, 2] and H. Makari[1]

A comprehensive numerical study has been carried out to explore the influence of part through cracks of various size and orientation in a thick welded ferritic steel cylindrical vessel, on the beneficiary effect of autofrettage loading (AF).

The results suggest that in presence of cracks, the localised near crack tip residual stress fields interact with in service stresses and influence the enhancement in load carrying capacity of autofrettaged vessel. Furthermore it is concluded that depending on the crack/loading configuration the influence varies from noticeable in some cases to marginal in others to negligible for cases where the crack tip is not significantly disturbed by the service loads.

INTRODUCTION

The beneficiary effect of AF loading on the load carrying capacity of pressurised defect free vessels is well established. This is mainly due to the residual stresses arising from plastic deformation induced in the vessel due to AF. This issue is widely addressed in literature. Examples include the investigation of the Bauschinger effect as well as generalised three dimensional elastic-plastic stress and strain field solutions (Parker [1], Perry and Aboudi [2] and Perl. and Perry [3]).

A CDM-BASED STUDY OF FATIGUE-CREEP INTERACTION BEHAVIOR

FAN Zhichao[1**], CHEN Xuedong[1], CHEN Ling[2], JIANG Jialing[2]

Based on the ductility dissipation theory and effective stress concept of continuum damage mechanism, a new fatigue-creep damage model is developed. As to 1.25Cr0.5Mo steel, series of high temperature stress-controlled fatigue-creep interaction experiments were carried out, and the damage evolution laws under various conditions are derived. Results indicate that the damage model presented in this paper are applicable to describe the damage evolution of fatigue-creep interaction under stress-controlled mode.

0 INTRODUCTION

In industries, such as petrochemical, power, aeronautics and astronautics, plenty of machinery and equipments are subjected to low cycle fatigue (LCF) stresses at high temperature conditions. Therefore, effects of fatigue, creep and their interaction should be considered when damage assessments and life predictions are carried out[1].

Fatigue-creep(FC) interaction has been investigated by the Continuum Damage Mechanics (CDM) [2-6]. Most of these models have many constants, which must be obtained from pure fatigue, pure creep tests. This shortage restricts their application.

SEMI-ANALYTICAL ELEMENT METHOD FOR CONCRETE CRACK PROPAGATION BASED ON BILINEAR COHESIVE FORCE MODEL

ZHENG Chang-liang* and WANG Cheng-qiang**

The stiffness matrices and external force vectors of ring and circular singular hyper-analytical-element are formulated by substituting basic analytical solutions into variational equation in Hamiltonian form. The assemblage of the two hyper-analytical-elements leads to a precise description of the displacement and stress fields in the vicinity of crack tip for a cracked plane acted a bilinear cohesive force on the crack surfaces. Numerical results of benchmarks show the efficiency and accuracy of the method.

INTRODUCTION

Since the strip-yield model proposed by D.S.Dugdale in 1960 [1] and the cohesive force model by G.I.Barenblatt in 1962 [2], these simplified elato-plastic fracture models have been attracting many researchers' attention. As a consequence, the fictitious crack model (FCM) proposed by Hillerborg et al. in 1976 [3] and the crack band model by Bazant et al. in 1983 [4] for quasi-brittle materials like concrete. Simplified bilinear expressions of softening traction-separation law were presented by Hilsdorft and Brameshuber[5] and by Reinhardt and Xu[6]. This paper deals with semi-analytical finite element method for crack propagation problems based on bilinear cohesive force model.

RANDOM COEFFICIENT TVARMA MODEL WITH APPLICATION TO RELIABILITY ASSESSMENT FROM DEGRADATION DATA

MA Xiaobing**, LIN Fengchun†, ZHAO Yu*

Time-varying autoregressive moving average (TVARMA) model is widely used in non-stationary signal processing such as fault diagnosis, performance

test, automatic control and finance analysis, etc. However, the traditional TVARMA model can almost do nothing about multi-sample non-stationary time series in nonergodic condition. In this paper, random coefficient TVARMA models is established by randomizing coefficients of time-varying function, and used for reliability assessment from degradation data. In addition, the sample periodgram and multi-point averaging method is introduced to determine the function form of the time-varying coefficients, and then the integral function of the trend and the variance terms can be synthesized. The approach is an effective way to assess the reliability of highly reliable components and systems with small sample by monitoring performance degradation, as it is the most significant advantage that model building for degradation data is completely independent of degradation paths. Consequently, it can be applicable to a broad class of degradation models. An example of reliability assessment from crack propagation data is given at last, which can illustrate the superiority of the presented methodology.

INTRODUCTION

Reliability assessment for performance degradation data can be found in engineer for a variety of industrial materials and products. Degradation of metal properties, including creep, crack propagation, corrosion, oxidation and wear are failure mechanisms considered in these problems. Meeker W. Q. and Escobar L. A. [1] provide a good overview of random effects models for degradation analysis and reliability estimation. Much of this is based on the work of Lu C. J and Meeker W. Q. [2] on a general random effects model. But the degradation path curve approach can not be used to model degradation processes for many products as appropriate path curves based on physics are not known. Obviously, this approach requires a known physics model of degradation failure. If this is not available, a statistical model is needed to obtain the degradation path curve. However, the traditional approach based on degradation path is sensitive to statistical path model, Huang W. [3].

FATIGUE LIFE IMPROVEMENT AND PREDICTION FOR AS-WELDED AND PEENED CAR COMPONENT UNDER AXIAL-TORSIONAL LOADINGS

J.Z.LIU*, L.F.WANG*, W.H.LI++, L.Y.XIE+, L.J.CHEN+

Both shot and ultrasonic peening treatments were used to improve fatigue strength of a welded specimen. Fatigue tests were conducted under in phase

axial-torsional loading for three kinds of specimens. It is found that the ultrasonic peening is better than the shot peening for fatigue life improvement. Based on the testing data and FE analyses of the critical damage planes of the specimens, a new damage parameter was used to correlate well the fatigue lives for as-welded and the welded specimens with the ultrasonic peening treatment. Based on the relationship between the new damage parameter and fatigue lives obtained from the as-welded and peened specimens respectively, the FE results of a welded component were used to predict the fatigue lives of the component with and without the ultrasonic peening treatment. It is found that the predicted lives agree reasonably with the testing data for the as-welded component, the predicted fatigue life improvement of the welded component after ultrasonic peening treatment is obvious.

INTRODUCTION

Multiaxial fatigue is a particularly important issue in the assessment of welded automotive thin sheet structures. A rear axle of the passenger car SANTANA is a typical of welded thin steel sheet component. Although multiaxial fatigue problem for welded structures have been widely studied [1-3], so far, few studies on fatigue life prediction, and especially an assessment of life improvement method for the welded rear axle have been reported.

In this paper, a small welded specimen is designed to simulate the local loading condition near weld toe of the rear axle. Both shot peening and ultrasonic peening treatments are used to improve the fatigue strength of the welded specimen. Fatigue tests are conducted under in phase axial-torsional loading for three kinds of specimens, i.e., as-welded specimens and the welded specimens with two kinds of peening treatments. The ANSYS software is used to analyze the stresses and strains on the critical damage planes of both the base metal and welded specimens, and the welded rear axle. Based on the testing and FE results of the specimens, a new damage parameter is used to correlate the fatigue lives of the specimens under different loading cases. Based on the relationship between the new damage parameter and fatigue lives obtained from the as-welded and peened specimens respectively, the FE results of the welded rear axle are used to predict the fatigue lives of the welded component with and without the ultrasonic peening treatment.

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AN EXPERIMENTAL STUDY ON FAILURE OF ALUMINUM GAS-FILLED PRESSURE VESSELS UNDER HIGH-VELOCITY IMPACT

Guan Gongshun*, Pang Baojun*

In order to investigate failure mechanisms of thin-walled aluminum pressure vessels under hypervelocity impact of space debris, a non-powder two-stage light gas gun was used to launch Al-sphere projectiles impacting on unshielded and shielded vessels. Damage patterns and mechanisms leading to catastrophic rupture are discussed. Experimental results indicate that impact kinetic energy of projectile and gas pressure in vessel are important factors affecting the damage modes of vessel. On the one hand, high pressure gas can lead to vessel blast. On the other hand, high pressure gas can mitigate the impact of the debris cloud on the rear wall of the vessel. Catastrophic rupture of unshielded gas-filled vessels can be avoided when the impact energy is less than a certain limit value. When the bumper is perforated, damage of shielded pressure vessel might be fatal for vessels with high gas pressure.

INTRODUCTION

Pressurized vessels are widely used on board of spacecraft. A pressure vessel subjected to hypervelocity impact by meteoroids and orbital debris can represent a significant hazard to spacecraft because of the energy stored within the vessel (Swift [1] and Schaefer et al [2]). Impacts of particles on pressure vessels that result in catastrophic failure were extensively investigated during the past years (Olsen et al [3] and Christiansen et al [4]). Results showed that damage can range from simple wall plate perforation to severe rear wall side cratering, perforation, bulging, cracking, to in the worst case, complete rupture of the pressure vessel in several pieces. Damage intensity is shown to depend critically on kinetic impact energy and vessel pressure. The use of a shield can significantly decrease the probability of a catastrophic failure (Palmieri et al [5]), thus reducing the hazard to the surrounding components and the generation of additional debris. In this study, impacts on unshielded and shielded vessels were investigated experimentally in a systematic manner to generate a large database of impact results and enable a better understanding of the processes that occur upon impact of hypervelocity particles on pressure vessels. Results showed that two main types of pressure vessel catastrophic failure are likely to occur: pressure vessel fracture from the front side and failure from the rear side. Damage intensity

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was shown to depend critically on kinetic impact energy and vessel pressure.

DOMAIN-INDEPENDENT VALUES OF THE *J*-INTEGRAL FOR CRACK IN WELDS SUBJECT TO MODE-I LOADING

Chin-Hyung Lee[†], Kyong-Ho Chang[*], Gab-Chul Jang[**] and Hyun-Chan Park[*]

This paper describes an approach for computing domain-independent values of the *J*-integral for crack in welds subject to Mode-I loading. For the analysis of crack in welds, residual stress analysis and fracture mechanics analysis must be performed sequentially. In this study, residual stresses in welds are obtained by carrying out three-dimensional thermal elastic-plastic FE analysis. Then, FE analysis method which is able to calculate domain-independent values of the *J*-integral for crack in three-dimensional residual stress bearing bodies is developed to evaluate the *J*-integral for mode-I centre-crack in welds when mechanical Mode-I loading is superimposed on the residual stress field. It is shown that the *J* value for the case when mechanical stresses are superimposed on the residual stresses is larger than that for the case when only residual stresses are present.

INTRODUCTION

Welding is a reliable and efficient metal joining process in the production of many engineering and structural components. However, due to the localized heating and subsequent cooling, welding process induces undesired residua stresses. Welding residual stresses can have various kinds of influences on the integrity of the welded part. Therefore, it is very important to predict welding residual stress and its effect on structural failure behavior in the analysis of fracture of the structure.

In the elastic-plastic fracture mechanics analysis, the *J*-integral [1] is generally adopted as the fracture parameter to characterize the severity of a crack tip [2-3]. However, studies on the *J*-integral for crack which is subject to residual stresses or the combination of residual and mechanical stresses have been scare in the open literature.

Therefore, the objective of this study is to analyze the residual stress distribution developed in and

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around the weld by the thermal cycles during welding and to determine domain-independent values of the *J*-integral for mode-I crack in welds by three-dimensional FE analysis.

FRACTURE BEHAVIOR OF LASER ZONE-REMELTED METASTABLE EUTECTIC AL_2O_3/YAG/ZRO_2 *IN-SITU* COMPOSITE

Haijun Su*, Jun Zhang, Lin Liu, Hengzhi Fu

The microstructural features and fracture behavior of metastable eutectic Al_2O_3/YAG/ZrO_2 *in-situ* composites grown by laser zone-remelting technique are studied. The microstructures of the composites are investigated using SEM, EDS and XRD. Fracture toughness and crack propagation behavior of the composites are examined using the Vickers indentation technique. The metastable eutectic consists of Al_2O_3, YAG and ZrO_2 phases, showing a typically refined irregular lamellar eutectic structure with eutectic spacing as fine as 0.5μm. The fracture toughness of the metastable eutectic Al_2O_3/YAG/ZrO_2 is 3.9±1.0 MPa·$m^{1/2}$. The addition of ZrO_2, crack deflection and microcrack toughening are the predominant toughening mechanisms.

INTRODUCTION

Directionally solidified oxide eutectic *in-situ* composites have attracted a lot of attention because of the outstanding flexural strength, thermal stability and creep resistance at elevated temperatures [1], which prompts a wide search and development of new eutectic oxide ceramics on a global scale. Among a variety of oxide eutectics, directionally solidified Al_2O_3/YAG eutectic ceramic has been demonstrated as one of the most promising candidates of a new generation of ultra-high temperature structural materials serving in oxidizing environments over a long period of time in the field of aerospace, aeronautics and high-efficiency power generator systems due to the excellent mechanical properties up to nearly the melting temperature [1, 2].

However, one important limiting property for the widely practical use of this kind of eutectic is its low room fracture toughness because of the strong interface bonding between the eutectic phases [1]. In order to further improve the mechanical properties, much more attention has been recently paid to the Al_2O_3/YAG/ZrO_2

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ternary eutectic composition with obviously increased toughness [3]. Nevertheless, the study about the metastable eutectic composition has seldom been reported up to now, which is highly required for better understanding the ternary system and further improve the properties. With laser zone-remelting technique, the present study aims to rapidly prepare the metastable eutectic Al_2O_3/YAG/ZrO_2 *in-situ* composite reinforced with a ZrO_2 phase by controlling the microstructure using a eutectic reaction in the Al_2O_3-Y_2O_3-ZrO_2 system, and characterize the mechanical behavior of the metastable eutectic Al_2O_3/YAG/ZrO_2.

SUBJECTED TO ECCENTRIC PATCH LAODING

Guo Peng*, Guo Chengxi

Based on the latest experimental study, the load carrying capacity of the thin–walled steel I-girder subjected to eccentric patch loading has been analyzed in this paper. And a new predicting expression is proposed to determine the load carrying capacity of the thin-walled steel I-girder subjected to eccentric patch loading in this paper. The comparison of the calculating results obtained from the new predicting expression with the test results shows that the new proposed expression is reasonable and conservative.

INTRODUCTION

The thin–walled steel I-girder subjected to eccentric patch loading has been analyzed in this paper. Patch loading is the loading which is applied in a small area. And the web of the girder is locally compressed in this loading. This is a very complex problem about elasto-plasticity and geometry nonlinearity.

So far, more than thirty tests have been carried out and more than twenty-five mathematic models or experiential expressions have been proposed in the world. But there are still many problems that have not been settled. The parameters influencing the load carrying capacity of the thin-walled steel I-girder subjected to eccentric patch loading are still not clear. And the expressions predicting the load carrying capacity which can be applied in the real engineering are not perfect.

In 1972, M.Z.Khan [2] used the simplified energy method to educe the calculating formula for the elastic buckling load of the four-side simply supported plate under local compressive loading. In 1975, Mohammed Z.Khan and Kenneth C.Johns [3] adopted the four-side simply

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supported plate model and the energy method to present the correlated curve of the critical stress of the elastic buckling of the web under moment, shear and local compressive loading. In 1997, T.M.Roberts and A.C.B.Newark [4] carried out a research about the load carrying capacity of the thin–walled steel I-girder subjected to centric patch loading in the midspan or in the supports and presented the formula for calculating the load carrying capacity. In 2000, F.Shahabian and T.M.Roberts [5] revised the calculating formula for the load carrying capacity of the thin–walled steel I-girder subjected to centric patch loading presented by T.M.Roberts and A.C.B.Newark in 1997. *Code for design of steel structures* (GB50017-2003) [6] modifies the calculating formula for the local buckling stress of the web of the welded steel I-girder, but the eccentricity of the loading is not taken account of in this code. In 2004, the elastic local buckling of the web of the steel I-girder subjected to centric patch loading was analyzed by Ren Tao and Tong Genshu [7] in Zhe Jiang University, and the correlated calculating formula was presented.

THE UNIAXIAL FATIGUE CHARACTERISTICS AND FATIGUE FRACTURE OBSERVATION FOR AN A356-T6 ALUMINUM ALLOY

Xiaoshan Liu[1], Guoqiu He[1,*], Songjie Fan[1], Qigui Wang[2]

In this paper, the uniaxial fatigue properties of an A356-T6 aluminum alloy under different stress amplitudes was tested and analyzed. The fatigue life under different stress amplitudes and the cycled hardening conditions during the fatigue process were carefully observed. Besides, the cross-stress-loading uniaxial fatigue of this alloy was also carried out and compared with the single-stress-loading uniaxial fatigue. The fatigue fracture was then carefully examined with the method of SEM (Scanning Electron Microstructure). The EDX (Energy Dispersive X-ray) method was also used here to identify the element composition of the inclusions in the alloy. The inner microstructure of the fatigue fracture was observed by TEM (Transmitted Electron Microscopy), in which the dislocations and precipitates were detailedly displayed and analyzed.

INTRODUCTION

The fatigue properties was a main factor to effect the utility of A356 aluminum alloy, and many researchers [1-10] has studied it in the past decades. In this paper, a

certain cast A356 aluminum was chosen to have its uniaxial(tension-compression) fatigue properties tested. As the prior work of a systematical study of the fatigue properties for the A356 alloy, its results and conclusions can make the preparation to the following multiaxial fatigue research. In the paper, the uniaxial fatigue properties of the alloy under different stress amplitudes were tested. Besides, the cross-stress-loading uniaxial fatigue of this alloy was also carried out and discussed. The fatigue fractures were examined with the method of SEM. And the inner microstructure of the fatigue specimens was observed by TEM. Especially, the microstructure evolution during the fatigue process was displayed by the TEM study.

THE FINITE ELEMENT ANALYSIS OF TRAIN BOGIE WELDING CRACK UNDER DYNAMIC LOAD

Cheng Kai, Li Qihan, Liu Jianmin,Ju Haomin,Ji Youmhang

In the paper finite element model is built based on train bogie welding frame of some factory. According to the straight way, the curve way and the slope way, dynamic load is loaded in Ansys finite element analysis. By seeing about the stress and strain state of the welding line in post-process, reasons and laws are analyzed, furthermore, corresponding reformative methods are put forward.

INTRODUCTION

The bogie welding skeleton analyzed in this article is some factory's DF4D overhaul locomotive, after its decomposition the crack of the bogie welding skeleton is discovered, the repair must be carried on. In order to be convenient for the repair and the examination, this article used the finite element method to carry on mechanics analysis, discovered reasons and rules which the crack produced, and proposed the practical feasible improvement program according to this result, after several years' actual confirmations, the locomotive movement is good.

FRACTURE ANALYSIS OF THE FRONT EDGE OF COMPOSITE WAINSCOT

FAN Jinjuan[1], TAO Chunhu[1], ZHANG Baocai[2], ZHAO Xu[1]

The front edge of a composite wainscot fractured during service. The fracture mode and fracture course of the front edge of the composite wainscot are analyzed by inspecting the appearance and the fracture surface. Furthermore, static experiments, finite element analysis and nondestructive examination were carried out and the reason of the fracture of the composite wainscot was concluded. The author suggest that whether technological operation can satisfy the demand of structure integrity and accidental external loads should be paid more attention in design of the structure of the composite materials.

1. INTRODUCTION

Advanced carbon fiber reinforced composites appear great advantage and high-tech characteristics in structural design, fabrication process, mechanical properties and service environment，and have become widely used engineering structural materials[1]. With increase of the application of composite materials, damage and failure are unavoidable. And the failure of these composite material parts may lead to structure collapse [2~3]. There are great differences between the damage and fracture of composites and that of metals [4]. Most fractures of metals under static and cyclic loadings were caused by the origin or propagation of single crack or several cracks. Failure modes of metals are relatively simple, but are complicated to composites, which are relied on many parameters and resulted from the interaction of many failure modes such as matrix crack, interface debond, fiber breaking and delamination. For the complexity of composite failure, specialists in this field hope to look for the reason of failure resort to fracture surface analysis. AFRL and RAF [5,6] had listed special topics to investigate the failure mechanism and the characteristic of fracture surface in order to analyze the failure of composite parts, and had got some progress.

In this paper, fracture surface inspection was used to analyze the fracture of front edge of one type of composite wainscot which occurred in service. Fracture mode of composite wainscot was determined by fracture characteristic analysis. Accompany with static test, finite element analysis and non destructive testing (NDT) , the fracture course and reasons were analyzed. Conclusion of this paper can provide information for structure design and improvement of composite wainscot.

ANTI-FATIGUE DESIGN OF ULTRASONIC BONE CUTTER BASED ON FINITE ELEMENT METHOD

Ying Chen*, Zhaoying Zhou^

For ultrasonic bone cutters used in precise bone surgery, reliability and life is especially important because patient's life is priceless. To solve the crack problem of ultrasonic saw cutter, reasons of crack are analyzed. Stress decentralization measures are taken to optimize the structure of ultrasonic bone cutter, FEA (Finite Element Analysis) method is used to analyze stress distribution before and after structure improvement. Life of bone cutter is measured by statistical experiments, which shows after structure improvement, the total working time of the bone cutter is 7 times longer than the original structure.

INTRODUCTION

Power ultrasonic has been applied in surgery for over fifty years. Many kinds of ultrasonic surgery scalpels have been developed, including ultrasonic dentistry tool to wash teeth[1], phacoemulsification scalpel to aspirate cataract, aspirator to fragment tumor and other pathological tissues [2-3], soft tissue cutter to cut blood vessel [4], and bone cutter to incise bone [5-9] etc. Limited by size and shape, ultrasonic bone cutters have structures tending to bring stress concentration, and then crack will generate and the bone cutter will break. In late 1980's, Russian began to develop ultrasonic bone cutter. They found that teeth knife is easily to fragment tissues while it is fragile. In Japan, bone cutters without teeth were developed, their disadvantages are slippery and difficulty to control when cutting [8]. Researches about designing ultrasonic tools with analytical method [8], equivalent circuit method and FEA method [10-15] have been carried out, performance and loading characteristic of ultrasonic surgery tools [7,9,16] have been studied, yet no report has been found to solve the crack and fatigue problems for the ultrasonic bone cutter. Solving of tool safety problem will greatly accelerate the commercialization and clinical application of ultrasonic bone cutter. In this paper, FEA software ANSYS is utilized to solve the fatigue problem.

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ELIABILITY ANALYSIS OF THE STOCHASTIC STRUCTURAL SYSTEM FOR STATIC STRENGTH AND STIFFNESS BASED ON THE CUMULATIVE DAMAGE

ZHAO Wei-tao*, YU xiu-kun, XU xiao-feng

Based on the understanding of passive impact of cumulative damage induced by fatigue load on ultimate static strength and stiffness of structural system, the paper gives expression of residual static strength and stiffness by the form of cumulative damage and analyzes its digital character. A numerical example is indicated that the fatigue reliability index of structural system can fulfils the demand of fatigue reliability in the design life, but the static strength and stiffness reliability index of structural system descends with the increase of the service life, and the static strength or stiffness reliability index not fulfils the demand of the design when the service life over some numbers. Thus, the structural system reliability of static strength and stiffness analyzed considering the cumulative damage is essential.

INTRODUCTION

In general, there are many factors effecting on the structural system reliability, for example, load and yang module, size of element etc. At present, the static strength and stiffness reliability analysis of structural system have processed a large number of studies [1-3], and the literature [4] and [5] have given analysis method with considering static strength and fatigue and stiffness of structural system. But, the study of cumulate damage by fatigue load influence on the structural static strength and stiffness was not many. In fact, the deterioration of the structural static strength and stiffness was effected by the fatigue load, it must affect the structural normally using need. For many aviation and space flight structures, the structural reliability of static strength and stiffness fulfils need at initial structural design, but along with service time increase, the structural static strength and stiffness deteriorated by fatigue load, and then it is likely to the lack of static strength or stiffness leads to the structural failure. In the paper, based on the understanding of passive impact of cumulative damage by fatigue load on static strength and stiffness of structural system, the paper gives expression of residual static strength and stiffness by the form of cumulative damage and analyzes its digital character. The paper makes the sensitive analysis by stochastic finite element method and gives the reliability analysis

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method of the stochastic structural system for static strength and stiffness based on the cumulative damage.

FUZZY RELIABILITY APPROACH TO PREDICT FATIGUE LIFE OF AIRCRAFT STRUCTURE AND EXPERIMENTAL VALIDATION

TAN Xiaoming, MU Zhitao, CHEN Yueliang, JIN Ping

The failure process of aircraft structure under corrosive environment is significantly complicated; there are not only random factors but also fuzzy factors. According to the failure mechanism and fracture mechanics, the failure process was divided into three stages, namely pro-corrosion stage, pit growth, short fatigue crack growth and long fatigue crack growth. Based on fuzzy mathematics, a fuzzy reliability model to predict corrosion and corrosion fatigue holistic life of aircraft structure. The dog-bone fatigue specimens were machined from the military retired aircraft skin, which had serviced for more than twenty years at a high temperature, high humidity and high salt fog airport. The specimens were tested in laboratory air with different stress ratio and stress level, and the residual lives were obtained. By comparing test lives with calculating lives, the rationality and feasibility of the model was verified. The results show that they agree with each other to some extent.

Harlow and Wei[1] proposed firstly that corrosion fatigue life of aircraft structure should be composed of the three stages: crack nucleation life, surface crack growth life and through crack growth life; and a probabilistic model was established. Vasudevan[2] thought that the fatigue life should be sum of four stages. And a seven-stage probabilistic model was proposed by Shi[3-4]. However, there were two limitations of these models. Firstly, they were all based on constant amplitude spectrum, without consideration for the effect of stress ratio on fatigue life. Secondly, the models have not been validated by experiment.

The aircraft in question has serviced for more than 20 years in a costal airport which is high temperature, high humidity and high salt fog. The corrosion damage behavior is typical among the navy aircrafts. The fatigue coupons were machined from the skin structure that did not endure load. All the fatigue tests were performed with different stress ratio through Material Test System 810. It was supposed that the corrosion and fatigue failure process include pre-corrosion stage, short crack stage

and long crack stage, a fuzzy reliability model to predict fatigue life was established. The residual life was computed using Monte Carlo method. And the predicted result was compared with the testing result. Furthermore, the feasibility and correctness of the fuzzy reliability model was verified.

RELIABILITY JIS CIRCUIT OF PNEUMATIC REGULATOR

MA Jungong * , CHU Dandan * , ONEYAMA Naotake * *

In order to evaluate JIS test circuit of pneumatic pressure regulator, some items had been tested, such as step response, valve opening, feasible opening frequency, air consumption, cycle response and so on. The results show that, regardless of test circuit specifications, the regulator always repeats full closing and full opening. The relief valve of the regulator operates too. At the same operating frequency, air consumption is one sixth of ISO/CD circuit. In the end, improved circuit was put forward as an ISO reliability circuit of pneumatic pressure regulator.

INTRODUCTION

Pneumatic pressure regulator is an important element in pneumatic fluid power systems; its performance determines the system's performance, so its reliability must be grasped. However, there were no evaluating standard and test methods in ISO standard. The JIS test circuit about the reliability test circuit of pneumatic pressure regulators had been put forward to Technical Committee ISO/TC 131in 2005. In order to evaluate it, some items had been tested, such as step response, valve opening, feasible operating frequency, air consumption and so on. In the end, an improved test circuit had been put forward as the scheme of ISO reliability test circuit of pneumatic pressure regulators.

APPLICATION OF MORPHOLOGY FILTER IN THE EARLY FAULT DIAGNOSIS OF ROLLING BEARING ACOUSTIC EMISSION SIGNALS

Rujiang Hao*,#, Wenxiu Lu* and Fulei Chu*

In this paper, the experiments were carried out in the rolling bearing test rig in the lab. The AE signals were collected by the AE sensors. Morphology filter is used to process the AE signals collected from the defective rolling bearing then the fault frequency characteristics are obvious in the frequency spectrum. The morphology filtering method has high efficiency and simple algorithm. It is fit for early and online diagnosis of the rolling bearings.

INTRODUCTION

Rolling bearing condition monitoring has received considerable attention for many years. The classical failure mode of rolling bearing is localized defect. Failure alarms for a rolling bearing are often based on the detection of the onset of defect. Acoustic emissions (AE) are defined as transient elastic waves generated from a rapid release of strain energy[1]. The formation of subsurface cracks owing to the contact stress induced by the rolling action of the bearing elements will generate AE activity. AE signals originating from the defect location will incur significant attenuation across the transmission path to the receiving AE transducer. As for the early faults, the size of the defects is very small and the failure AE signal is so weak as to emerged in the background noise. The original signal must be preprocessed and the noise must be eliminated before analysis.

Morphology signal processing comprises a broad collection of theoretical concepts and mathematical morphology tools for signal analysis[2,3]. The traditional tools of linear systems and Fourier analysis are of limited use for solving geometry-based problems. Contrarily, morphology signal processing is perfectly able to quantify all aspects. However, applications of morphology processing to mechanical engineering are relatively unknown except for some analysis to EGG signals[4] and power transmission line protection[5].

In this paper, firstly, an introduction on basic concepts of mathematical morphology is provided in section 2. Then, the different morphological operators are used in the simulated signals and measured signals with defective bearing in section 3.

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The conclusion is drawn in section 4.

STUDY ON THE NDT OF C/C COMPOSITES

Liao Xiao-ling*, Xu Wen-feng, Gao Zhiqiang, Song Zhong-rong

Carbon/carbon composites (C/C composites) are the only material that can maintain high strength and toughness up to high temperatures of more than 3000 K. Thus, it has been considered as the most promising candidate for high temperature structural material for various purposes. Modern nondestructive testing (NDT) technology has been a reliable artifice for inspecting quality and security of material. As preferred high-temperature structural materials, the NDT play an important role in development for C/C composites. In this paper, the research on NDT of C/C composites was reviewed and the characteristic of these NDT methods were summarized.

INTRODUCTION

Carbon-carbon composites with continuous carbon fibers are used for high-temperature aerospace structures, due to the high-temperature resistance of the carbon matrix in these composites. The carbon matrix, though much more high-temperature resistant than a polymer matrix, is much more brittle than a polymer matrix. This brittleness makes carbon-carbon composites prone to matrix cracking [1–3]. As a result, there is a need for monitoring the condition or health of a carbon-carbon composite structure while the structure is in use, in order to minimize hazards. With the development of C/C composites, more and more NDT methods play important role in application for C/C composites. In this paper, the research on NDT of C/C composites was reviewed and the characteristic of these NDT methods were summarized.

RESEARCH AND APPLICATION OF CRACK PROPAGATION

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SECURE ESTIMATING AND INSPECTING FOR CRANE MECHANICAL OF SHANGHAI PORT

Sun Yuantao ,Wang Shaomei

The port crane mechanics is the most major equipment for ports operation. Many of them have been put into use for decade or more years and will be still employed because of heavy duty and shortage of renewal capital. It is an urgent requirement for the ports to secure estimating and inspecting especially when the cracks appear in the crane. In generally, the Paris's model is applied for crack propagation life. To simplify the secure estimating process, the Paris's formula is put forth as the form of the relation between stress value and crack length. The method how to get the stress value is studied to crack propagation secures estimating through Paris's formula. The Shanghai Port Cooperation applies the method to all kinds crane to ensure the crane security and the port run normally. Their estimating process to a crane and inspecting experience also are set forth in the paper.
Keywords: Crack; Secure esitmate; Paris model

INTRODUCTION

The port crane mechanics is the most major equipment for ports operation. Most of them have been put into use for decade or more years and will be still employed because of heavy duty and shortage of renewal capital, so that many faults have appeared in metal structure. According to statistics in ports, the crack is a most fault in crane metal structure [1]. The crane crack's length ranges from several tens millimeters to several hundreds millimeters. Even if the crane with crack has a simple repair, the crack often appears in a period of time yet. It is also an important reason of the accident coming forth generally. For example, a 16/25-ton port's crane boom fracture accident took place in Rizhao port shown as Figure.1. The disaster directly caused more than millions of economic loss, also resulted in personnel casualties. In additional, the port crane structure is huge also so that the maintenance interval is very long, that results in expensive production loss for port cooperation. To avoid those problems, it is an urgent requirement for the ports to secure estimating when the cracks appear in the crane, and then the technician can schedule the optimal maintenance.

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DESIGN AND APPLICATION OF INTEGRATED DIAGNOSIS EXPERIMENTAL PLATFORM FOR MONITORING AND DIAGNOSIS OF PIPELINE

HU Jinqiu*, ZHANG Laibin, WANG Zhaohui, LIANG Wei

In the midst of oil and gas pipeline leakage detection and location system development, it is difficult to acquire typical leakage pressure waves from pressure sensory system at each pump station, not only because pipeline leakage seldom occurs, but also fault signals are usually drowned by industrial noises. Moreover, oil and gas pipeline leakage mechanism and its corresponding characteristics have not been studied intensively due to lack of pertinent experiment. This research designs an integrated diagnosis experimental platform, simulating the actual oil and gas pipeline system, which is a comprehensive system integrating overall control, data acquisition, data communication and transmission, fault simulation, fault detection and diagnosis, as well as integrated diagnosis database (IDDB). In addition, new methods for characteristic waveform extraction and classification, which are key steps in fault repository establishment and pipeline fault diagnosis, are introduced. The successful implementation of the platform also lays a solid foundation for the study of pipeline integrity.

INTRODUCTION

As increasingly service years of transportation pipeline, there are frequent pipeline accidents due to inevitable ageing, corrosion and other natural or human damage, therefore leakage prevention, pipeline structure integrity, pipeline maintenance and management have become important research issues, giving rise to a high degree of attention around the world.

A set of integrated diagnosis experimental platform has been designed in this paper as a simulation of oil and gas pipeline transportation system, based on which a lot of experiments can be achieved, such as power mechanical equipment fault simulation (bearing wear fault, rotor-stator disequilibrium, gas valve plugging, etc.) and pipeline fault simulation (leak, break, corrosion, vibration, etc.) to acquire various data under all kinds of pipeline running conditions and study fault mechanism. The implementation of hardware and software of the platform (Fig.1) as well as new characteristic waveform automatic extraction and improved dynamic clustering

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modules are of great significance in pipeline integrity research, and practicality for resolving practical pipeline problems.

THE QUANTITATIVE RISK ANALYSIS OF CRUDE DISTILLATION UNIT

Weiwei LI, Jianping ZHAO*

Quantitative risk evaluation of crude distillation unit was introduced in this paper. As we known, risk is the production of the likelihood of failure and the consequence of failure according to API risk-based inspection method. First, corrosion thinning and stress corrosion cracking are distinguished as the failure modes of this crude distillation unit. Then, according to each failure modes' limit state functions, the failure probability was calculated. Consequence of failure was compound of flammability, toxicity, and business interruption consequence. According to fluid properties and the total mass available for release, the consequence of failure was determined by fire and explosion models. Then according to quantitative risk matrix given in API581, the risk category of this crude distillation unit can be obtained, which is important to predict the residual life and extend inspection periods of the crude distillation unit.

WEAR-ABILITY STATES QUANTIFICATION EVALUATION OF BEARING BASED ON SIGNALS OF THREE-DIMENSIONAL VIBRATION IMPACTS

WANG Zhao-hui* ZHANG Lai-bin WAN Bo

The three-channel vibration acceleration signals were used to draw three-dimensional vibration impulse tracks with eight kind's colors in each quadrant of three-dimensional coordinate system, which were visualized, audio-visual, and easy-distinguish. According to figure1, some indexes were

refined, scilicet, quadrant volume vectors and quadrant areas vectors and its entropy refined from the XOY coordinate system. The vibration impulse situation of bearing seat in a cycle can be described integrated by the volume vectors including three indexes information, the phase, and the radius of impulse track. Quadrant area vector and it's entropy in XOY coordinate system which include two indexed information of the phase and the radius of impulse track, offer the character of distributing uniformity in XOY plane. The diagnosis nicety rate was improved by comprehensive utilization of the three indexes. At last, through many experiments, the validity of the method and the refined indexes used to fix quantify evaluating of bearing abrasion status were validated.

Key words: bearing; three-dimensional vibration impulse tracks; quadrant volume vectors; quadrant areas vectors; Quantification Evaluation

1. INTRODUCTION

Bearing seat was impacted differ degree in horizontal, vertical and axes orientations. The evaluations of bearing running state and wearing status have quite errors in that the information refined only from horizontal or vertical orientation or both (WANG et al. [1], WAN et al. [2], ZHANG et al. [3], CHEN et al. [4]). So bearing wearing status evaluation in whole used the three orientations impact signals is absolutely necessary. The three-dimension impact tracks can reflect a bearing running states and wearing status completely.

THE QUANTITATIVE RISK EVALUATION FOR IN-SERVICE PRESSURE RELIEF VALVE

Jianping Zhao*

Pressure relief valve (PRV) is the safety device of pressure vessel system, which is the effective tool to avoid over-pressure accident. In this paper, some main factors, which influence on the reliability of PRV, such as set pressure and service status and service fouling potential and orfice area and MSWP and bench test history and chatter history and so on, were considered. First, the probability of the relief system failing to open on demand was calculated by a Weibull distribution against time t, which includes the relief valve either fails to open or opens above the set pressure. Second, likelihood of equipment

failure caused by relief system failure was calculated by the likelihood per year of equipment failing. Finally, consequence for equipment failure caused by the relief system failing to open was calculated by the different damage mechanisms such as thinning and SCC and fatigue. According to above model, the risk of in-service PRV can be determined quantitatively by risk matrix suggested by API581.

INTRODUCTION

Pressure relief valve (PRV) is the safety device of pressure vessel system, which is the effective tool to avoid over-pressure accident. When the equipment system operated under the normal working pressure, PRV should be closed without any release scenario. While the operation pressure value was deviated over than the set pressure value, PRV should be opened to discharge the redundant fluid and expected to fall within the normal operation space of equipment system. Otherwise, the equipment system will be failed or explosion due to the relief system failing to open on demand. In this paper, the likelihood of equipment failure caused by relief system failure and consequence for equipment failure caused by the relief system failing to open were calculated and the risk of in-service PRV was also determined by risk matrix.

A SYNTHETIC METHOD FOR SERVICE LIFE ASSESSMENT OF STEAM TURBINE BLADE CONSIDERING MANY UNCERTAIN FACTORS

Yonghui Xie* and Di Zhang*

As there are many factors which affect blade life can not be analyzed exactly, it is difficult to evaluate service life of blade by numerical analysis. Firstly, by introducing Neuber's rule and the rainflow counting method, based on dynamic stress, a model to evaluate the fatigue life of steam turbine blade has been developed. Secondly, based on fatigue life analysis and fuzzy comprehensive evaluation, a synthetic method for service life assessment of blade considering many uncertain factors has been developed. At last, Life assessment of a 323mm blade was carried our and reasonable result was obtained, so the method is usable for engineering application.

INTRODUCTION

It is well known that reliability of steam turbine is very important for power plants. Blade, which transfers the thermal energy of steam into power, is basic component in steam turbine. The reliability of blade is heavily influenced by the operating environment, the rotating blade experiences large inertial load and variation of aerodynamic load from wake of nozzle flow. The most common failure mechanism of blade is normally forced vibration which results in the fatigue failure of blade (Dhar et al. [1]). Meanwhile, there are still many factors such as manufacturing quality, metal quality, installation status, operation status, erosion status and metal toughness affect the service life of blade, and they can not be analyzed exactly. So it shows significant engineering application to develop a service life assessment method for steam turbine blade considering such uncertain factors.

APPLICATION OF ITERATIVE SINGULAR VALUE DECOMPOSITION DE-NOISING TO FLUE GAS TURBINE SIGNAL ANALYSIS

WANG Hao*, ZHANG Laibin*, WANG Zhaohui*

Noise has great influence on the signal analysis for flue gas turbine. To eliminate the noise, the iterative singular value decomposition (ISVD) de-noising is applied. Firstly, the algorithm of this method is introduced. Secondly, the accuracy of this method is tested by the signal of Lorenz attractor. Finally, this method is used in the flue gas turbine signal analysis. It is proved that it can reduce noise effectively.

INTRODUCTION

Noise influences greatly on describing the non-linear characteristics for flue gas turbine. Kostelich and T. Schreiber [1] showed that, noise makes the pseudo-phase portrait irregular, reduces the width of the scaling region on the log-log plot of correlation integrals and causes an increase of the correlation dimension. To reduce noise, the iterative singular value decomposition (ISVD) de-noising [2-4], which is

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based on the phase space reconstruction, is applied in this paper.

RELIABILITY TEST AND EVALUATION OF MAN-MACHINE COOPERATED MANUFACTURING SYSTEM

Guang Yu Zhu

Reliability of man-machine cooperated manufacturing system has great influence on the running performance of the system. In this paper, the method for the reliability test and evaluation of the man-machine cooperated manufacturing system is presented based on the established reliability model. By using reliability test data obtained during a series of reliability increasing tests of certain man-machine cooperated manufacturing system, the reliability guideline of the system is evaluated.

INTRODUCTION

In man-machine cooperated manufacturing system, most of the work is completed by man and machine and the advantages of human and machine can be fully used (Sun [1]). There are certain failure probability existed for a system, and great loss will be caused by lower reliability. During developing stage, the reliability of the system is keep increasing (Zhu [2]). In this paper, based on reliability test data obtained during a series of reliability increasing test, the reliability model is established, the method of reliability valuating by the reliability increasing model is presented.

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VIBRATION ASSESSMENT METHOD AND ENGINEERING APPLICATIONS TO SMALL BORE PIPING IN NUCLEAR POWER PLANT

Fei Xue*, Lei Lin, Wenxin Ti, Xiaolong Wang, Nianwen Lu

Vibration measurement and corresponding assessment method for small bore piping are introduced. Based on ASME OM-S/G part3, small bore piping vibration measurement and assessment of unit 1 in GuangDong DaYa Bay NPP were performed, which indicates that the screening effective velocity 12mm/s may be not conservative for several small bore pipes. Dynamic stress analysis or special monitoring and inspecting program should be determined to prevent vibratory fatigue or failure occurring.

INTRODUCTION

Steady-state or transient vibration of piping systems in nuclear power plants (NPPs) can be introduced by pressure pulsation or vibration of connecting machines. Fatigue induced by piping vibration can result in occurrence of fatigue crack, fluid leakage, and even pipe fracture, all of which significantly influence the basic function and safety function of the piping system. As a result, more and more attention is being paid to piping vibration fatigue failure in NPPs.

The statistics of EDF (France) indicates that pipe crack caused by vibration fatigue mainly occurred at nozzles with diameter below 2 in., which are defined as "sensitive pipes". Vibration fatigue of small bore piping are classified as 'sensitive piping' problems. According to the IAEA's (International Atomic Energy Agency) report[1], small bore piping fatigue failure in primary loop mostly occurred at the socket weld joint. Furthermore, vibratory fatigue failures of socket welds have occurred predominately at weld roots. If the weld is incorrectly proportioned, either through bad design or through faulty fabrication, the stress across the weld throat may be sufficient to initiate a crack at the weld root. In DaYa Bay NPP, several small bore pipes have been found to crack at the weld joint of tube socket connected with large bore pipe, resulted in the leak of content.

ASME OM-S/G part3 provides three vibration monitoring groups (VMGs) and corresponding assessment criteria to monitor the vibration level in the initial start-up and during the operating conditions [2]. The visual method is most fundamental to

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determine whether any significant vibration exists in the evaluation of VMG3. For pipes screened from VMG3, vibration measuring is employed to determine whether the vibration displacement/velocity exceeds the screening threshold and the allowable value defined in VMG2. Pipes exceeding the allowable value belong to VMG1, and vibration stress of which should be determined by modal response or stress testing Technique.

In VMG2, the allowable peak velocity method evaluates pipe vibration level by peak velocity, which is not representative for long time duration of steady state vibration to consider its acceptability. Sébastien Caillaud deduced the allowable effective velocity method [3] to screen the sensitive pipes considering the multi-modal property and other influences.

In this paper, monitoring steps proposed by ASME OM-S/G part3 and the effective velocity assessment method are applied to assess the vibration level of small bore piping in some CI (Conventional Island) systems of DaYa Bay NPP. Potential sensitive pipes are screened and differences between the allowable peak and effective velocity methods are discussed.

STUDIES ON NONLINEAR-ANALYSIS BUCKLING OF SANDWICH SHELL WITH FOAM CORE

LI Yi, WANG Sheng-nan

Sandwich shell with large size and complicated geometry is used in the fields of civil aviation, transportation and so on. The weakness of sandwich shell is buckling. In this paper, the shell element with modified stiffness , which is based upon the conventional shell element is developed to simulate the sandwich shell with soft foam core by NASTRAN. It is proved that the shell element with modified stiffness is valid by comparing with the results of the Ahmad shell element. And then the influences of the elastic modulus of core, facesheet and the thickness ratio of facesheet to core on the buckling of sandwich shell with foam core are calculated and discussed. Some suggestions to enhance the stability of sandwich shell with foam core are then drawn out.

With the development of technology, sandwich structures are abroad used to achieve light weight and sound insulation. In the traffic field, honeycomb and foam sandwich structures used by

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the magnetically levitated train are large shells with complex shape.[1]So, the stability of sandwich structures is important. In this paper, according to strength theory and the constitutive equation of sandwich, we modify the stiffness of shell element through the port offered by NASTRAN, and then we compared the solution of the Ahmad shell element with our solution to prove the shell element with modified stiffness effective, Lastly we used the shell element with modified stiffness to study the non-linear stability of sandwich by the arc-length method and discussed the influences of the elastic modulus of core, the elastic modulus of facesheet, the thickness ratio of facesheet to core on the stability of sandwich shell with foam core(PMI).

THE EVALUATION METHODS ON THE EXISTING SINGLE-SPAN HIGHWAY ARCH BRIDGE

Li.Bin.Wang[1,2], Guo.Fen.Li [1], Ming.MingYang[1]

In the Code for Maintenance of Highway Bridge and Culvers, the whole bridge is divided into 17 components and the weight to each one is recommended and given in a table. But when coming to the inspection and the assessment of the existing single–span highway bridges, the recommended weight to each member can't be used directly, because in the single-span arch bridge there are no components such as the piers, the bearing etc. So the weight has to be adjusted and redistributed in the existing components again to be available to the need in evaluation. Here, several methods were recommended. The first method takes advantage of the hierarchy-weight evaluation method in the code CJJ-2003, the weight proportion of the same part in the two codes is found after the virtual layers was set up corresponding to the layers in CJJ-2003, the final index of the single-span bridge is found by the virtue of the valuation thought in the assessment on the substructure and the proportion transfer. The two other methods based on the weight redistribution easily operated were given also. One is to keep the ration of each assemble fixed but to adjust the proportion of each component in the same assembly, the other is to adjust the weight in the whole structure.

INVESTIGATION OF THE SURFACE INTEGRITY OF NON-FERAL MATERIAL AFTER THE BURNISHING PROCESSING

Jianying Liu [*1)] Zhaojun Yang[1)] Hongyun Luo[2)], Qunpeng Zhong [2)]

The components of non-ferrous metal, non-metal and a lot of new synthetic materials which are applied widely are difficult to process. Surface integrity of these components is getting more concerned these days with the developing of the industries. The surface integrity of non-feral material which was markedly improved by the no-chip machining process- burnishing processing was investigated. The optimum burnishing processing parameters were obtained under the experimental condition.

1. INTRODUCTION

With the developing of industries such as aviation and astronavigation, automobile, etc., more and more non-ferrous metal, non-metal and a lot of new synthetic materials are applied frequently to meet the conditions of higher pressure, higher temperature, higher velocity, severer corrosion etc. Following that, the processing of these materials is more difficult as well as the demanding of the surface integrity of the components is expanding [1]. Burnishing of metals is a process that leads to an accurate change on the surface profile of the workpiece by a minor amount of plastic deformation. Microscopically, the profile of the machined surfaces is composed of hills and valleys, and during burnishing, the hills are pressed down and valleys distended up which resulting in a smoother surface of excellent finish [2].The surface integrity which was markedly improved by the no-chip machining process-burnishing process was investigated. To get the relationship between the various employ parameters (spindle speed n, depth $\boldsymbol{a_p}$, feed $\boldsymbol{f}$,) and surface integrity parameters such as surface roughness, waveness and hardness of the non-ferrous components, much studies were carried out experimentally with a theoretical analysis. The experiments were conducted with a simply self-designed cylindrical surfaced polycrystalline diamond tool.

A NEW RISK BASED ASSESSMENT METHODOLOGY TO OIL&GAS PIPELINE ----SECURITY VULNERABILITY ASSESSMENT (SVA)

Xue guoxing[1] Zhang zheng Zhong qunpeng

Risk assessment is important for safe operation of pipeline, The American Petroleum institute(API)and the National Petrochemical and Refiner's Association (NPRA) have developed a guideline for conducting SVA of petrochemical facilities in 2003.This guideline systemically assesses risk of the active damage. This paper presents the concept of SVA, assessing procedure and application in pipeline industry. The disadvantage and research trend of SVA are also indicated.

Risk is not only a general terminology, but also an important scientific term. Society for Risk Analysis (www.sra.org, 2005) describes risk as a potential for realization of unwanted, adverse consequences to human life, health, property, or the environment. Nowadays the International Standards Organization (ISO) defines risk as a synthesis of the incident probability and consequence. Risk assessment originates from American. After nearly forty years development, risk assessment mainly divides into qualitative risk assessment and quantitative risk assessment. Each has strengths and weakness, including costs of the evaluation and appropriateness of an evaluation to a situation.

American Petroleum Institute (API) developed the first edition Risk-based inspection resource document (API 581) available to petroleum and petrochemical industry in 2000. API 581 clearly states the approach of risk analysis, including consequence of analysis and likelihood analysis [1]. API and the National Petrochemical&Refiners Association (NPRA) developed the first edition of the Security vulnerability assessment Methodology in 2003[2, 3].

The information contained in the document was developed in co-operation with government and industry, and is intended to help refiners, petrochemical manufacturers, and other segments of the petroleum and petrochemical

Industry maintains and strengthens security of their personnel, facilities, and operations. In 2004, API/NPRA enhanced their guidelines by extending their methodology from addressing the risk at fixed facilities to transportation security risks. (I.e. pipeline, rail).this paper outlines the security vulnerability assessment and expounds the application in pipeline industry.

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AN UNBIASED POINT ESTIMATION METHOD OF MAXIMUM MAINTENANCE TIME FOR LOGNORMAL DISTRIBUTION PRODUCT

Jin Xing*, Hong Yanji, Zhai Yingmin, Xiong Longfei, Wang Guangyu

The lognormal distribution is often used in maintenance time distribution. A new unbiased point estimation statistic is proposed for maximum maintenance time of lognormal distribution product. The unbiased estimation statistic is calculated by fast convergence series. Using Monte-Carlo method, the conventional estimation statistic is tested and proved a biased statistic, which has big error. The proposed method can be applied any sample size. The theory of design and analysis can be provided by the method.

INTRODUCTION

According to the finite sample maintenance experiment data, calculate the maximum maintenance time for the product that the maintenance time obeys lognormal distribution. The method is a biased statistic which has low precision and big sample size [1-3]. We present unbiased point estimation method of maximum maintenance time for the product which the maintenance time obeys lognormal distribution. It solves the exactly estimation problem of the maximum maintenance time for the product that obeys the lognormal distribution.

PARAMETER ESTIMATION METHODS FOR 3-PARAMETER WEIBULL DISTRIBUTION

Bingfeng Zhao* , Sujun Wu*

Present parameter estimation methods for 3-parameter Weibull distribution mostly need complicated computer program, which restricts its application. This paper makes an important improvement to correlation coefficient method for 3-parameter Weibull distribution and then reduces its computation largely.

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Grey method which is suitable to small size sample is introduced and curve fitting method is also proposed. Parameter estimation is made by one sample, and K-S test is done. It is shown that all the four methods are feasible.

INTRODUCTION

Weibull distribution, derived from the weakest link theory, can adequately reflect the impact of the material defects and stress concentration source on fatigue life. In virtue of increasing failure rate, it is the appropriate model of life distribution and fatigue strength in the given life for materials and parts. Especially, the curve becomes a line after double logarithmic transformation. Because of there being three parameters, it is difficult to estimate parameters for the three-parameter Weibull distribution. The different scope and accuracy of existing methods of parameter estimation brings much inconvenience, so it is necessary to compare various methods.

PROBABILISTIC SAFETY ASSESSMENT FOR A PRESSURE PIPE WITH CIRCUMFERENTIAL SURFACE FLAW

Y. Zhou*, Q.P. Zhong, Z. Zhang

Due to the random of flaw size, applied loads and material properties, a probabilistic safety assessment on a pressure pipe with circumferential surface flaw is adopted with the failure probability calculated, applying Mento Carlo (MC) simulation. An analysis of p (L_r, Kr), the joint probability density function for (L_r, Kr), is performed together with single sample Kolmogorov-Smirnov (K-S) goodness-of-fit hypothesis tests on L_r and K_r. It is found that contours of p (L_r, Kr) are supposed to be series of ellipses approximately; the distributions of Lr and K_r fit the lognormal distribution well. Sensitivity of the failure probability to stochastic parameters is performed using an interval method, instead of the calculus of differences.

1. INTRODUCTION

Flaws initiate during the manufacturing, installation and operation of the piping system, then could propagate further under specific mechanical and natural environmental conditions, ultimately it could lead to local or global damages. Usually the major failure modes in pipelines are unstable fracture and plastic collapse. Dowling and Townley [1] presented a two-criteria failure assessment diagram (FAD) to correlate this two failure modes. British Standards Institution (BSI) published

BS7910: Guide on methods for assessing the acceptability of flaws in metallic structures in 1999. The assessment is based on fracture mechanics, and is carried out by FAD. In this study the random of assessing parameters are considered, and it is of certain reference to calculate the structure failure probability, using probabilistic method during the assessment.

STRUCTURAL IMPROVEMENT AND RELIABILITY OPTIMUM DESIGN OF SELF-EXCITATION OVERRUNNING SPRING CLUTCH

Chengyi Pan*

This paper improved the structure of self-excitation overrunning spring clutch and proposed reliability optimum design of its strength. Both the strength reliability is fulfilled and a group of optimum structural parameters are obtained. Consequently, the improved clutch has more perfect structure and more rational parameters. This paper put forward reliable theory foundation and advanced design method for exploiting and applying of the clutch.

LOW CYCLE FATIGUE LIFE PREDICTION USING ENERGY APPROACH AND CRITICAL PLANE PARAMETERS FOR TWO MATERIALS

D. Jin[1], X. Chen[2], J. H. Wu[1]

A series of low-cycle fatigue experiments of tubular specimen under uniaxial, torsional and proportional multiaxial loading are performed on 63Sn-37Pb

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solder and a series of fatigue experiments of tubular specimens of 304 stainless steel under variable amplitude axial-torsional loading are employed. Two approaches of the low-cycle fatigue life evaluation, i.e., energy (LKN) and critical plane approaches (SWT, FS) are systematically analyzed by the fatigue life data for two materials. A life computation procedure is employed in which rainflow cycle counting on suitable plane for different model and linear damage rule are used to calculate the damage. The life prediction results are compared between the two materials. On the whole, the shear damage parameter is suitable to multiaxial fatigue life evaluation of 63Sn-37Pb solder. For 304 stainless steel, in spite of the models based on the different critical plane, the predictive results are acceptable. Two materials show different material properties in the same loading path that can be proved by previous papers, so the same model gives the different prediction results, better for one material and worse for another.

INTRODUCTION

With the development of modern industry, most engineering components are subjected to operate under multiaxial loadings. In the present, there are two acceptable approaches for the evaluation of multiaxial low-cycle fatigue life, energy-based approach and the critical plane approach, respectively. Energy-based approach under multiaxial loading was proposed by Garud [1] firstly. An energy model (LKN) accounting for normal and shear deformation for predicting fatigue lives under variable amplitude multiaxial loading was suggested by Lee et al [2].The critical plane approach concept for low cycle fatigue was proposed by Brown and Miller [3]. By considering the different critical plane, the scholars gained different damage parameter. There have been many earlier researches under constant amplitude, out-of-phase tension-torsion loading and some other simple non-proportional loading condition. Smith, Watson and Topper [4] proposed the SWT model for the material shown tensile failure. The maximum normal strain plane was considered as the critical plane and the normal stress on the plane was considered in the model. Wang and Brown [5] applied the Kandil-Brown-Miller [6] model to variable amplitude tension-torsion loading with the maximum shear strain range plane as the critical plane and the better results were gained for nonproportional loading. Fatemi and Socie [7] proposed the FS model in accordance with the failure mechanism. The maximum shear strain plane was considered as the critical plane and the normal stress on the plane was used to replace the normal strain in the KBM model. Recently, energy approach has been developed for fatigue prediction under the random loading.

In this paper, energy-based approach (LKN) for 63Sn-37Pb and 304 stainless steel, and the critical plane approach, two damage models are employed for correlating fatigue data, i.e. SWT, and FS. A life computation procedure is employed in which rainflow cycle counting on suitable plane for different models and the linear damage rule is used to calculate the damage for 304 stainless steel.

RESEARCH OF THE FATIGUE LIFE OF PIPING BRIDGE IN WIND ENVIRONMENT

LIU-Qinggang*, SHEN-Shiming

Piping bridge is a way oil and gas pipeline crossing the rivers or channels. For piping bridge, wind load is one of the main loads leading to the failure. The rigidity of the piping bridge is usually more weak than that of bridge, and the amplitude of the piping bridge may change among a large range when the speed of the wind changes. The fatigue life of the piping bridge in wind environment is usually calculated by the fatigue load in average speed of the wind by statistics during a certain time, but when the speed of the wind varies seriously in the fatigue process, the fatigue life calculated by average load may not match the reality. In this article a new method is introduced, the fatigue loads of the piping bridge is simulated by math software based on real wind speed during a period and the fatigue life of the piping bridge is calculated by the simulated loads.

INTRODUCTION

When wind is the source of the fatigue loads, the material is usually supposed as without any defect. In wind environment, highest load or average load and Miner rule were used in the fatigue life analysis; the stress of the piping is calculated by experience formula [1,2]. But actually the material contains defects and the fatigue life calculated by highest load or average load may not match the truth. The fatigue behavior of the piping bridge should be studied by a new method.

In this article, a new method is introduced. In this method, the material is supposed containing defects, the fatigue loads in wind environment is distributed load and calculated by finite element analysis software.

RELIABILITY LIFE ANALYSIS OF LARGE KEY EQUIPMENT IN REFINERY

YU Xiaohong*, ZHANG Laibin, WANG Zhaohui

The flue gas turbine is the large key equipment in Catalytic cracking unit of refinery, it is a very important energy-saving equipment and making reliability life analysis of it is significant. The paper put forward a new method based on

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maximum likelihood estimate exponential distribution parameters to make reliability analysis of the flue gas turbine. During actual running, the flue gas turbine is in random failure period and its life time obeys exponential distribution and its failure rate can be estimated by maximum likelihood method. The result shows that this method is practicability to reliability life analysis of the flue gas turbine.

INTRODUCTION

The flue gas turbine is the large key equipment in Catalytic cracking unit of refinery, its fault will cause chain reaction and enormous economic losses and people safety. So its reliability analysis is very important. Equipment reliability [1] is always denoted by probability, it is the capacity of the parts or the system to finish preconcerted functions in stated conditions and stated time. The common indexes include: distribution function distribution density reliability rate and failure rate. Failure rate is the most important parameter among these indexes. The paper put forward a new failure rate-estimating method to make reliability analysis of flue gas turbine.

CRITICAL SAFETY FATIGUE CRACK SIZES FOR THE RD2 TYPE AXLE OF CHINESE RAILWAY FREIGHT CARS

Y. X. Zhao[1,2*], B. Yang[1] and M. F. Feng[1]

The critical safety fatigue crack sizes are investigated for the RD2 type axle of Chinese railway freight cars. Attention is paid on the axle load relief grooves near the axle boxes, where more fatigue cracks were early appeared even result in at least six derailed accidents. Load history corresponding to the peak and valley points of wheel-rail contact forces, in which the wheel flat effect has been taken into account, is collected by vehicle dynamic simulation with on-line inspection. Different from the existent work, two axle crack/defect models, i.e. semi-elliptical and external circumferential cracks, were employed by the field inspections. Crack shape changes are taken into account in calculations of the crack growth driving stress intensity factors. The shear stress at the tip of semi-elliptical crack is also considered. Critical safety sizes for the two crack models are considered as the initial crack sizes, from which to axle fracture the residual life is equal to the overhaul inspection interval of axle. A step-by-step method is applied to determine the sizes. Results show that the external circumferential crack is more dangerous than the semi-elliptical crack. The critical sizes and the action of abolishing the load

relief grooves have been applied in the field management. Two years practice has verified the availability.

INTRODUCTION

Since 1 April 1997 China started to carry out the trains promoted speed strategy, fatigue cracking phenomena were frequently revealed at the RD2 type axle's load relief grooves of Chinese C64A and C64H freight cars. At least six derailed accidents were taken place from the axle failure [1-4]. Evaluating the critical safety crack size over which may result axle collapse becomes an urgent task.

Most of the existent researches for axle are based on semi-elliptical crack defects, NASGRO crack growth rate equation, and European structural integrity assessment procedure [5-7]. To address the urgent task, present work draws the determination method of the critical safety crack sizes of RD2 type axle. Different from the existent researches [5-6], some new elements are given in present crack models, fatigue crack growth rate modeling, and assessment method

REVIEW OF CALCULATION METHOD OF FAILURE PROBABILITY

LiFeng Li , Hongyun Luo*, Hongwei Wang

The investigation on the calculation methods of failure probability in recent years is reviewed in this article. According to the principle and characteristic, the various calculation methods were grouped into four categories including Numerical integral method, Numerical simulation method, approximate solution method and Statistical estimate method. After contrasted and analyzed in tense of the needed parameters, methods for acquiring parameters, methods for calculating, the volume of solution, accuracy and operational costs, the merits and defects of the various methods were made clearly, which can provide a reference for the project application.

INTRODUCTION

The calculation of failure probability is one of the main aspects of probabilistic safety assessment. Failure probability can measure the security situation of the assessed object. It is important to find a simple, accurate and reliable calculating method of failure probability to the safety research about the assessed object. Many calculation methods of failure probability were investigated in resent years. According to the principle and characteristic, the calculation methods were grouped into four categories which has been introduced as followed.

RECENT DEVELOPMENT OF RESEARCH ON FATIGUE MECHANISM IN VERY HIGH CYCLE RANGE

Hu Yan-hui[2, *], Zhang Zheng[A], HAN BANGCHENG[3], Zhong Qun-peng[A]

With the development of modern technologies the designed lifetime of many mechanical components like railway wheels exceeds 10^8 cycles. Some investigations indicated that fatigue failure of metals could occur in regime beyond hundreds millions of cycles. Failure mechanisms of metals in very high cycle fatigue range have become a new topic for durability design of engineering structures. Researches on VHCF in recent years are summarized such as testing method of ultrasonic fatigue, characteristics of VHDF and some life prediction models for VHCF etc. Some problems to be solved and some practical methods are discussed.

1. INTRODUCTION

With the development of modern technologies fatigue life of many industrial applications are up to 10^8 or 10^9 cycles. In fact fatigue failure in service beyond 10^8 cycles of some structural components such as gears of helicopter reducers take place. Safe-life design based on infinite life criterion has become incorrect and even unsafe. Very high cycle fatigue(VHCF) of metals in the range of 10^6 to 10^9 has become a major concern in durability design of engineering components. Recently Engine Structural Integrity Specification of America states, “All engine parts should have a minimum HCF life of 10^9 cycles (ENSIP [1]).”

In the past two decades fatigue behavior of many kinds of materials beyond 10^7 cycles has been studied all around the world. Many concepts and mechanism has been established. In this paper it is summarized recent research of metals on VHCF and some valuable tasks are pointed out.

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INCOMPATIBLE FINITE ELEMENT CONSTRAINED BY LAGRANGE MULTIPLIER ON COUPLE-STRESS THEORY

ZHANG Bo[1], WANG Xi-ping[2], Li Shu-cai[1], YANG Xue-ying[3], GE Yan-hui[1]

There is a constraint condition that macro rotation equal to the micro rotation in couple-stress theory. In recent studying, the constraint condition is introduced by a penalty function technique mostly, the penalty function technique has some disadvantages that make the couple-stress theory difficult to use. In this paper the constraint condition is introduced by Lagrange multiplier method to overcome these disadvantages of the penalty function technique. As the couple-stress theory has special demand of c^1 continuity, four nodes incompatible element is introduced to meet this demand .The good accuracy and high efficiency of this method is proved by numerical example.

INTRODUCTION

The scale effect can be explained by the couple-stress theory which takes the length dimension into account (Mindlin [1]). There is a constraint condition that micro-rotation φ equal to macro-rotation ω in couple-stress theory, which is introduced by penalty function technique mostly(XIAO Qi-lin et al.[2]).Although the demands of penalty function technique are less than other methods and can be made easily, the coefficient α of penalty function has no definite value ,which made couple-stress theory difficult to use. In this paper the Lagrange multiplier method is used to introduce the constraint condition, which avoid the disadvantages of function penalty technique and make the couple-stress theory easy to use in practical.

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SAFETY EVALUATION AND MONITORING OF BLASTING EXCAVATION FOR TUNNELS WITH CHANGING SPACE

Li Liping[1], Li Shucai[1], Zhang Qingsong[1], Wang Gang[2], Li Liyan[2]

Based on the problem of blasting vibration influence on close-spaced tunnel, the monitoring way, dynamic characteristics and controlling study on blasting vibration induced by close-spaced tunnel excavation are studied for Qishucao diverging tunnel. Via analysis of the peak velocity and its main frequency of concrete lining and revised mathematical model of propagation for blasting seismic wave through regression analysis for the results of monitoring on blasting vibration, longitudinal attenuation of maximal vibration velocity, the dominating vibration frequency of concrete lining, vibration velocity distribution of cross section and vibration near the excavation face are presented. Focused on the near-blast side vibration of close-spaced tunnel, the vibration reduction technology measures of close-spaced tunnel are put forward from the circle footage, millisecond vibration, undermine pattern and so on. Conclusions can offer helpful reference to blasting control design, blasting excavation and in-site monitoring of similar close-spaced tunnel.

INTRODUCTION

The analysis of the vibration behavior of blasting excavation remains an important topic in rock mechanics, due to it being a critical phenomenon in ongoing challenging issues such as tunneling near ancient structures, coupled seismic response under high groundwater pressures, and blasting excavation of close-spaced tunnel. Despite continuing and extensive efforts, such analysis continues to be difficult, especially the blasting behavior of close-spaced tunnel. In order to find the blasting vibration behavior of close-spaced tunnel, a test series has been set up for Qishucao diverging tunnel. In addition to these tests a more precise new mathematic mode for blasting vibration velocity has been established and some measures have been adopted to reduce the blasting vibration damage to adjacent tunnel [1].

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A VEHICLE BODY STRUCTURE SAFETY TEST RIG AND ITS MEASUREMENT SYSTEM

Wu Weiwei*, Xu Zhaokun*, Deng Zibing**

A vehicle body structure safety test rig has been developed to enhance the ability of research and development of safe vehicles. It can carry out all tests of vehicle body structure described in the American vehicle safety standards and the upcoming national standards. The test rig has four adjustable installation parameters, so it is compact and has a good precision. It can test not only vehicle body, but also a broad range of automobile components. The test rig has a satisfying performance. In addition to measure and display the data of loading force and absorbed energy in real time, the device can also provide the information of deformation vector at some predefined points by using image processing algorithms. The data can be used in vehicle safety evaluation and in further studies.

1 INTRODUCTION

Vehicle safety has become a key issue in the safety research field. The purpose of current vehicle impact tests all over the world is to find out the key factors threatened the occupant's life during collision. The most concerned parameters include the stiffness and strength[1] of the vehicle body, the collision energy and etc. By analyzing the test data, measures can be taken to improve the protection for occupant and optimize the present safety regulations, and enhance the compatibility of impact standards[2]. Digital visual photogrammetry is used in measurement because of its non-contact feature and effectiveness. In recent years, with the rapid development of digital CCD imaging device of high resolution and high SNR, as well as computer image processing and pattern recognition technology, digital visual photogrammetry is qualified to be one of the most promising 3D measurement technologies.

RELIABILITY-BASED STRUCTURAL OPTIMIZATION OF

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SPATIAL GIRDER-PANEL SYSTEM CONSIDERING STABILITY

YAN Xinchi

The questions like how to model the three dimensions spatial girder-panel structural system, take reliability-based structural optimization, and ensure girder stability, have been studied in this paper. Considered the material intensity, girder section area, panel thickness and loads as stochastic variables, mathematic model of optimization was constructed. Project variables were established focus on having enough stability, in the iterative procedure, the optimum vector method was adopted to optimize the object, the gradient step and the optimum vector step have been used alternatively, and these can make the iterative procedure more quickly. The calculation of the numeral example shows this method is exact and free from the selection of searching start point, further more the convergence is stable and quickly.

INTRODUCTION

Reliability-based structural optimization takes into account some indeterminate factors, so it is more logical design method[1,2]. Ensure structures like spatial girder-panel system have enough stability is also very important for designer[3].

VIBRATION-BASED CONDITION MONITORING FOR THE PUMP USING FUZZY TECHNIQUE

CUI Houxi*, ZHANG Laibin, WANG Zhaohui, DUAN Lixiang, FAN Xiaojing

Fuzzy technique has been widely used in the condition monitoring of the equipment. However, some limitations exist in the application of the technique due to the insufficient utilization of the information and the subjective expert judgment. The condition monitoring using fuzzy technique based on the vibration analysis is presented in this paper in order to solve these issues. Furthermore, A load modification theory proposed in this paper is centered on

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the signal preprocess. In addition, the degradation theory is utilized aiming at increasing the accuracy and reducing the error caused by subjective human judgment. The condition is evaluated on the basis of the degradation degree of the characteristic parameters and the fuzzy relation matrix. The application shows that this technique provides an efficient approach for the condition monitoring.

INTRODUCTION

The condition monitoring for the Centrifugal pumps in the oilfield is a matter of increasing concern nowadays [1] due to the widely spread use of the equipment in the oilfield. The steady running of the pump is of crucial importance in the production of oil and gas in the oilfield, thus the effective condition monitoring of the pump is in urgent demand.

As intricacy and ambiguities exist between vibration symptoms and conditions, the vibration-based condition monitoring using fuzzy technique is presented. Moreover, A load modification model is built aiming at signal preprocess before the fuzzy monitoring. The degradation of RCM theory and the fuzzy matrix are applied in the monitoring in this research, which is different with traditional fuzzy technique. And the condition is judged according to the comparison between the fuzzy conclusion and the threshold value, thus this optimized fuzzy algorithm will be reduce the error caused by subjective human judgment and improve the accuracy and effectiveness of the monitoring remarkably.

MAINTENANCE DECISION-MAKING BASED TIME LIMITATION AND LIMITED RESOURCES ON BARRACKS

FAN Min[1] CHI Wei-sheng[2] ZHANG Rui[3]

A fuzzy sets appraisal model is used in barracks maintenance decision-making. Project cost-time trade-off and some military factors are taken into consideration in the model.

1 INTRODUCTION

Usually, repair cost and repair time according to the structural carrying capacity and wear ability is most important factor in civil engineering maintenance (Wei-liang,

J.[1]). Fuzzy sets theory is used in risk appraisal in project (Chao-guang, J.[2]). To military barracks maintenance, military order, limited resources and time limitation should be considered. So, the present paper put forward a cost –time trade off model to appraisal military barracks maintenance by fuzzy sets theory.

DEVELOPMENT AND APPLICATION ON INTEGRITY INSPECTION AND ASSESSMENT TECHNOLOGY FOR UNDERGROUND STEEL PRESSURE PIPELINE

He Renyang*，Liu Changzheng，Zuo Shangzhi, Li Xiufeng，Shen Gongtian

This paper mainly introduced the integrity inspection and assessment technology for underground steel pressure pipeline, including external inspection technique, internal inspection technique, NDT technique, environmental corrosive inspection technique, leak inspection technique and comprehensive assessment, etc. The paper also introduced the status quo and development on inspection technique, feature of different technology, as well as the research and application of new technology and new device. In view of the integrity management of pipeline, the paper introduced some specified methods of integrity inspection and assessment for pipeline.

INTRODUCTION

With the economical development and widely application of pressure pipeline in China and abroad, more attention was paid to the safety operation of underground pipeline. Gradually, the pressure pipeline is one of the five biggest transportation systems. In 1990s, the conception of Fitness in service and risk assessment, which was the key point of the Pipeline Integrity Management (PIM), was provided in European and USA, at the same time, the standard and regulation of PIM for the pressure pipeline was published by API and ASME. The PIM is a system and dynamic processes to provide a systematic, comprehensive, and integrity of pipeline system, it starts sound design, material selection, construction of the pipeline, and includes the prevention, detection, and mitigation activities.

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The integrity inspection and assessment is the basis of PIM of underground steel pressure pipeline. The integrity inspection and assessment mainly includes the corrosion protection system inspection, the pipeline corrosion condition inspection, the welding performance inspection, the leakage inspection, the environment investigation on corrosion and the synthesis appraisal.

SIGNAL ANALYSIS OF ULTRASONIC SYSTEM WITH PHASED ARRAY AND TOFD TECHNIQUE APPLIED ON INSPECTING PIPELINE WELDS DEFECTS

Weibin Wang[1], Yuqin Wang[1], QingZhao[2], Ke Wang[1], Jinyu Yang[3],Chen long[4]
Guangqin Yu[4], Dongqiao Bai[4]

The integrated ultrasonic technology of phased array and time of flight diffraction (TOFD) was used to inspect pipelines with typical defects such as cracks, lack of fusion, pores etc. The signal gained by A-Scan, B-Scan and S-Scan methods was analyzed and explained. The respective image feature of various defects was studied which provide a theoretical basis and practical experiences for inspecting pipeline welds defects.

INTRODUCTION

In ultrasonic fields, the phased array and TOFD are both latest inspecting technologies [1~3], which have been widely applied to solve many difficult problems, due to their unique advantage, [4]. Since the two techniques may complement each other very well, it is meaningful to be combined in application. However, the high safety requirement of the pipeline welds challenged the combination of the two techniques to locate and inspect the defects precisely.

The new ultrasonic system use two kinds of probes, phased array and TOFD probes, whose echo image will be displayed on one screen. Then the results are analyzed and compared. Experiments on defected pipelines have been carried out to gain some useful conclusions.

THE DEVELOPMENT OF INSPECTION, MONITORING AND SAFETY ASSESSMENT FOR LARGE-SCALE STEEL FRAME OF PORT MACHINERIES IN CHINA

XU Chuanjiang, LUO Hongyun*

To prevent the steel frame of port machineries from failure, there are many methods to monitor their status and inspect defects like cracking, structural deformation, corrosion, abnormal vibration. The development of defects inspection, status monitoring and safety assessment for large-scale steel frame of Port machineries in china are introduced.

INTRODUCTION

Large-scale Port Machineries include port cranes, bulk ship unloaders, the quayside container cranes, coal unloading electromechanical equipment, and so on. They are the most important equipments at many ports, and very expensive. Steel frame of these machineries，just like the bones of humankind, is the support of all its facilities. The quality of the steel frame directly determines the performance and life of Port machineries. But many regrettable incidents often occurred which caused by the defects in the steel frames. But it is gratifying to see that there started to research these machineries frame's safety. Several research projects were carried out in China, for example, Shanghai Maritime University, Shanghai Transportation University, Beijing University of Aeronautics and Astronautics, and so on, have achieved many promotions on these subjects. The purpose to study the steel frame is to avoid sudden failures, control gradual expansion of the fault, to ensure port machineries security.

WORK SAFETY EARLY WARNING MANAGEMENT BASED ON RISK MANAGEMENT

GONG Yunhua*, LUO Yun

This paper provides a method for work safety early warning. Once dangerous states occur, early warning system can send out early warning signals to tell others to take measures to prevent accidents. The early warning management (EWM) this paper discussed is a safety management method integrating early warning, risk control and emergency rescue. It is a safety management method that is characterized by effective and timely prevention. To put early warning management into practice, the framework of work safety early warning management system (WSEWMS) is designed, and the disciplines ensuring the well run of the system are also discussed.

INTRODUCTION

Work safety early warning is a method that can timely inform both frontline workers and managers the workplace risks. It is based on real time, dynamic risk assessment. People can take measures to control the risk according to early warning signals.

In work safety early warning management, first, we identify and assess all the possible hazards in workplace, and then monitor them to send out early warning signals and control risks. This progress is based on the three phases of risk management: hazard identification, risk assessment and risk control. The hazards are called early warning elements. The risk of a workplace is determined by the monitored results. There are four risk levels of the hazards: high, medium, less medium and low. Workplace has four risk levels, which are shown as Ⅰ, Ⅱ, Ⅲ, Ⅳ four early warning grades and four early warning signals (red, orange, yellow, green).

APPOACH TO MONITORING AND VALIDATING EXPERIMENT FOR STRAIN OF IN-SERVICE PIPELINES

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Xueli Wang[2], Qingshan Feng[1,2], Zupei Yang[2], Muyang Ai[2], Guangwen Liu[2], Hongsheng Cui[3], WeiBin Wang[2]

The paper describes approach to monitoring for geological hazards that are usually applied for in-service buried pipeline in the world, and introduces application conditions of some monitoring instruments. By site experiment, to validate that the strain gauges in the pipeline can monitor variation of pipeline stress that geological hazards cause. It is necessary for operators to monitor the pipeline so that it can ensure that the pipeline stay safe status.

1 INTRODUCTION

Pipelines are considered a practical means for the carriage of very large volumes, and are generally recognized as the safest and most economical way of carrying dangerous substances[1]. At present, pipeline transport of oil and natural gas as pillar industry affects national economy and social stability. However for pipeline operators, it is "safety and economy" that operating management of pipeline mainly focus on.

Transmission pipeline networks carry medium over long distance and across rivers or mountains, however that natural condition effects on safety of pipeline is an inevitable problem[2-3]. Safety of transmission pipeline has been a more and more complicated and hard problem. Geological hazards can make in-service pipelines failure, and can bring higher level risk to them, and is one of the main causes of natural gas and oil incidents. Once cracking and rupturing, a large volume of medium transported would release out, and which might cause significant casualty accident, damage environment nearby, and lead to property losses. Currently, due to outside loads, such as soil displacement or landslides, many in-service pipelines have been in non-design situation, and need to be made judgment and taken actions to eliminate stress. In order to minimizing geological hazards of operating pipelines and managing efficiently, monitoring to pipeline is popularly applied to the industry. Continuous online, real-time monitoring is required to help ensure that the pipeline is performing in the right way. Many companies in the world have installed pipe-monitoring devices in areas prone to unstable ground movement, such as landslides, to detect any further land movement that may cause damage.

MONITORING PITTING CORROSION OF 1CR18NI9TI STAINLESS STEEL BY ESPI

Wang Meifeng[a, b], Du Nan[a], Zhao Qing[a], Li Xiaogang[b]

In this paper, an ESPI (Electronic Speckle Pattern Interferometry) based monitoring system was introduced. The system could carry out noncontact, whole-field, continuous, in-situ measurement; and it was used for the first time to observe the dynamic pitting process of 1Cr18Ni9Ti steel in 3.5 wt. % NaCl solution during the chrono amperometry experiment. Results are presented here to demonstrate the application of this system in pitting corrosion.

INTRODUCTION

ESPI is a fast developing whole field optical technique used for the measurement of optical phase changes under object deformations and has evolved as a powerful Non-Destructive Evaluation (NDE) tool [1]. The technique employs a speckle pattern created by reflecting coherent light off a rough surface. The speckles are interference images created when the path lengths of converging rays reflected off the illuminated surface differ by half the wavelength of the coherent light source. The method allows whole-field, noncontact, non-contaminating, real time, high-resolution and continuous analyses to be performed and has been used to make measurements of displacement and shape in an extensive and diverse range of application [2, 3].

Pitting corrosion is a big problem in industries because it often causes catastrophic failures in engineering structures. It is very important to monitor and detect corrosion at its early stage, best on its initiation, and then proper measures could be taken to prevent its development and effectively protect structures from being corroded.

In the present investigation, ESPI is employed for the first time to monitor the initial stage of pitting corrosion of 1Cr18Ni9Ti steel in 3.5 wt. % NaCl solution.

CALCULATION OF CREEP PRESSURE ON WORN CASING SUBJECTED TO NONUNIFORM LOADING IN CREEP STRATUM

Chuan-Kui Zheng* & De-Li Gao and Cheng-Jin Tan

A research on the behavior of worn casing subjected to salt loading is done in this paper. The viscoelastic model is adopted to simulate the mechanical behavior of creep stratum. However, the elastoplastic model with linear

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hardening is used to study that of casing. The F.E. model was built on several parts including of worn casing, cement sheath, hydrate area and salt stratum. Such factors as geologic, engineering-oriented, and combined geologic and engineering-oriented are studied in order to illustrate the pressure distribution outside casing. The calculator program was developed to search for the optimal iterative factor automatically to accelerate its convergence. Furthermore, the Successive Over Relaxation Method (SOR) was adopted to solve large-scale FEM equations. It indicates that the maximum external pressure is in the same direction with the minimum terrestrial stress and the opposite is also right. The external pressure of the worn zone was greatly increased. So compared with the nonuniform terrestrial stress, the external pressure is more sensitive to casing wear. These numerical results can be used to guide casing design in oil and gas fields.

INTRODUCTION

According to Gao's [1] survey the creep stratum is widely distributed in petroleum industry. The creep pressure distribution outside casing becomes complicated in this stratum as what Tan [2] concluded. About this problem Pro. Yi-Jin Zeng established the analytical model in his research. He studied the effect of salt depth and creep trait on capacity of casing subjected to loading. But all relative studies are on the assumption that casing sections are ideal annulus. And worn defaults are also out of consideration. Therefore it is necessary to explore rules of creep pressure distribution under these complicated conditions.

COMPARISON WITH CALCULATIONS OF SUBMARINE PIPELINE CRITICAL SPAN BY DIFFERENT METHODS

Xuechao Wang, Jianping Zhao*

Critical span of submarine pipeline is calculated by three methods, which include static method, avoiding vortex vibration method and DNV-RP-F105 based on Miner linear accumulated fatigue damage. Given by example, characteristics of the methods are analyzed in this paper. Static method is idealized because environmental factors are not considered. Stress in the span is analyzed with method that maximum bending stress is less than allowable stress, and critical span is calculated. Static method is not complete. In addition to static stress, dynamic stress derived from vortex induced vibration should be considered in course of calculating critical span. Avoiding vortex vibration method is more developed than static method. The third method is

DNV-RP-F105 based on Miner linear accumulated fatigue damage. Environmental factors such as flows, waves, wind seabed situation and etc. are considered in the method compared with the above methods. Results of the third method are much different from the others because 100 year return period value in the example of Hangzhou bay is much higher than routine value. The third method should apply to calibrate practical span.

INTRODUCTION

Submarine pipeline is affected by dynamic loads due to waves and currents, ice loads and incidental loads. Free spans may be caused by seabed unevenness and change of seabed topology such as scouring or sand wave. Free spans became longer and longer and finally failed [1]. Submarine pipeline fail will be because vortex vibration and wave vibration emerge when currents scour free spans. Mostly pipeline failed because of “frequency locks”. There are four reasons for span: erosion of seabed, bumpy seabed, submarine pipeline climbing slope, pipeline ascending to offshore platform. Here we only study spans due to erosion of seabed. In engineering design or checkage stage, considering span length effect on pipeline bending distortion and on pipeline natural frequency, there are three methods to determine the free span.

INTEGRITY ASSESSMENT FOR CORRODED PIPELINE

Yuqin Wang[1], Weibin Wang[1], Qingshan Feng[1], Yihan Lin[2]

The RSTRENG Effective Area method and the methods of ASME B31G and RSTRENG 0.85dL are used to compute and evaluate the remaining strength of one segment of a pipeline which has been carried on ILI. With the computed results analyzed and assessed, the maximum safe pressure, safety factor and burst pressures are given in this paper, which provide a reliable safe guarantee and excellent management and operation for pipelines.

The reason to conduct the integrity assessments and evaluate the remaining strength of pipelines is to find the maximum safe pressure and the burst pressure of pipelines. The scheduled restoration and safety management and operation of oil & gas pipelines can therefore be guarantee

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TEMPERATURE BASED ON CREEP DAMAGE MECHANICS

Luyang Geng*, Jianming Gong, Xiaochi Niu, Juntao Bao

In this paper, the modified Karchanov-Rabotnov creep damage constitutive equation has been incorporated into finite element program ABAQUS through its user subroutine to predict the creep damage and remaining life of a serviced steam pipeline made of STAP23 heat resistance steel. Creep tests and short-term tensile tests were carried out to get the material constants in creep damage constitutive equation, which are necessary in the mentioned creep damage and life prediction. The damage distribution of the pipeline serviced for 100,000 hrs was obtained. Based on this, remaining life of the pipeline was analyzed, and the conclusion is consistent with the actual serviced life and metallographic examination results.

INTRODUCTION

Main steam pipelines, which operated at elevated temperature and high pressure, are important components widely used in power plants and chemical plants. For these pipelines, Creep is considered as a significant cause of failures[1]. Creep cavitations and cracking are often observed in the inspection of these pipelines, which indicate that damage occurs in the pipe material[2].

As most of the damage occurs at local position such as pipe bends, welds and T-type joints, etc., most the past investigations about pipelines operated at elevated temperature and high temperature emphasized on these locations [3-5]. But about the whole steam pipelines operated at elevated temperature and high temperature, there are few investigations have been reported. In this paper, creep damage simulation and life prediction of a main steam pipeline operated at 520℃ was performed by incorporating the modified Karchanov-Rabotnov creep damage constitutive equation into finite element program ABAQUS through its user subroutine.

STUDY ON HIGH TEMPERATURE DAMAGE TO Cr5Mo FURNACE TUBE IN A PETROCHEMICAL PLANT

GAO Zengliang*, ZHANG Wei and LU Zhiming

Cr5Mo steel samples from different furnace tubes exposed to high temperature conditions in a petrochemical unit were investigated experimentally and assessed. Tensile test at various temperature were carried out and the fracture morphology of the specimens was analyzed by scanning electron microscopy. Impact and hardness tests were also employed. Microstructures of the specimens were obtained. The experiment results showed that the mechanical properties of Cr5Mo steel were degraded due to the high temperature and the grain size grade of the furnace tube samples were found to be increased. These results indicated that Cr5Mo furnace tube can experience degradation of mechanical properties at high temperature situations, which may cause the decrease of its service life.

INTRODUCTION

Chromium-molybdenum (Cr-Mo) ferric steel has been widely used in various components in chemical industry, petrochemical industry and the power-generation industry because of its excellent mechanical strength, toughness and good corrosion resistance [1-3]. Cr5Mo ferric steel is often designed as structural material for oil refining and processing applications such as pressure vessels, furnace tubes and pipes and worked in various operation temperatures especially at high temperature conditions[4]. However, the equipments made by Cr5Mo ferric steel sometimes could be damaged in the case of being subjected to extended exposure or under the condition of high service temperatures. Under the extreme heat situation, the structural and mechanical properties of Cr5Mo ferric steel may be degraded, which is often associated with whether the equipments are suitable for continuing service or not.

The present work is to study the mechanical properties and fracture morphologies of Cr5Mo furnace tube exposed to high temperature conditions in a petrochemical plant. The size of the tube was 127×10mm. The performance and microstructure of the material will be described by chemical compositions analysis, tensile test and SEM. An assessment will also be made to determine the suitability for continued service of the furnace tube.

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FUZZY FAULT TREE ANALYSIS METHOD FOR THE THIRD-PARTY DAMAGE OF HANGZHOU BAY OFFSHORE PIPELINE

Wang Qian, Zhao Jianping*

By means of fault tree analysis method, a systemic analysis on the relevant factors of the third-party damage of Hangzhou Bay offshore pipeline was given in this paper, and its fault tree is also established. The fault tree include 30 minimum cut sets, the failure probability of the top event can be calculated, and the importance of the basic events can be analyzed. Expert inquiry method, combined with fuzzy sets theory, is adopted to assess the failure probability of the basic events. The calculating of 'self-buried effect bad'─ one of the basic events of the third-party damage of Hangzhou Bay offshore pipeline, is given as an example of this method.

INTRUDUCTION

As a tool of transportation fluid, offshore pipeline have some merits, such as continuous, and quickly. During the application of offshore pipeline, the safety problem is being paying attention to. Demars and other scholars researched offshore pipelines' accidents from 1967 to 1975, who found corrosion, flow scouring, the third-party damage and seabed movement （Ma [1]）are the principal reasons. The third-party damage of Hangzhou Bay offshore pipeline mainly is studied in this paper by fault tree analysis (FTA) and expert inquiry method. Fault tree analysis (FTA) is an applicable and useful analysis tool, it is an analytical technique used for identifying and classifying hazards, and calculating system reliability for both simple and complex engineering systems. The analyst defines a top event (TE), which is a failure or accident, and then builds the sequence of faults leading to this TE（Grosh et al. [2]）.

INVESTIGATION INTO EFFECT OF HYDROGEN

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CONCENTRATION ON HIC SUSCEPTIBILITY OF 08CR2ALMO STEEL IN SATURATED H_2S SOLUTION

ZHANG Yaofeng*, GU Boqin**, DING Yi

08Cr2AlMo steel is a type of material developed especially for heat exchanger pipe bundle used in the mediums containing H_2S in the recent years. The relationship between hydrogen concentration and hydrogen induced cracking (HIC) susceptibility of 08Cr2AlMo steel with different plastic deformation in saturated H_2S solution was investigated by means of improved electrochemical test, tensile test and scanning electron microscopy (SEM) technology. Improved electrochemical method introduced in this paper is a simple and effective method for measuring hydrogen concentration in steel. For the material with the same plastic deformation, the longer the immersion time, the more hydrogen atoms will migrate into the steel. For the same immersion time, the larger the plastic deformation, the higher the hydrogen concentration in the steel is. HIC susceptibility is linearly related to the hydrogen concentration in 08Cr2AlMo steel in saturated H_2S solution. For HIC type of stress corrosion cracking (SCC), by measuring I_{HIC} in various hydrogen concentrations at different immersion time, HIC susceptibility of the material in service can be predicted, and then the structural integrity of pressure-containing component can be estimated.

INTRODUCTION

Aqueous H_2S in petroleum and natural gas systems is very aggressive to the steel equipment used for transporting and processing these products. Inspection programs indicate that 25% of equipment failures in the petroleum refining industry are in some way associated with hydrogen induced cracking (HIC)[1]. HIC has become an important factor influencing structural integrity of petrochemical equipment. The reaction between wet H_2S and steel generates atomic hydrogen, part of which gets absorbed into steel. The hydrogen in the steel causes distortion of crystal lattice, intensity weakening of intercrystal joint, and nucleation and propagation of micro-cracks, which results in steel fracture with little plastic deformation or under low stress at last. Although there is a considerable amount of evidence [2] that hydrogen plays a critical role in HIC of steel, the relationship between hydrogen and susceptibility of HIC has seldom been studied quantitatively.

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08Cr2AlMo steel is a type of material developed especially for heat exchanger pipe bundle used in the mediums containing H_2S in the recent years. The objective of this work is to study the effect of hydrogen concentration on HIC susceptibility of 08Cr2AlMo steel in saturated H_2S solution by means of improved electrochemical test, tensile test and scanning electron microscopy (SEM) technology, and to establish the method for predicting HIC susceptibility of this material.

ON THE FRACTURING BEHAVIORS OF FRP-STRENGTHENED CONCRETE STRUCTURES INFLUENCING OF INTERFACIAL MATERIAL CAPACITIES

*Juanxia Zhang[1], Xianzhang Guo[2], Chun'an Tang[3], Wancheng Zhu[2], Xiuyan Zhou[1], Shengguang Zhuo[1]

The applications of Fiber Reinforced Polymer (FRP) sheets as tension reinforcement have been widely used in repair and upgrading of concrete structures. The significance of the bond is due to its critical role on transferring the stress from the existing concrete structures to externally bonded FRP sheets and keeping integrity and durability of the composite performance of FRP-concrete system. So how to improve the interfacial load transferring performances and ductility and how to improve the strength efficiency of FRP materials should raise more concerning. In this paper, a numerical simulation code named Realistic Failure Process Analysis was used to estimate failure mode of FRP-reinforced concrete beam with different bond between FRP and concrete, which has different mechanics parameters. The numerical test predictions are compared with experimental results, the numerical tests show that properties of the interfacial adhesive layer and concrete are considered to significantly influence the failure modes and crack distribution. The interactions between the interfacial bond strength and tensile strength of concrete are discussed through a parametric study; the effects of these properties on the interfacial debonding types and concrete crack distribution are clearly studied.

INTRODUCTION

Fiber reinforced polymers (FRP) with their excellent mechanical properties have been utilised in construction in a variety of ways. The use of FRP for strengthening concrete structures provides a fast and economical way of rehabilitation or repair of beams, columns or slabs. External confinment of concrete by high-strength fiber

composites can significantly enhance its strength and ductility, the enhancement performance of such hybrid beams, however, depends on bonding quality and property of interface between concrete and FRP. Apparently , performance of the interface between concrete and FRP plays an important role in hybrid beams due to the stress transfer from concrete to FRP laminate through the interface[1-5]. Properties of the interfacial adhesive layer and concrete are considered to significantly influence the debonding propagation types and crack distribution [5].

In this paper, a newly developed numerical simulation method Realistic Failure Process Analysis (RFPA3D) has been used to analyze the crack initiation, propagation and final failure mode of the FRP strengthened concrete structures. The numerical results are similar to the laboratory test observation that are carried out to investigate the failure mode of the FRP strengthened cocnrete structures.Present research focuses on the effect of property of the interface adhesive layer on the failure mode of the specimen.style.

OMOLYBDRIC ACID ON STAINLESS STEEL DURING ACETATE PRODUCTION

WANG Jun, LIU Wen-bin*, QIU Qi-hao, MA Xin-peng

Corrosion behavior of the complexes of para-toluenesulfonic acid (PTSA) and 12-phosphomolybdric acid (PMoA) on 316L stainless steel was investigated in the media simulated synthesizing butyl acetate in this work. In addition, industrial experiment was conducted in a plant of producing butyl acetate on 500 t/a scale. The experiment results indicated that PMoA was a highly effective corrosion inhibitor in improving the resistance to pitting and crevice corrosion of stainless steels in solutions containing PTSA and acetic acid (HAc), and improving the resistance of the passive film to breakdown, enhancing repassivation characteristics of the bare metal. Under researched conditions, the concentration of HAc, PTSA, and PMoA is 40%, 1.0%, 0.1%~0.2%wt., respectively, the corrosion rate of specimens was lower than 0.05mm/a at 100~140ºC. Heat exchanger made by 316L stainless steel had no obvious corrosion, and showed metallic luster for 7 months.

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INTRODUCTION

Acetate, such as ethyl acetate and butyl acetate, is normally produced via reversible reaction of acetic acid (HAc) with corresponding alcohol in the presence of catalyst (Larock [1]). The catalyst for this reaction, H_2SO_4 or PTSA, was shown to cause more severe corrosion on process equipments (vessels, heat exchangers, valves, etc.) than HAc under the process conditions commonly practiced in industry. Increased maintenance costs and downtime have placed a greater emphasis on the need for reliable, safe and versatile performance of process equipments (Qi and Lester [2]).

The use of inhibitors is one of the most practical methods for protection against corrosion, especially in acidic media. Inorganic compounds, such as chromate, molybdates, heteropoly acids or salts, etc., have excellent resistance to pitting and stress corrosion, especially molybdenum. Mo is a highly effective element in improving the resistance to pitting and crevice corrosion of stainless steels in solutions containing chloride ion (Kaneko and Isaacs [3]). Various models have been proposed to explain the beneficial effects of Mo, including improving the resistance of the passive film to breakdown, enhancing repassivation characteristics, or reducing the active dissolution rate of the bare metal inside the pits (Li and Mu [4], Han and Fang [5]).

In this investigation corrosion behavior of PTSA, PMoA, and complexes of PTSA and PMoA on 316 stainless steel was investigated in the media simulated esterification. And it was first proposed that PTSA was used as esterification catalyst, PMoA as corrosion inhibitor so as to settle corrosive problem of process equipment which directly contacted with acidic catalyst and acetic acid. In addition, industrial experiment was conducted in a plant of producing butyl acetate on 500 t/a scale.

BOUNDARY ELEMENT ANALYSIS OF SURFACE WAVES INTERACTION WITH FINITE-SIZE, SURFACE-BREAKING CRACKS IN THE RAILHEAD

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The interaction of surface acoustic waves with finite-size, surface-breaking, semi-circular cracks in the railhead is studied numerically, and experimentally.

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We focus on the behavior of the reflection coefficient of the Rayleigh wave from such cracks in the far field of the crack, when the depth of the crack is comparable to the wavelength of the interrogating surface wave. The theoretical, boundary element, and experimental results presented are in very good agreement over the range were the crack depth is much smaller or much larger compared to the wavelength of the incident Rayleigh wave. In the transition regime, between these two limiting cases, only the boundary element and experimental data show good agreement since the theoretical predictions are no longer applicable. In the high crack depth to wavelength ratio regime, the boundary element and experimental results close to the crack approach the limiting value of the reflection coefficient from a 90-degree corner. The results of this study is very useful to the design of the wheel probe for rail ultrasonic inspection and the signals analysis to detect gauge corner cracking in railhead.

INTRODUCTION

A major challenge for the maintenance of modern railways is the detection of critical surface cracks on the running surface of rails. Such defects are mainly induced by rolling contact fatigue (RCF) caused by high traffic loads [1]. In order to ensure that rail sections containing critical defects are identified and replaced in time, the rail network has to be inspected with efficient and reliable methods. For many small fatigue cracks develop near the surface of the railhead, so that Rayleigh surface wave are in many cases an appropriate tool for ultrasonic inspection [2-4].

The problem of Rayleigh wave interaction with surface breaking cracks has been recently studied theoretically, numerically, and experimentally by many authors (Achenbach[5], Resch [6], Viktorov [7] et al.). The extensive effort in studying the interaction of surface acoustical waves with surface breaking cracks is quite clear from the numerous number of articles found in the literature on this topic. Unfortunately almost all these studies concentrated on the far field response due to such an interaction. The near field response due to Rayleigh wave interaction with surface breaking cracks has not been studied as extensively, due to the fact that most of the nondestructive techniques utilized in detecting and sizing such cracks use piezoelectric transducers that have finite, large sizes (compared to the size of the crack) that puts them inherently in the far field of the crack. Recent developments in point detection of surface ultrasonic waves using laser interferometry, and the availability of efficient computational boundary element tools over the opportunity to investigate in detail the difference between the far field and the near field.

In this paper Rayleigh wave interaction with finite size, surface-breaking, semi-circular cracks in the far is studied by theoretical model of Resch et al. [6], experiments and 3D-boundary element analysis. The material used in this study of BEM is rail steel with the following properties: density ρ=7890kg/m^3, longitudinal

velocity: c_L=5900m/s, and shear velocity: c_s=3240m/s. This gives a Rayleigh wave velocity of about c_R=2996m/s.

STRESS CORROSION CRACKING BEHAVIORS OF 2205 DUPLEX STAINLESS STEEL IN HYDROGEN SULFIDE SOUR ENVIRONMENTS

Liu Zhiyong*，Zhi Qing，Dong Chaofang，Li Xiaogang

The electrochemical and stress corrosion cracking (SCC) behaviors of the 2205 duplex stainless steel in sour H_2S and H_2S + CO_2 environments have been investigated by SSRT, soaking U bend specimens and potentiodynamic polarization curve measurements. The results show that 2205 duplex SS has a good resistance to SCC in hydrogen sulfide sour environments. The sensitivity to SCC increases with pH value loared and concentration enhanced, and pH value has more influence to 2205 SS. When the pH value is 4.5 or more than it, the susceptivity of 2205 is very low under normal temperature and pressure, and it is affected little by the concentration of H2S; The existence of CO_2 can increase the sensitivity of 2205SS to hydrogen sulfide stress.

INTRODUCTION

Duplex stainless steels are used to produce portal equipment since 1980s, representing excellent anti-corrosion properties. Former datas show 2205SS has a good resistance to SCC in Cl^- environments, and a better corrosion resistance to SCC in H_2S environments than 316L stainless steel[2]. However the existing literature studies little about the influence of pH value to SCC and partial pressure of H_2S, temperature, CO_2 and Cl^- are studied more[3-7]. The H_2S concentration of gas fields in China exceeds range of study and engineering specification and many classical evaluation approaches can't assess it and the co-action of CO_2 and H_2S are studied

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little. Therefore, it needs to be studied whether it can be used in H_2S environments of high concentration and its resistance to SCC.

CHARACTERIZATION OF STRESS CORROSION CRACKING BEHAVIOR OF NITROGEN-CONTAINING 304NG STAINLESS STEEL IN HIGH TEMPERATURE WATER FOR STRUCTURAL INTEGRITY

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Stress corrosion cracking (SCC) of stainless steels in high temperature water coolant has become a key problem affecting structural integrity of nuclear power systems in the world. In this work, the SCC behavior of nitrogen-containing steel 304NG in high temperature water environments has been characterized through investigating the effects of environmental factors (electrode potential and Cl^- content) and heat treatment by means of slow strain rate testing (SSRT). The environments were pure water doped with 2, 5 and 50ppm Cl^- at 250°C. For the steel in solution annealed state, the susceptibility to SCC at each Cl^- level increased with increasing potential and there was a minimum potential for SCC, E_{SCC}, below which no SCC occurred. The E_{SCC} value decreased with the rise of Cl^- content in the solution. The failure mode was transgranular cracking. The sensitization at 550°C for 730h caused high SCC susceptibility and intergranular cracking at potentials of +200mV or above in the solution with 5ppm Cl^-, and also resulted in some transgranular SCC at -700mV. The mechanisms of the effects of environment and heat treatment are discussed.

INTRODUCTION

Long–term operation experience of nuclear power plants in the world indicates that SCC of stainless steels and Ni-based alloys in high temperature water coolant has become one of the main problems affecting system integrity (Jones [1]).

For widely-used austenitic stainless steels, sensitization degree and environmental factors such as electrode potential, water chemistry and temperature have been shown as key factors for the SCC (Ford [2], Congleton [3], Ljungberg [4] , Li [5] , Peng [6]). Widely used austenitic stainless steels, such as types 304 and 316,

are susceptible to intergranular SCC and intergranular corrosion mainly because such materials can be easily sensitized during manufacturing processes such as welding. This sensitization problem can be overcome by decreasing the carbon content, which would reduce the strength level. Replacing much of the carbon with nitrogen can offset this deterioration (Anita [7]). Together with chromium and molybdenum, nitrogen additions to austenitic stainless steel can improve resistance to pitting and crevice corrosion, intergranular corrosion and SCC. Now nitrogen-containing stainless steels have become an increasingly important new class of engineering materials. The purpose of this work was to characterize the SCC behavior of nitrogen–containing stainless steel 304NG in high temperature water environment as a function of sensitization and environmental factors.

THE FRACTURE BEHAVIOR ANALYSIS ON BRAZED JOINT OF TI-6AL-4V AND 1CR18NI9TI TUBES

Qu Wenqing, Zhang Lei, Zhuang Hongshou

Using the copper-base and silver-base brazing filler metals, the experimental study on high frequency induction brazing of thin-wall and small diameter dissimilar metals tubes,such as Ti-6Al-4V and 1Cr18Ni9Ti is conducted. Their qualities and properties are largely superior to the bolt connection tubes structures. The static tensile test results indicate that all the joints brazed by silver-base brazing filler metal have failed on 1Cr18Ni9Ti base metal, and their mechanical properties are slightly better than those using copper-base filler metal. It is found from the microstructures observation after tensile tests that, all the cracks in the joint brazed by silver-base brazing filler metal germinated and propagated in the brazing seam, and then stoped when they met with the interfaces. The cracks in the joint brazed by copper-base filler metal germinated in three locations: the boundary of two phases in the brazing seam, the interface between brazing seam and Titanium alloy, the interface between brazing seam and Stainless Steel, and then propagated in the brazing seam. The crack driving force consisted mainly of the static tensile load and the mismatch behaviour of dissimilar metals brazed joint. And the crack extension resistant force is related to the microstructures in the brazed joint.

INTRODUCTION

Ti-6Al-4V and 1Cr18Ni9Ti tubes are widely use in propulsion systems in aeronautical and space technology, such as the fuel tubes, cooling tubes etc. The fusion welding process can be used to join the same material tubes, not to join dissimilar metals tubes (Ti-6Al-4V and 1Cr18Ni9Ti). Because the microstructures and properties of dissimilar metals have the large difference, some problems appear when they are welded together, for example, ① the brittle metallurgic compound forms on the interface because of their metallurgical incompatibility, ② the residual stress come forth on the bonded zone because of the different thermal phisical properties, ③ the stress singular behavior appears at the edge of the bonded interface because of the different mechanical properties. Now only the bolt connection can be used for Ti-6Al-4V and 1Cr18Ni9Ti dissimilar metals tubes, which has many disadvantage, such as large weight, low strength, and low qualities etc. To solve the above problems, only several special bonding processes can be used. The brazing process [1-2] is one of the best bonding methods to bond the dissimilar metals.

For a brazed joint of dissimilar metals, the brazed seam is the most dangerous zone. The crack can be easily germinate from the brazed seam and then propegates. The crack propegation will be severious effect on the safety of dissimilar metals bonded structure.

The study emphasis is placed on the vacuum high-frequency induction brazing of Ti-6Al-4V and 1Cr18Ni9Ti tubes. The qualitis and properties of the brazed joints were tested, and the cracks distribution in the brazed joint were analyzed. The result will provide the important technical reference for the brazing, and the fracture control of dissimilar metals bonded structure.

RESEARCH ON EDDY CURRENT ARRAY TESTING TECHNOLOGY OF MULTI-LAYERED STRUCTURES OF ALUMINIUM ALLOY

HAN Tian-long, ZHANG Zheng*, ZHAO Zi-hua

This paper presents an eddy current array NDT (non-destructive testing) technology that is applied to detect the corrosion damage which occurred on the second layer of hard aluminium alloy. The specimen with embedded corrosion defects in the multi-layered aircraft structure is tested. The

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experiment results indicated that the Eddy Current Array(ECA) have the advantages of detecting the embedded defects in the single or multiple structure, fast detection and having the ability of identifying the size and location of embedded defects, which makes the ECA have the broad using foreground in the testing of aircraft structure.

INTRODUCTION

Due to the effect of corrosion and accumulative fatigue damage, the corrosion fatigue damage greatly influence the safety of aircraft in service. Therefore how to find various defects as well as quantitatively evaluate the degree of defect is very important to ensure the flight safety. However, the aircraft fuselage general is multi-layered alloy composite structures, and defects usually occurred on the second layer of the multi-layered structures. It is difficult to discover these defects in time. How to fast, accurately and quantitatively detect these defects is a serious challenge for the field of aviation NDT [1]. The traditional methods such as ultrasonic, radiographic, infrared technology can not detect faults occurred on the second layer. So it is urgent to find an effective NDT method which is more effective in large area outfield detecting. At present, the major technologies researched on aircraft for detecting hidden corrosion flaws were infrared thermal wave imaging technology, pulsed eddy current NDT technology, ultrasonic testing technology and radiographic technology etc [2,3,4,5,6,7,8].

THE BELLOW STRUCTURAL INTEGRITY DESIGN BASED ON PARTICLE SWARM OPTIMIZATION

Yu Ying*, Li Yong-sheng, Zhu Qing-nan, Yu Xiao-chun

In this paper, the structural integrity design of bellow which is widely used in engineering fields is discussed, in which fatigue life, strength, stability, stiffness, manufacturing technology, economy and equivalent axial movement under the work condition should be satisfied. A bellow optimization design model of structural integrity is proposed, the objective function is the maximum of bellow equivalent axial movement per weight unit. An advanced optimization approach—Particle Swarm Optimization Algorithm (PSO) is applied to implement the bellow design, and some engineering numerical examples are also given. The results show that the bellows designed by the proposed approach have better performance and are more economical than the

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bellows in-service, and the bellow structural optimization design by PSOA is feasible and highly effective.

1 INTRODUCTION

Bellow expansion joints are employed in piping systems to absorb differential thermal expansion while containing the system pressure. They are widely applied in refineries, chemical plants, fossil and nuclear power systems, heating and cooling systems and cryogenic plants etc. Bellow is main component part of bellow expansion joint, which decides thermal compensation performance of expansion joint.

In general, the bellow design process is quite complicated. In the design process, strength, stability, fatigue life, stiffness and manufacturing technology must be satisfied, meanwhile the bellow must have supply certain flexibility to satisfy the requirement of deformation compensation. Therefore, the structural parameter design of bellow should be the structural integrity optimization design in which each kind of performance constraints and compensation requirements should be considered.

In this aspect, some scholars have done some work, for example Yang Ling et al [1] had designed bellows by the discrete complex-method, but they didn't give out a reasonable mathematical model based on structural integrity design. Sun Ai-fang et al [2] designed the bellow based on ANSYS, in fact, ANSYS is not suitable for the structural integrity optimization design. So, to establish integrity optimization design mathematical model of bellow and use new and efficient optimization method to the design of bellow is necessary.

In this paper, the integrity mathematical model of bellow structural design is established based on EJMA (Standards of The Expansion Joint Manufactures Association, INC), and in which the optimization objective function is the maximum of bellow equivalent axial movement per weight unit subjected to all kinds of performance constraints. Particle swarm optimization algorithm (PSO), is applied to structure integrity design of bellow and some engineering numerical examples are given.

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SIMULATION OF CARBURIZING CONCENTRATION FIELD OF METAL DUSTING CORROSION WITH APPLIED LOADING

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Metal dusting is a catastrophic phenomena of high temperature corrosion, which occurs in severe carburizing environments (carbon activity aC>1.0) at temperatures 400-900℃. Metal dusting causes not only phase changes but also removal of materials (pitting or thinning) and serious material deterioration. Carburizing is the precondition of the occurring of metal dusting corrosion, and the ultimate cause of phase changes and removal of materials. Generally the effect of the loading has not been considered against metal dusting corrosion in present study. This paper focuses on the simulation of carburizing concentration field by finite element method under the condition of metal dusting and applied loading, which is compared with the experiment results. A preliminary study of the coupling effect of diffusing and applied loading (chemical and mechanical) has been carried out.

INTRODUCTION

Metal dusting is defined as a catastrophic carburization leading to formation of a dust of graphite, fine metallic and other particles. It has been frequently observed in many industrial processes such as synthesis gas production, coal gasification, and iron ore reduction. Lots of researches have been carried out in laboratories using Fe, Ni, Fe-base, Ni-base, and other low and high alloys in strong carburizing environments (Grabke [1], Grabke et al. [2], Chun [3], Zeng [4] and Yin [5]). At present, the phenomenon of metal dusting may be divided into four main mechanism building blocks (Szakálos [6]). However the effect of applied loading has not been considered against metal dusting corrosion. Actually, the materials used in different industrial processes undergo certain stresses that will affect the carburizing concentration field of metal dusting corrosion. In the present work, the simulation of carbon concentration field of metal dusting corrosion with applied loading has been finished. And compared the simulation results with the experiment results. The preliminary coupling effect of carbon diffusing and applied loading (compressive and tensile) will be discussed.

THE COMPUTERIZATION OF THE 3-D STRUCTURAL PLANES AND GEOMETRIC STOCHASTIC BLOCKS IN ROCK TUNNEL STRUCTURES

Yabing Zhang, Shuhong Wang*, Yi Li, Peng Jia

Existence of structural planes affects dynamical properties greatly in rock tunnel structures. According to the typical block theory and reliability analysis, a new system-GeoSMA for simulating tunnel structural planes in rock mass is put forward to develop by based on objective-oriented visual C++ and openGL. In this study, firstly the stereographic projection model is improved so that it is able to group the structural planes and seek out the preferring centers of the iso-intensity diagramming automatically. Secondly, on the basis of these specimen data, both the structural planes and the whole structure of rock mass are simulated and regenerated using Monte-Carlo method. In the end, the process for searching stochastic block is displayed.

INTRODUCTION

The most important distinction between man-made materials and the natural material rock is that rock contains structural planes, of many kinds on many scales. The structural planes dominate the rock mass geometry, deformation modulus, strength, failure behavior permeability etc.Clearly, an understanding of the presence of the structural planes is therefore of paramount importance to tunnel engineers. In this paper, based on the object-oriented visual C++ and openGL, new software is built up for simulating structural planes.

CALCULATION MODEL AND TESTING ON A NEW SORT OF SPREAD FOUNDATION WITH CONCRETE SLAB

LI Chun[1], WANG Shu-hong[1], ZHU Fu-sheng[1], PAN Xiu-yan [2]

The background reaction and reinforcement bar stress of a new sort of foundation named “Spread Foundation with Concrete Slab” now are solely tested by two kinds of sensors called GYH-2 and GJL-2. At the same time, the foundation settlement is also tested by a kind of equipment called N3 in-situ monitoring. So the first-hand dynamic data have been griped. The allocation proportion of background reaction between spread foundation and concrete

slab and reinforcement bar stress can be nailed down. The regularities of spatial distribution and virtual condition of the new foundation are also confirmed. The practical calculation model is nailed down based on the test data, and the calculation formula about allocation proportion of background reaction can be deduced too. As a result, concrete slab can take on about 30% the upper load of structure. Reinforcement bar stress changes alternately, the biggest tensile stress occurs at span centre of slat under the poles, it displays about 22% of reinforcement bar intensity less than allowable value.

INTRODUCTION

When the height of a structure approaches the criterion of high building and the bearing capacity of foundation soil is much bigger than the upside load, if raft foundation or box foundation is all the same used, the design will be conservative. So designers in some companies decide to use a new sort of foundation called "Spread Foundation with Concrete Slab", that is to say, RC spread foundation is used below the poles, while concrete slab is used between the two adjacent poles, they are all put together so as to form a unit. During the calculation, designers usually think that spread foundation completely takes on the upper load, while the allocation proportion of background reaction of concrete slab between two poles is so small that it can be neglected. Concrete slab can take on partial sub grade reaction and hold out balance together with spread foundations below poles. Therefore, spread foundation can't take on all of foundation soil reaction. It is impossible that there isn't sub grade reaction under the concrete slab at all. They are actually co-workers [1-2]. Case study, Liaoning cultural artistic center and new museum, locates in the east of office building of the government, the whole floor space is about 5hm^2. There is one underground chamber, while four floors over ground. It is 22 meters high. The span between two poles is 9.0m×9.0m. Frame construction and spread foundations with concrete slab are used in the engineering practice. Embedment depth of foundation is 7.60 m. supporting course of natural foundation is sandy gravel stratum, Characteristic number of bearing capacity of natural foundation soil is 420kPa. The stratum layer shows much representation in place.

The test facility called GYH-2 for groundwork reaction of the foundation is a sort of sensor (it will be called GYH-2 in the following text). Before GYH-2 is inbuilt, the characteristic points of structure must be found out, and then test facility can be intercalated here. Thirty-nine GYH-2 were used this time, but GYH-2 of number 30 was disabled during the testing, as shown in Figure.1. All of test data are disposed now because the exceptional and illogical data have been abnegated during analytic process. Curve between time and base pressure of the foundation can be solely plotted according to testing sequence and position of GYH-2, see Figure.2. Curve between

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time and compressive stress of the slab under the poles can be plotted too. Figure 3 has illustrated it. So the spatial distribution characteristic and mutative disciplinarian of groundwork reaction can be found out in the course of loading-on in the whole test specification.

NUMERICAL SIMULATION OF BUCKLING ANALYSES AND OPTIMIZATION FOR GRID-STIFFENED CYLINDRICAL SHELLS

Shi B.J.[*,†], Shu D.W.[†], Zhang Y.M.[*] and Yuan W.S.[*]

Grid-stiffened cylindrical shells are cylinders with stiffeners which can significantly increase the buckling load of a cylinder without much increase in its weight. Numerical simulation was conducted for calculating its buckling load of a grid-stiffened cylindrical shell using finite element method. Parametric studies were investigated for the cylindrical shell on the influences of the grid spacing, the stiffener's size and the skin thickness; respectively. Some optimal parameters were obtained which minimize the structure weight under a given buckling load. In the simulation, there are two main buckling modes, i.e., local buckling mode and global buckling mode. Numerical results indicate that high buckling load is reached when the global buckling mode dominates while the local buckling mode is suppressed. In other words, the global buckling mode should be used as the design criteria for a stiffened cylindrical shell.

INTRODUCTION

Cylindrical shells in general are fairly complicated to work with, especially when buckling is concerned. Grid-stiffened cylindrical shells are cylinders with stiffeners which can significantly increase the buckling load resistance of a cylinder without much increase in weight. The stiffened cylinders play an important role and are widely used in aerospace, pipes, tanks and launch vehicles.

The buckling of a stiffened cylindrical shell generally occurs in two modes, i.e., global buckling mode and local buckling mode. Three main approaches have been applied in the buckling analysis of stiffened cylindrical shells and panels [1-4], i.e., the discrete approach, the branched plate and shell approach, and the smeared stiffener approach. The discrete approach is difficult to use when the panel is stiffened

in more than two directions or when the stiffeners are not symmetric about the skin mid-surface. The branched plate and shell approach is more flexible and more accurate than the discrete approach. The smeared stiffener approach is applicable in general to stiffened panel where the local buckling load is equal to or greater than the global buckling load.

AGA-BP SYSTEM'S APPLICATION ON STRESS FORECAST OF CULVERT STRUCTURE

FAN He[1], ZHANG Hong-hai[1], WANG Shu-hong[1], FAN Ze[2]

Through experimental analysis on culvert mechanical capability, culvert stress is monitored in key positions. According to culvert project locating on loop line of highway in the middle of liaoning province, China, model test with similar material performed in the lab. Forecast ability of neural networks is satisfied in large literature search. Adaptive genetic algorithm by adding adaptive cross and mutation operators to standard genetic algorithm has strong optimum ability. Combined with advantages of two intelligence methods, AGA-BP system is developed. The system is used to search the optimal network structure which forecasts stress distribution of culvert key position. The results show that AGA-BP system forecast ability is good. The study provides guiding suggestion to early culvert design and late lifespan evaluation.

1. INTRODUCTION

Culvert is a common structure in civil engineering, hydraulic and highway engineering. Culvert usage probability is great whether project cost or quantity (Zhao [1]). Model test is a direct-vision method which can reproduce results in a short time. According to culvert project, similar index is deduced based on similar theory and dimension analytic method to guide experiment. Back-Propagation Network (Kerh [2]) has excellent forecast abilities which can establish nonlinear map relationship of input vector and output vector. Standard genetic algorithm's global search is strong, but gets local optimum solution easily. Adaptive genetic algorithm (AGA) improves weakness by adaptive cross and mutation probability formula. Using model test data as sample, optimal network which AGA searches forecasts stress distribution regularities of culvert key position along with soil high increasing. The obtained information indicates that result is satisfying. It may provide reference to culvert after-work and lifespan evaluation.

STRUCTURE INTEGRITY ANALYSIS FOR SOLAR PARABOLIC TROUGH COLLECTOR BY FEM*

Lei TAO** Xiang LING Yuezhao ZHU

Structural integrity analysis of the collector by using finite element software ABAQUS incorporated with genetic optimal algorithms were presented in this paper. The bending and torsion failure models concerning on the optical accuracy were established for the trough collector. The conversion of the wind load into the dead load was acted on the collector. The stress, strain and displacement for the collector under respectively 6th level gale, 8th level gale and 10th level gale were obtained. Detailed FEM investigations on the structural behavior under various load cases (dead load, wind loads for a range of pitching angles of the collector and wind directions) for alternate designs, complex computer modeling and ray tracing were performed to obtain the best possible relationship of optical accuracy and collector cost. The results obtained in this paper are available for reference to the structural optimum design of the trough collector.

INTRODUCTION

Concentrating Solar Power could provide an important, low carbon contribution to electricity production over the coming decades. Parabolic trough technology is nowadays the most extended solar system for electricity production or steam generation for industrial processes. Collector field represents more than half the total plant cost. Therefore, it is needed to improve current state of the art of parabolic trough collector (PTC) design in order to reduce plant cost [1].

In this paper, design of the structure has been improved by using genetic algorithms and detailed FEM investigations on the structural behavior under various load cases (dead load, wind loads for a range of pitching angles of the collector and wind directions) for alternate designs, complex computer modeling and ray tracing were performed to obtain the best possible relationship of optical accuracy and collector cost.

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SHAKEDOWN ANALYSIS OF MORPHOLOGICAL DEFECT IN THERMAL BARRIER COATING

Y. Yuan*, Xu Yingqiang, Lv Guozhi

Morphological defect and cumulation of residual stress represent a source of failure in some thermal barrier systems during high temperature operation. A simple analytical model of three concentric circles is adopted to represent top coat, oxide coat and bond coat of thermal barrier coating. The model denotes interface morphological defect of thermal barrier coating. A self-equilibrated residual thermal stresses is given based on simple analytical model of three concentric circles, and then a shakedown analysis is established based on the model. The result is important to stabilities research of thermal barrier coating.

INTRODUCTION

The use of thermal barrier coating (TBC) allows the increase of the turbine inlet temperature and hence an increase of the efficiency of turbine engines. A typical plasma-sprayed TBC system consists of four constituents: (i) a thick Ni-super-alloy substrate, (ii) a relatively thin bond coat layer, (iii) a very thin thermally grown oxide (TGO), and (iv) a thermal barrier coating. TBC failure often results from a cyclic displacement instability occurring in the TGO [1]. In practice, at high temperature, the bond coat is relatively soft, while the TBC layer remains elastic. Thus, the displacements occur preferentially into the bond coat. A series of simulations [2] have revealed that the propagation of the instability depends on the interaction between three different strains: cyclic plasticity in the bond coat, growth in the TGO, and the thermal expansion misfit between the TGO and the substrate. The purpose of the present study is to explore shakedown of TBC embodies a geometric imperfection under cyclic high temperature operation. To achieve this, a simple analytical model of three concentric circles was adopted. First, the results for elastic limit and shakedown limit of TBC as functions of the TGO thickness are given. Then, residual stresses under shakedown condition at the top coat/TGO and the TGO/bond coat interfaces as functions of the TGO thickness are presented.

NUMERICAL ANALYSIS OF THE INCREMENTAL BLIND HOLE DRILLING- METHOD FOR THE STUDY OF RESIDUAL STRESS

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IN MULTI-LAYER MATERIALS

Xu Yingqiang*, Li Jianfeng ,Yuan Yuan, Wang Zhenlong and Lv Guozhi

Advanced multi-layered ceramic coatings applied on metallic substrates are being used increasingly as protective coatings for engine metal components to improve performance at high temperature, e.g. thermal barrier coatings (TBCs) for use in gas turbine components and diesel engines.It is well known that the residual stresses due to the mismatch between metallic bond coat and ceramic top coat as well as the stresses due to the oxidation of the bond coat generate debond- ing of the TBC, leading to a collapse of all thermal barrier system. The incremental hole-drilling strain-gauge method for measuring residual strain in elastic multilayer materials was studied. Theoretical analyses were developed to convert the residual strain measured to stress. The techniques used allow the main stresses to be resolved on planes that are normal to a deep hole. In order to link the surface strain to the residual stress, calibration coefficients were computed with the finite element method The result is that the coefficients depends on the substrate and the type of coating, the strain gauge used and the size of the step drilled. The method proposed enables the residual stress gradient of a thick section of multilayer material to be calculated.

INTRODUCTION

Residual stress experimental analysis is of great importance for the evaluation and optimization of multilayer materials processes. Residual stresses are determined by means of different experimental techniques, such as X-ray diffraction, neutron diffractionand and the curvature(1). XRD can not be applied to depth without material removal. Neutron diffraction can determine stress profiles in thick coatings but relatively complex and time-consuming in experimental procedure. The curvature does not give any information about the stress distribution in the laminate. In composite laminates, residual stress is not uniform in the through-thickness, the incremental hole-drilling method is possible to measure residual stress distributions in depth(2) with the development of the finite element method. As a difficulty, large effort has to be spent on calculation and selection of calibration coefficients. This paper has the objective in research the influence of corrected finite element model, increment drilling size and size of TBCs on calibration coefficients.

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STUDY ON SAFETY PREDICTION OF AIRCRAFT STRUCTURES

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Safety prediction is actually prediction of structural integrity state. For a designed aircraft, the two sides of safety prediction are endurance life prediction and structural health monitoring(SHM). On one hand, one-dimension life prediction and two-dimension life prediction are presented in the domain of endurance life prediction. On the other hand, the latest progresses of SHM are introduced. At last, It is suggested to combine endurance life prediction and SHM together in safety prediction for critical positions of aircrafts.

INTRODUCTION

All aircrafts serve under various operational conditions which including fatigue loads, corrosive environments and flight intensity conditions. After same period of service, the cumulative damage of every aircraft is rather different. So it is necessary to perform safety prediction for every aircraft according to the actual damage degree of critical positions. Safety prediction is actually prediction of structural integrity state. For a designed aircraft in active service, the two sides of safety prediction are endurance life prediction and structural health monitoring(SHM). For endurance life prediction, the purpose is to predict fatigue life and corrosive /aging state; and for SHM, the purpose is to monitor the initiation and propagation process of the cracks.

To optimize this technology it seems reasonable to make intermediate conclusion after about 60-year history of safety prediction in aircraft structures and to consider specific problems arising while developing contemporary technology. On one hand, one-dimension life prediction and two-dimension life prediction are presented here in the domain of endurance life prediction. On the other hand, the latest progresses of SHM are introduced in detail.

PREVENTIVE MEASURES TO ENSURE DURABILITY OF CABLE-STAYED BRIDGES

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Shenyuan Liu [1], Zeying Yang[2*], Jianbo Qu [3]

Today, there're more and more cross-sea cable-stayed bridges will be erected in Shandong province of China. Considering the structures of all these bridges will be built in reinforcement concrete and the service life of reinforcement structures will reduce because of many complex aggressive factors, this paper presents a series of preventive measures to ensure durability of cable-stayed bridges. Against the special corrosive environment and various parts of cable-stayed bridges, a multilevel comprehensive measures for the durability of cable-stayed bridges is proposed. Which include durability indexes and the corresponding evaluation methods, standard for construction and quality acceptance, essential preventive measures, as well as additional preventive measures, etc. The series of preventive measurements has been used on an actual cable-stayed bridge: Binzhou highway bridge over yellow river in Shandong province in China.

INTRODUCTION

Constructed between 2001 and 2004, Binzhou highway bridge over yellow river in Shandong province in China is a 1698 m long cable-stayed bridge, with a main span of 768 m ($2\times42m+2\times300m+2\times42m$) (Fig. 1). A brief description of the cable-stayed bridge follows, but details are provided by [1]. The bridge comprises three cable-stayed cantilever sections, and has 32.8m wide deck (which is the widest PC box girder bridge in China.) made up from PC box girder.

In the back spans, two concrete piers provoid additional restraints to the superstructure. Restraints to the deck are symmetrical about its longitudinal axis, and vertical and lateral movements are restrainted at the piers and the pylons.

The major factor contributing to concrete structures in the surrounding environmental and climatic conditions to which this cable-stayed bridge exposed is not ice abrasion, alkali-silica reaction (ASR), sulfate attack, or frost damage, but the attack of Cl^-.

ANALYSIS ON STRUCTURAL INTEGRITY OF PROPELLANT GRAINS USING SCHAPERY'S CONSTITUTIVE MODEL

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Physical properties of solid propellants used in solid rocket motors change significantly with age. In this paper, based on the constitutive relationship of viscoelastic material using the Schapery's nonlinear model and the corresponding viscoelastic finite element method, the computational model is established to value structural integrity of propellant grains. The parameters in the Schapery's model are obtained through the experiments. The constitutive equation is implemented into a finite element code for the analysis of propellant grains. A commercial finite element package 'ABAQUS' is used for the analysis and the model is introduced into the code through a user subroutine, UMAT. The stress and strain in three-dimension model of propellant grain is analyzed during the rise portion of the ignition event.

INTRODUCTION

Physical properties of composite propellants used in solid rocket motors change significantly with age. To predict the margin of safety and to reevaluate the remaining service life, the structural integrity analysis of solid propellant grains of aged rocket motors is performed at various stages of their life span [1]. To have the reliable results from these analyses, it is mandatory to use the current physical properties of the propellant at the time of analysis. Change in physical properties due to aging is more significant at exposed surfaces.

The stress analysis of solid-propellant grains requires a constitutive, or stress-strain, relationship for the solid propellant material. Linear viscoelastic model has been widely considered as inadequate models of propellant behavior, except under special loading conditions. Despite the need for more general constitutive relationships, progress in this area has been difficult [2].

In this paper, based on the constitutive relationship of viscoelastic material using the Schapery's nonlinear model and the corresponding viscoelastic finite element method, the computational model is established to value structural integrity of propellant grains. The parameters in the Schapery's nonlinear constitutive model are obtained through the experiments. The constitutive equation is implemented into a finite element code for the analysis of propellant grains. A commercial finite element package 'ABAQUS' is used for the analysis and the model is introduced into the code through a user subroutine, UMAT. The stress and strain in three-dimension model of propellant grain are calculated during the rise portion of the ignition event.

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ANALYZING THE SAFETY OF DEEP EXCAVATION TUNNEL BASED ON DIFFERENTIAL EVOLUTION ALGORITHM AND 3D NUMERICAL SIMULATION

Jiang Annan Zhang Jiao Yi Nangai

The paper proposes an integrative feedback analysis method combining difference evolution algorithm, orthogonal design method and three dimensional numerical simulation. It could dynamically obtain the rock mechanics parameters and appraise the deep tunnel safety based on monitoring data. The integrative method and algorithm steps are discussed in detail. The proposed integrated method is used to back analyze the rock mechanics parameters and appraise the surrounding rock safety of the tunnels of Jin-Shan-Dian Iron Ore. The analyzing results have guide meaning to Jin-Shan-Dian Iron Ore production and indicates that the proposed method is feasible.

INTRODUCTION

Along with more and more deep mining, how to analyze and appraise the excavation safety of deep tunnel becomes a focal subject[1-3]. Though three dimensional numerical simulation could calculate complex underground structure problem, deep underground rock has more complicated induced stress field and rock mechanics parameters are uncertainty, which reduce the calculating accuracy. Because 3-D numerical simulation spends much time, the conventional parameter optimization methods to identify rock mechanics parameters are limited. In this paper, differential evolution algorithm introduced, combining with orthogonal design and three dimensional numerical simulation, an integrative feedback analysis method for appraising deep tunnel stability and safety is proposed, which is used to analyze Jin-Shan-Dian Iron Ore tunnel, proving that the method is feasible and available, and the result has a good meaning to guide the tunnel excavation.

A MICROMECHANICS-BASED THERMODYNAMIC MODEL FOR MARTENSITIC VARIANT REORIENTATION IN

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MAGNETIC SHAPE MEMORY ALLOYS

Yuping Zhu*, Guansuo Dui*

In this paper, combined the micromechanical and the thermodynamic theory, a constitutive model for magnetic shape memory alloys is developed. The model is applied to a NiMnGa single-crystal specimen under a constant compressive axial stress. Model predictions of magnetic field-reorientation strain hysteresis loops under different applied stresses are discussed. The theoretical results are found to be in general agreement with experimental data.

INTRODUCTION

Magnetic shape memory alloys (MSMAs) have received great attention due to their ability to induce very large strains with an applied magnetic field[1-2].The macroscopically observable strain is the result of rearrangement of the martensite variants. In order to optimally predict the behavior of the MSMA it is important to build a simple, yet accurate model to describe its magneto-mechanical behavior relation.

Several groups have proposed models capturing the variant reorientation process [3-4]. In these studies, the effect of the evolution of microstructure and variants shape, which is important to the nonlinear and hysteretic constitutive response, has not been considered. In this paper, based on the micromechanical and the thermodynamic theory, a model for martensite variant reorientation strain of MSMA is developed. The model is applied to a NiMnGa single-crystal specimen under a constant compressive axial stress. The theoretical results are found to be agreement with experimental data.

STUDY ON OPTIMIZATION TECHNOLOGY OF SHEET METAL DEEP DRAWING WITH VARIABLE BLANK HOLDER FORCE

Li Qihan, Li Mingzhe, Cheng Kai, Wang Juan

A non-axial symmetry part—automobile headlight reflector is taken as the research object. The objective function is obtained by approaching function of artificial neural network (ANN). Numerical simulation and multi-object

genetic algorithms are adequately linked, whereafter, optimization model of variable blank holder force (VBHF) is established. At last, the reasonable VBHF curve is obtained. The result indicates that the VBHF curve optimized tallies with the tendency of plastic deformation in deep-draw better than traditional constant BHF and makes for even deformation and high quality product.

INTRODUCTION

Along with the development of finite element technology, the precision and the efficiency of numerical simulation in sheet metal forming obtained widespread approval. However, because the sheet metal forming has the high non-linearity, the factors which affect the product final quality affect and couple mutually. Finite element analysis is unable to research into these factors for rule among them, so that, it is primarily used to confirm forming project. Optimization theory provides an effective way for further studying the relations among the sheet metal forming quality influence factors and scientifically controlling them.

This research takes automobile headlight reflector as the research object. The objective function is computed out with the approaching function of artificial neural network (ANN). Numerical simulation and multi-object genetic algorithms are adequately linked, whereafter, optimization model of VBHF in drawing is established. At last, reasonable VBHF curve is obtained.

A REVIEW OF FAILURE MODELS OF NUCLEAR POWER KEY EQUIPMENT AND COMPONENTS ASSEMBLY

Meng Shaopeng Luo Hongyun*

Nuclear power is now the urgent need for the development of economy in the world. It was reported that the nuclear power installed capacity of China will develop from 6.1GW in 2002 to 40GW in 2020. During the development of nuclear power industry, the problem perplexing people all the time is the safety of operating nuclear power plant(NPP). And the research regarding damage and failure models is pivotal for the safety of operating NPP. This paper reviews the failure models of nuclear power key equipment and components assembly, such as reactor pressure vessel(RPV), steam generator(SG) etc. The failure models of RPV mainly include irradiation embrittlement, stress corrosion cracking(SCC), and for SG mainly include inner-diameter

SCC(IDSCC), outer-diameter SCC(ODSCC) etc. Besides, fatigue, wear and fretting damage are also common failure models in NPP.

1. INTRODUCTION

During the development of nuclear power industry, the problem perplexing people all the time is the safety of operating nuclear power plant. Because the influence of special nuclear environmental factor, such as radiation, high temperature, high pressure and complex hydrochemistry, the nuclear key equipment and components assembly can engender compositive failure. Analysis of the failure models will provide gist for the design, maintenance of them, thus enhance security, reliability , and reduce accident of operating NPP.

Fission reaction occurs in RPV which is the pressure boundary of primary loop. RPV is the very important equipment for the safety of NPP, and cannot be replaced. In the NPP of pressurized water reactor(PWR),CANDU reactor and water-moderated water-cooling in Russia, SG is the large-scale expensive primary equipment linking primary and secondary loop(Ding [1]). It is considered to be a weak link, for 80% of power loss in NPP is due to SG damage. Reliability problems have puzzled steam generators since the introduction of commercial PWR technology in the late 1950s.Various forms of steam generator tube degradation have resulted in the plugging of many tubes to date around the world.

Anyhow, RPV, SG, tubes, nuclear pipes, etc. are taken as the nuclear key equipment and components assembly. So this paper mainly reviews the failure models of RPV, SG and other correlative parts.

BP NEURAL NETWORKS MODEL FOR ATMOSPHERE CORROSION FORECAST OF LY12 ALUMINUM ALLOYS

HAN Desheng[1], LI Di[2]

BP neural networks model is built and trained with accelerated corrosion data of LY12 aluminum alloys for atmosphere corrosion forecast. Temperature, humidity, Cl^-, SO_2 sedimentation and time are designed as the networks input, while corrosion weight gain and maximum corrosion depth as the networks output. Practical application showed the model has good accuracy for corrosion forecast of LY12 aluminum alloys served in oceanic atmosphere.

INTRODUCTION OF THE BP NEURAL NETWORKS MODEL

Neural networks is a model for information processing which simulates creature nerve system. It is a nonliner system built up by large numbers of simple computing units, can simulate the function such as information processing, memory and searching of human cerebra(WEI Haikun [1]).

In this paper, series of corrosion data of LY12 aluminum alloys were gotten from accelerated corrosion test simulated marine atmosphere environment(HAN Desheng [2]). The data is sortted randomly and transformed to unitary matrix. BP neural networks is built for atmosphere corrosion forecast of LY12 aluminum alloys, with the former 100 data as the training samples and the last 6 data as the testing samples. Temperature, humidity, Cl^-, SO_2 sedimentation and time are designed as the networks input, while corrosion weight gain and maximum corrosion depth as the networks output.

The factors of the BP neural networks are: goal mse(means square error of training goal)=0.001；epoch(maximum training epoch designed)=1000；Neurons：3-9。Training course of the BP neural networks is shown as FIGURE:1.

If means relative error of simulated output (re) is selected as evaluating parameter, the best networks factors are: neurons=7， epoch=238， re=0.378(corrosion weight gain)/1.035（maximun corrosion depth）. The second best factors are: neurons=5， epoch=672， re=0.574(corrosion weight gain)/1.687（maximun corrosion depth）.

Means relative error of simulated output of all test samples are shown as FIGURE: 2. The relative errors of annual corrosion rate (or corrosion weight gain) of test samples are less than 0.5, while the errors of corrosion depth are high partially.

NUMERICAL MODELING OF FAILURE PROCESS OF UNDERGROUND TUNNELING CONSIDERING THE EFFECT OF SUPPORT-

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This paper outlines the construction process mechanics principle for analyzing the stability of underground opening and presents numerical simulation and

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prediction on the deformation and failure of the rock masses surrounding opening under excavating and support conditions. Stress redistribution induced by excavation of underground engineering results in the unloading zone in parts of surrounding rock masses. A micromechanics model has been proposed for brittle rock material undergoing irreversible changes of their microscopic structures due to existing of the support. Based on numerical modeling, a series of predicting plots are obtained. The numerical simulation and computation show that different schemes of construction have significant impact on underground opening stability and deformation. Therefore, the numerical analyses should be performed before construction to select optimal construction schemes, especially for poor rock condition. Based on the results of the in situ stress measurements and other field investigations as well as numerical tests, a numerical modeling analysis by RFPA methods was completed. The analysis proved the feasibility of the support and provided a series of suggestions on maintaining stability of the underground opening. The part of lining should be strengthened specially.

INTRODUCTION

Poor geological conditions are often encountered during underground construction. Additionally, buildings, underground infrastructures and other facilities are more densely situated along or under the surface. Although the supporting measures are applied in engineering, but it is very diffucult to realize the failure process of underground opening during the construction for researchers [1]. This article presents some of the wide applications that large underground cavern has received in China using the Realistic Failure Process Analysis code [2-5], which is developed at the center for Rockbursts and induced Seismicity Research, Norteastern University, China.

NUMERICAL SIMULATION AND OPTIMIZATION OF UNIAXIAL TIME-INDEPENDENT CYCLIC PLASTICITY

LI Jun, ZHANG Zheng

The uniaxial cyclic plasticity of IN100 material is simulated and optimized by iSIGHT software with constitutive model which is adopted according to the characteristics of the time-independent fatigue test in this paper. The concept of yield surface and the decomposition of hardening into kinematic and isotropic hardening are used in the model. The material parameters of the constitutive model are analyzed and identified through the optimization. The selected model and parameters can present accurate simulations for the corresponding experimental data.

INTRODUCTION

The approach for predicting the inelastic response of cyclic loading is necessary to predict fatigue life of materials. The constitutive modeling of cyclic plasticity has been developed and advanced significantly in the last few decades (Chaboche [1], Onho [2] and Bari and Hassan [3]). However, from the practical point of view, it is desirable to adopt the right model and estimate its parameters with emphases on the simplicity and feasibility to application. The aim of this paper is thus to analyze and select the constitutive model and identify its parameters. In order to search the method to estimate the parameters, the cyclic plasticity of IN100 under uniaxial time-independent loading is simulated and analyzed.

NUMERICAL STUDY OF STRENGTH AND STIFFNESS OF CENTRIFUGAL IMPELLER USING FLUENT AND ABAQUS SOFTWARE

SHAO Chunlei*, GU Boqin**, CHEN Ye

Impeller is one of the important components in centrifugal pumps. The strength and stiffness of the impeller were investigated by fluid-structure interaction (FSI) simulation. A multiple reference frame technique was applied in order to address the impeller-volute interaction. The distribution of pressure and shear stress on the blades and the hub was obtained by FLUENT. Centrifugal force, pressure force and friction force were imposed on the impeller, and its stress and displacement distributions under design conditions were obtained using ABAQUS. The results indicate that in comparison with pressure, shear stress has negligible influence on impeller deformation. The impeller is structurally safe under design conditions, and its maximum rotational speed is 1780r/min. At this rotational speed, the impeller will collide with the volute tongue while the stress still remains at a lower level. Furthermore, two improved design methods for the impeller were put forward in consideration of both strength and stiffness of the impeller.

INTRODUCTION

Impeller is one of the important components in centrifugal pumps. In order to investigate the inner flow field in centrifugal pumps using PIV conveniently, the

impeller was made of PMMA and designed according to the empirical formulae [1, 2]. In contrast to steel impeller, the strength and stiffness of the impeller made of PMMA or other engineering plastics must be taken into consideration simultaneously because these materials have smaller allowable stress and are more deformable.

Fluid-structure interaction (FSI) simulation is very effective method for investigating the mechanical behavior of centrifugal pump impeller, by means of which, the safe operating conditions for the impeller can be determined and the structure of the impeller optimized. The interaction between fluid flow and the impeller wall must be taken into account because of its significant influence on the strength and stiffness of the impeller. So, a fluid-structure interaction (FSI) scheme is required in order to obtain an accurate solution. The deformation of the impeller is generally small, and it does not affect the flow field in centrifugal pumps considerably. That allows CFD and FEA solutions to be run independently, with loads transferred in only one direction.

Here, FLUENT6.2 was chosen as computational fluid dynamics (CFD) software to solve the fluid flow problem, and ABAQUS6.5 was chosen as finite element analysis (FEA) software to solve the structure problem.

THE CASE STUDY OF STRAIGHTENING FRACTURE FOR W4MO3CR4VSI LOW ALLOY HIGH SPEED STEEL

Gao Zhiqiang*, Xu Wen-feng, Liao Xiao-ling, Liu Xi-Dong

$W_4Mo_3Cr_4VSi$ low-alloy high speed steel has excellent capability, and has good feedback from consumers, which lead to sell well. Whereas, the phenomenon of straightening fracture had usually occurred, but the annealing hardness was not high for $W_4Mo_3Cr_4VSi$ low-alloy high speed steel, this fracture had caused prodigious economic loss. In this paper, the phenomenon of straightening fracture of $W_4Mo_3Cr_4VSi$ low-alloy high speed steel has been classed, and the reason has analyzed and discussed. Finally, it is suggested that the design of chemical elements affected the range of temperature and texture, which was the reason of the straightening fracture of $W_4Mo_3Cr_4VSi$ low-alloy

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high speed steel.

INTRODUCTION

$W_4Mo_3Cr_4VSi$ low-alloy high speed steel is a new material for ordinary tool.From the birth year of 1990, this steel had produced and used, we had produced steel rolling tube with the standard of ϕ16~ϕ28 mm for 10 years from this $W_4Mo_3Cr_4VSi$ steel chipping by using AIM—ESR double-technics, and had been machininged as cone reamer、milling cutter、twist drill, etc. The capability and life of product had tested and been approved as eligible first-class product, which had obtained good feedback from consumers. But we had found that the steel usually appeared the phenomenon of straightening fracture. In this paper, the phenomenon of straightening fracture of $W_4Mo_3Cr_4VSi$ low-alloy high speed steel has been classed, and the reason has analyzed and discussed.

CAUSES ANALYSIS OF CRACKS AT A PREHYDROGENATION REACTOR WELDS

LU Zhi-ming, SHENG Song-en, GAO Zeng-liang

The cylinder of prehydrogenaton reactor of a refinery was made of complex steel plate, the material of base layer is SA387Gr11C12, and that of over layer is SA240TP321. after about 4 years service, many inner cracks were founded at the circumference welds of the prehydrogenating reactor cylinder by non-destructive inspection. The cracks were 35～50mm long, they all propagated along the vertical direction to the welds. In order to explore the crack causes, the chemical composition of base layer and the over layer were examined，the heat treatment process and weld process parameters of the reactor were analyzed, the sensitive index of the weld cracks of the reactor cylinder materials were calculated. It was concluded that the major factors of the weld crack of the cylinder were: lack of enough time for the high temperature temper insulation; bigger sensitive index of the weld cracks of the reactor cylinder; not high enough preheating temperature before welding and the weld complexity of base layer and over layer. Some heat treatment and weld process parameters were proposed for the reference of the similar reactors.

INTRODUCTION

The prehydrogenation reactor of a 80×104t/a continuous reforming equipments in a refinery started service in November 1996. During the nondestructive inspection in September 2000, there were 4 embedding cracks found at the circumference weld W2, see Fig.1. The cracks were 35～50mm long, they all propagated along the vertical direction to the welds. The prehydrogenation reactor was usually operated at elevated temperature and high pressure, the medium inside the reactor was flammability, explosive and poisonous, the continuous service of the reactor with weld cracks was dangerous, and the causes analysis of cracks was necessary. The main operation parameters of the reactor: the operation pressure is 2.70 MPa, the operation temperature is 330℃, process medium include gasoline,H_2 and H_2S. Inner diameter of cylinder is 2800mm. Thickness of cylinder is 42 mm base layer and 3 mm over layer.

The distributed longitudinal and circumferential welds are as Fig.1.

CONTINUAL VARIATION OF THE DISPLACEMENT AND GENERATION OF LIMIT STATE FUNCTION FOR EXISTING STRUCTURE

LI Yi[1], ZHAO Wen[1] ,YAN Yun-qi[2] , LIANG Lei[1]

Aiming at the insufficient research of reliability analysis on stiffness of system, based on the design principle of limit state provided in the Chinese structural design code, in which the designed structure allows no appearance of deformation that influence the normal usage of structure, the method of continual variation on displacement of frame structure is derived. The method was combined with probability calculation and numerical analysis and recurrence formula. It is used to continually generate internal force and limit state function of the displacement for continual variation structures. The repeated assembly of global stiffness matrix and repeated inverse matrix are avoided in this method. A new criterion of degenerating the structure into mechanism is introduced. An accelerating calculation method of reliability analysis on system stiffness is presented.

INTRODUCTION

The reliability research is merely confined to the strength analysis currently (Bucher [1]), the research of reliability analysis on stiffness of system is insufficient. Based on the design principle of limit state provided in the Chinese structural design code, in which the designed structure allows no appearance of deformation that influence the normal usage of structure as well as the topology structure has changed in the course of system failure, it is a difficult task to identify and analyze structural failure modes. It's always a focal problem for reliability theory research on how to identify main failure models quickly and exactly(Ayyub [2]). Many identifying methods, such as network search method, load increment method and other improved algorithm all need repeated analysis by constant changes of structure (Moses [3]). In view of the limitation of only strength analysis (Li Yi [4]), the method of continual variation on displacement of frame structure is derived. The method was combined with probability calculation and numerical analysis and recurrence formula. It is used to continually generate internal force and limit state function of the displacement for continual variation structure. The repeated assembly of global stiffness matrix and repeated inverse matrix are avoided in the method. A new criterion of degenerating the structure into mechanism is introduced.

THE ELECTRIC-HEATING BEHAVIOR OF CARBON FIBER CONDUCTIVE CONCRETE

Xuehua Dong，Liqiong Zhang, Zhihong Xu*

When mixing with short carbon fiber the resistance in the concrete decreases greatly and this material becomes carbon fiber conductive concrete (CFCC). In this paper, considering the main factors which influence the conductivity in CFCC; and in this paper, the CFCC can obtain well electric-heating efficiency with low voltage power and the uniform heating filed. All the results show that the fiber carbon conductive has a great future in the room-heating and deicing on the roads and bridges in freezing area.

INTRODUCTION

CONDUCTIVE CONCRETE HAS ATTRACTED RESEARCHERS' ATTENTION FOR ABOUT 20YEARS. THERE ARE MANY

CONDUCTIVE MATERIAL USED AS THE CONDUCTIVE PHASE SUCH AS THE STEEL FIBERS, GRAPHITE PARTICLES, CONDUCTIVE FIBERS AND SO ON[1][2]. IN RECENT YEARS, SHORT CARBON FIBERS ARE OFTEN BE USED BECAUSE THE CARBON FIBERS THEMSELVES ARE STRUCTURE MATERIAL AND BOTH THE STRENGTH AND CONDUCTIVITIES CAN BE IMPROVED WHEN MIXING THEM INTO CONCRETE. THIS KIND OF MATERIAL IS SAID TO BE THE CARBON FIBER CONDUCTIVE CONCRETE (CFCC). THE CONDUCTIVE CONCRETE IS JUST AS A RESISTOR AND ACCORDING TO THE OHM LAW WHEN THE CFCC IS ELECTRIFIED, IT WILL GIVE OUT HEAT. SO THE CONDUCTIVE CONCRETE HAS A GREAT FUTURE IN THE ROOM-HEATING AND DEICING ON THE ROADS AND BRIDGES IN FREEZING AREA BUT THERE ARE MANY PROBLEMS SHOULD BE SOLVED BEFORE THIS MATERIAL CAN BE WIDELY USED [3][4][5]. IN THIS PAPER, THE ELECTRIC-HEATING EFFECT OF THE CFCC WAS INVESTIGATED AND THE HEATING EFFICIENCY WAS TESTED IN DIFFERENT ENVIRONMENT CONDITION; THE FACTORS WHICH INFLUENCE THE CONDUCTIVITY AND HEATING ABILITY WERE TESTED AND ANALYZED; FROM

THE RESULTS IT CAN BE FOUND THAT THE CONDUCTIVITY OF CFCC EFFECTED GREATLY BY THE CARBON FIBER RATIO, INNER WATER CONTENT MOISTURE AND THE PREPARATION TECHNIQUE. IMPACT DAMAGE BEHAVIORS OF THREE KINDS OF CONCRETE BRIDGE PAVEMENT MATERIALS*

Yiping Liu**, Liqun Tang**, Xiaoqing Huang**

Impact damage behaviors of three kinds of concrete bridge pavement materials – Plain Concrete (PC), Steel Fiber Reinforced Concrete (SFRC) and Steel Fiber Reinforced and Polymer Modified Concrete (SFRPMC) are studied in this paper. By use of a Split Hopkinson Pressure Bar (SHPB), the dynamic responses of three kinds of concrete materials were investigated experimentally, the results show SFRPMC is more flexible and has better energy absorption ability than PC and SFRC. A linear visco-elasticity model concerning strain rate and damage is suggested to depict the impact damage behaviors of three kinds of materials; the simulation results showed the theoretical model could well describe the dynamic behaviors of the three kinds of materials. There exists a threshold damage value for concrete materials. Strain rate does great influent to damage evolution of PC and SFRC. But for SFRPMC, the influence of strain rate to damage is small and negligible. With the addition of steel fibers and polymer, the damage in SFRPMC is weaker than that in PC and SFRC under the same impact conditions.

INTRODUCTION

The concrete bridge pavements are occasionally damaged and broken in their service life [1], therefore to develop new kinds of bridge pavement materials with good damage resistance and especially under dynamic loading has been a common goal pursued by many researchers in recent decades. Steel Fiber Reinforced Concrete (SFRC) can retard the development of crack and improve the tensile strength, flexure strength and shear strength significantly comparing to plain concrete (PC), and the impact resistance, fatigue resistance, post-crack ductility and durability are improved as well [2]. But steel fibers contribute little to prevent generation of the crack in concrete; therefore SFRC shows not a perfect material for the bridge deck pavement. Steel Fiber Reinforced and Polymer Modified Concrete (SFRPMC) is a kind of new material adding polymer into SFRC to strengthen the bonding performance between

concrete and steel fibers, the preliminary experimental research and engineering applications show that SFRPMC is a potential ideal material for bridge deck pavement [1]. So far, the dynamic behaviors of SFRPMC are seldom reported, the damage behaviors of the material under dynamic loading are hardly seen.

Since Split Hopkinson pressure bar (SHPB) is one of the most widely used facilities for studying the dynamic behavior of materials in recent years [3,4]. In this paper, by use of a Split Hopkinson Pressure Bar (SHPB), dynamic responses of three kinds of concrete bridge pavement materials – PC, SFRC and SFRPMC are investigated experimentally, and the energy absorption abilities of them are compared and analyzed, with a reasonable mechanics model, the impact damage evolution behaviors of them are studied.

EXPERIMENTAL STUDY ON NEGATIVE FRICTION BEHAVIOR OF INTERFACE BETWEEN CONCRETE AND SOIL

Wang W[*], Lu T H[**], Sun B X[*]

Negative friction behavior of soil-concrete interface plays an important role in numerical simulating and safety estimating of mining and civil engineering, and it is necessary to properly understand it. In order to study it, we conduct negative shear tests on soil-concrete interface by using simple shear apparatus considering four previous shear ratios. Shear failure position of the interface is recorded, too. Theory analysis on the negative shear behavior of the interface is conducted in details. The result of this paper is helpful to corresponding engineering management.

INTRODUCTION

As basic concerns and micro-represent of soil-structure interaction, positive and negative shear behaviors of soil-concrete interface are complex and deserve enough attention. Many Direct shear tests have been performed to this subject (Desai [1], Frost [2], Yin [3], Hu [4] and Wang [5]). However, there are some restrictions during interface direct shear tests. For example, the section between soil and concrete is assumed to be shearing failure position. Simple shear tests were conducted to study

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the interface behavior with various saturation degrees to overcome the restrictions (Wang [5]), but negative shear is still not taken into account in the study. In fact, negative friction due to negative shear of interface exists extensively, and different previous positive shear histories of soil-concrete interface make big difference to its negative shear behaviors. So negative shear behavior plays an important role in safety and management of civil and hydraulic engineering. In order to understand and model the negative friction behavior of the soil-concrete interface, negative shear tests should be made.

In this paper, negative shear behavior of soil-concrete interface is studied by using improved simple shear tests, and their change principles are presented with different normal stresses and previous positive shear histories. The result of this paper is helpful to corresponding study on structure fracture process and engineering management.

EXPERIMENTAL INVESTIGATION ON LOCALIZATION OF CONCRETE DEFORMATION WITH WHITE-LIGHT-SPECKLE METHOD

Xinpu Shen * Lu Yang Jihang Liu

With white-light speckle method, evolution process of damage process zone has been investigated for a set of concrete specimen under mixed-mode loading. Geometrical parameters of the damage process zone have been measured. Double-notched specimens and 4-point shear loading conditions were adopted. The parameters measured include the width and length of the strain localization band. As the size of the concrete specimen were set as 400×150×37.5 (mm^3) with a notch of 5×25(mm^2) at each side, the maximum length of the damage process zone is about 54 mm. And this geometrical data basically keeps constant during stable deformation process. These data have presented an experimental basis for the determination of value of internal length parameter for a gradient-enhanced nonlocal model.

INTRODUCTION

Owing to the heterogeneous material property of concrete-like materials, nonlocal inelastic models are becoming more and more popular in deal with fracture and damage of concrete structures[1][2]. Internal length is an important parameter of a gradient-enhanced nonlocal damage model and of an area-averaged nonlocal model.

However, the definition of the internal length for a nonlocal model for concrete-like material has never been uniquely given, and consequently the calibration of internal length has not been investigated. Bazant and Cedolin [3] regards the length of the damage process zone as the internal length, but does not give its value. Someone even believes the width of crack occurred within a structure is its internal length. Shen, Shen and Chen [4] taken the internal length as an influence parameter of the damage(or equivalent plastic strain) gradient-term of a nonlocal damage (or plastic) model.

With reference to the principle of 'nonlocal energy dissipation', it is believed here that the internal length of a gradient-enhanced damage model should be the length of the damage process zone. This is because the damage process at points within the same damage process zone can influence each other, and it will not be influence by the energy value outside this damage process zone. Consequently the length of a damage process zone can represent the influence scope of a damage process, and thus it should be regarded as the internal length of a nonlocal damage model. The aim of this study is to experimentally measure the length of the maximum damage process with a double notched four-point shear concrete beam.

White-light speckle method is an experimental measure which is widely used for surface deformation measuring purpose. With this method, the in-plane displacement field can be recoded at every time-step, and strain field can then be calculated on the basis of the difference of displacement field at each time step. Because the loading condition is shear-dominated, maximum shear strain is taken as the reference valuable to calibrate the damage process zone. Damage process zone is determined through two critical strain values: γ_{c1} and γ_{c2}. Parameter γ_{c1} is the minimum strain value below which no damage will occur, and γ_{c2} is the maximum strain value above which damage will reach its limit 1 and this value corresponds to the initiation of macro-crack. The region where has maximum shear strain value continuously distributed between γ_{c1} and γ_{c2} will be regarded as damage process zone. This point has been numerically verified with the same values of γ_{c1} and γ_{c2} adopted here by finite element method.

INVESTIGATION ON THE HOLE INTEGRITY OF FRPS

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PROCESSED BY VIBRATION DRILLING WITH HYBRID VARIATION PARAMETERS

Wang Xin* Zhang Linbo** Liu Jianying* Wang Lijiang* Yang Zhaojun*

FRPs (fiber reinforced plastics) have been used widely for there excellent characteristic. Due to their anisotropy and non-homogeneity, drilling FRPs cause some problems such as fiber breakage, matrix cracking, fiber pull-out, spalling and delamination etc. Those problems not only reduce the structural integrity, but also have the possibility of deteriorating the long-term performance. In this paper, the critical thrust and the thrust force during the vibration drilling FRPs with hybrid variation parameters which could improve holes integrity of FRPS were investigated. From the drilling experiments, it was proved that high quality holes could be obtained and holes integrity can be improved by this new drilling method.

INTRODUCTION

FRPs, such as carbon fiber reinforced plastics (CFRP) and glass fiber reinforced plastics (GFRP), etc., have been widely used in aircraft and spacecraft structures because of their high specific stiffness, high specific strength, high damping and low coefficient of thermal expansion. As structural materials, joining FRPs structures to other materials could not be avoided, and the joining efficiency was largely depended on the quality of machined holes. Due to the anisotropy and nonhomogeneity of FPRs, drilling FRPs causes some problems, which do not occur in other material, such as fiber breakage, matrix cracking, fiber pull-out, spalling and delamination etc. The delamination was recognized as the most critical defect, which can result in a lowering of bearing strength, can be detrimental to the durability by reducing the in-service life under fatigue loads and reduces the structural integrity [1]. Delamination can often become a limiting factor in the use of FRPs for structural applications [1-4]. Therefore, how to achieve high quality holes and improve the hole integrity in drilling of FRPs was imperative. In the paper, the critical thrust force and the thrust during the vibration drilling with hybrid variation parameters of FRPs which could improve holes integrity of FRPs were investigated. The drilling experiments were carried out which proved that high quality holes could be obtained and holes integrity can be improved by this new drilling method.

POLE END'S MOMENT OF RIGID FRAME AND ANGLE

Guanghao Liu * S. J. Wu **

The influence of angles, sidesway, moment of first pole end on the moment of n-th pole was analysed. A Moment Link Formula for n-th Pole End was proposed using three pole end moments formula and unknown parameter bending moment diagram. Moment Link Formula of Frame Pole End is the moment expression of n-th pole end. It consists of the angle of first pole and n-load, however, it doesn't consist of sideway and other end moments of first pole end. In the moment link formula, linear stiffness distribution must accord with the linear stiffness formula. The n-load is couple moment at node from No. 1 to No. n-1. The n-load has no couple moment at n-th node and horizontal force. The format of moment link formula is not directly dependent on the balance of horizontal force. The end moment resulting from the first pole end angle is an alternating sequence. There is no expression using sidesway as the only parameter, and there is no relationship between other single parameter and the n-load.

INTRODUCTION

Interception of n-1 span parts of rigid frame is shown in Figure 1. It is called an n-frame. The force on n-frame can be simplified into nodal forces that are acting on nodes from No. 1 to No. n. It is made up of the n-frame load and other loads from other parts of structure. Removing horizontal force and n node couple moments, we could get n-load. For n-load, the moment in n pole down end is a function with parameters from first pole. They are top end angle of pole, and chord angle of n-frame, and top end moment of pole, and down end moment of pole. In common, the expression is $M = f\left(X_i \quad X_j \quad P\right)$ that requires two parameters of them. Bending moment diagram is a strong proof as follow. For it needs two paramters from those four parameters using the parameter bending moment diagram. Accordingly, there are six combinations in it. In all combinations, there is only four types of the bending moment diagram available. In the combination the parameter is X_i and X_j, then there are bending moment diagrams of them. If the stiffness distribution makes the end moment value equalling to zero in X_i parameter bending moment diagram, then the n-th end moment is a Moment Link Formula with parameter X_j. The format of the expression is $M = f\left(X_j \quad P\right)$. This is only for angle parameter. But not for single other parameter.

The linear stiffness of pole & beam is as Fig.1. The pole end moment sequence

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$\{L_1, L_2 \ldots\ldots, L_n\}$ is the ratio of each pole end moment to its linear stiffness. We also call it end moment.

DUCTILE ANALYSIS OF CORRODED REINFORCED CONCRETE BEAM

Fan Yingfang[a] Hu Zhiqiang[b]

The available of ductility of corroded doubly reinforced concrete beam sections with a range of rebar corrosion and concrete degradation were studied. Ductility of reinforced concrete beams corroded by sulfate and chloride were discussed respectively. Relations between deteriorated material and ductility of the corroded beam are achieved. Simplified expression is put forward to predict the ductility factor for the corroded reinforced concrete beam.

INTRODUCTION

To survive severe earthquake, structures designed to the level of seismic loading recommended by codes need to be capable of ductile behavior at the critical sections while undergoing horizontal displacements in the inelastic range (Park et al.[1]). Reinforced concrete(RC) is one of the most durable construction materials. However, field surveys indicated that owing to various corrosion effects, ample RC structures working in aggressive environments always failed in a sudden. Large numbers of mechanical experiments have been performed on the corroded RC(CRC) members. Experimental results verified that the ductility of CRC members would degrade. Till now, extensive researches have been carried out on ductility of RC members (Kemp et al.[2], Tholen et al.[3], Kappos et al. [4], Fukumoto et al. [5], Lee et al. [6]), while few researches related to CRC member.

In this paper, the available of ductility of corroded doubly RC beam sections with a range of reinforcement corrosion and concrete degradation were studied. Ductility of reinforced concrete beams corroded by sulfate and chloride were discussed respectively. Curvature ductility factor are applied to study the ductile character of the CRC beams herein. For SCRCB, the normal assumptions of plane section behavior still hold true, the section analysis method was applied; relations between the deteriorated material and the ductility of the beam are achieved. For CCRCB, the normal assumption of plane section behavior doesn't hold true, and a simplified expression for the curvature ductility is put forward to predict the ductility factor of CRC beam.

EXPERIMENTAL STUDY ON THE MECHANICAL PERFORMANCE OF ORDINARY STRENGTH HIGH PERFORMANCE CONCRETE

Sun Jing, Yao Qianfeng, Xiong Yaoqing

The ordinary strength concrete under C50 is widely used in the practical engineering. The research on ordinary strength high performance concrete seems particularly important in a bid to improve the structure durability. Based on the experimental study on the mechanics performance of ordinary strength high performance concrete, this paper puts forward the equation on tensile and compressive stress-strain curves of ordinary strength high performance concrete by analyzing complete stress-strain curves. It turns out comparatively good coincidence between theoretical analysis and experimental results.

INTRODUCTION

At present the researches on high performance concrete at home and abroad mainly focus on aspects like high strength and high fluidity centered on improving the durability of concrete, and the main research objects are concrete at C50 and above. However, in practical engineering the ordinary strength concrete under C50 is more widely used. So it is particularly necessary to study various performances of the ordinary strength concrete, which is meaningful for extending the life-span of the structure and saving resources and energy.

CHARACTERIZED WAVELET CONSTRUCTION BASED ON THE LIFTING SCHEME AND ITS APPLICATIONS

Duan Chendong[†] Gao Qiang[*] Li Xianfeng[††]

In order to get a characterized wavelet with expected properties, a new wavelet is constructed by using the lifting scheme (LS). Taking the low-pass filter of cubic B-splines wavelet transform as an initial filter, and designing a lifting operator based on interpolating subdivision, a new wavelet is obtained through

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one lifting step. The wavelet inherits the property of low-pass filtering that the initial filter possessed, and also has ability to extract transient impulse component from the analyzed signal. By making a block equivalent exchange operation to the LS framework, and removing decimators, a LS algorithm for undecimated wavelet transform (UWT) is proposed. Engineering application shows that the UWT can provide greater diagnostic information than the classical wavelet transform.

INTRODUCTION

Feature characteristics are often deeply buried in available signals and difficult to separate from the signals. So advanced methods are applied to find them. Wavelet transform (WT) is a time–frequency analysis approach which has good analysis properties in both time and frequency domain. It is usually used to handle non-stationary signals which are very common when machinery faults occur and found wide application in fault diagnosis (Andrew, et al [1]). WT algorithms proposed by S. Mallat employ decimators after filtering. Both approximation and detail signal are half in length after transformation. DWT is very efficient from the computational point of view. But its drawback is that it is not translation invariant (Lang, et al. [2], and Uytterhoeven [3]). To overcome this drawback, the undecimated wavelet transform (UWT) was proposed [2]. Decimators are removed in transformation, so that the signals are no longer decimated after filtering, the length of the approximation and the detail are the same as the original signal. It is helpful to feature extraction.

The lifting scheme (LS) is a flexible approach for constructing second generation wavelets (Sweldens [4]). The idea behind the LS is to modify the property of a known wavelet and build a new wavelet with some expected properties (Minbo [5]). In order to find a characterized wavelet with expected properties, we use the LS to build a new wavelet and propose an UWT algorithm. The UWT has been successfully used to extract fault features of friction in a gearbox.

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REGRESSION ANALYSIS OF THE TENSILE BOND PULL-OUT POST-ANCHORED METHOD TO CHECK CONCRETE STRENGTH

Shiqi Cui*, Jinshan Wang*, Zhaozhen Pei*, Hongdi Lv

The paper utilizes the tensile bond pull-out post-anchored method to evalute the in-place concrete compressive strength, the author makes large quantity of concrete cubics and designs the equipment and the procedures of the tensile bond pull-out post-anchored method to asses concrete strength,and analysize the test data,which reveals that tensile bond pull-out post-anchored, as a test method in which the pullout force has the direct relationship with the in-place concrete strength, the result of regression analysis reveals that the correlation coefficient of pullout force and concrete strength is close 1.0. because of its convenient in-place operation and reliability of the estimating the in-place concrete strength, tensile bond strength test is worthy to be generalized.

INTRODUCTION

When the civil engineer evalute the safety of the existing reininforced concrete structure bulidings, determining the in-place compressive strength of the concrete is one of the most vital task.the accuracy of the presumptive compressive strength of the concrete will determine the precision of the safety evalution. methods used to check the in-place concrete strength can be devided into the nondestructive methods including the rebound hammer,ultrasonic pulse and microdestructive methods such as pullout,drilled core.microdestructive methods measure the concrete mechanical property parameter,so the concrete strength estimation will be more reliable. pullout testing can be performed using metal anchorage member installed within the formwork prior to concreting, or by inserting an metal anchorage member into an under-reamed hole drilled into hardened concrete. the former is by far the more commonly used in early-age testing, the latter procedure would be used only when the preplaced inserts had not been installed prior to concreting.in china, Structure Institute of Shandong province academy of buildings issued the technical specification for inspection of concrete compressive strength by pullout post-insert method [1],however,this method have not been popularized widely because of its high requirement for the strength of the metal anchorage member and for lack of facilities on the market. in view of such limitations, we attempt to employ pull-out post-anchored method to estimate concrete strength.

CHARACTER AND APPLICATION OF FIRE RETARDANTS OF AMMONIUM POLYPHOSPHATES WITH HIGH DEGREE POLYMERIZATION

Gao zhi-qiang Song zhong-rong* He jia-hong

The polymeric conditions was optimized to prepare the APP with 600 average degrees polymerization ($\overline{DP}$). The effects of all kinds preparation condition, such as different ammonium phosphates, components proportion, reaction temperature, reaction atmosphere, reaction time, treating temperature, treating time, treating atmosphere and so on, on degrees polymerization of APP were investigated. The results showed that when (NH4)2HPO4, P2O5, and urea (molar rate for 1:1:0.3) were uniformity mixed, then polymeric reaction was aroused for more than 20 min and 280～300℃, at the atmosphere of dry NH3, after polymeric reaction was finished, it was heated for about 100～120 min and 250～280℃, at the atmosphere of dry NH3. In the end, the powder of high degree polymerization of APP was prepared, the average degree polymerization of the prepared APP was more than 600 degrees analyzed by end-group titrimetric analysis

INTRODUCTION

Ammonium polyphosphate (APP) is a widely distributed material which occurs in textile [1],rubber [2],wood, rubber, coating, plastic, and so on. As an inorganic fire retardant, there are many advantages of it, such as it has a satisfactory effect on inflaming retarding, low solubility, high decomposition temperature and so on.

The average degree of APP of abroad products usually reach to hundreds even thousands. However, the average degrees polymerization ($\overline{DP}$) of our own APP products are no more than 100 frequently, and main of them have characteristics of water-solubility and deliquescence. In principle, the more tremendous the $\overline{DP}$ of APP is, the better its application function and action effect of inflaming retarding appear. Therefore, it is great significant that study the synthesis process of APP at the high $\overline{DP}$.

AN ANALYSIS TO HUMAN BODY MOTION WITH RESTRICTION BUT WITHOUT GRAVITY BY APPLYING INERTIAL PARAMETERS

Fan Yifang*, Li Zhiyu**

The non-inertial human motion is represented as a process of acceleration and deceleration of human body multi-segments. When human motion analysis is simplified as multi-rigid linkwork, human body inertial parameters are the fundamental physical quantities. The basic inertial parameters of human body segments are obtained by employing the Hanavan model and the Barter regression equation, and thus the inertial parameters of human in motion are obtained through the transformational matrix. Kistler force platform system and SIMI high-speed digital camera are exploited to test and shot the athlete's squat jump (SJ) movement. When both the kinematical quantity and kinetic quantity are provided, the multi-rigid-body dynamics method is employed to study the human motion. Under the condition of zero gravity, human motion depends heavily on the exterior restrictive form and function. Based upon the human motion analysis of given gravity action, the gravity action is eliminated; the human motion analysis without gravity, but with restrictions is implemented via the given human inertial parameters.

INTRODUCTION

The human body inertial parameters have long been the fundamental issue in the research of biomechanics, ergonomics, anthropology, aerospace engineering and human body science. In the research of human inertial parameters, various methods have been employed to obtain the segments' weight, geometrical arrangement, each segment's radius of gyration, moment of inertia, standard anatomical posture human body centre of mass and inertial parameters such as the human body principal moment of inertia. These methods include Dempster's[1] cadaver averages, Hatze's[2] anthropometric segments, Zatsiorsky et al.'s[3] radioisotope scan, Martin et al.'s[4] MRI scan and Zheng Xiuyuan's[5] CT, etc. Hanavan [6]presents the 15-segment human body mathematical model, which is built upon the test result of 25 human parameters, and the segments' geometric parameter and inertial parameter are then computed via Barter's[7] regression equation. Yeadon[8] has brought forward a 40-segment human body mathematical model - it has brought up the segments' inertial parameters on the basis of Dempster's[1] human segment density parameters. Up till now, Hanavan[7] mathematical model has been considered as one with less data collection, but better accuracy.

When human body is set in a motion without restriction, due to the conservation of mechanical energy, its centre of mass will not change with the change of its posture. However, when human body is set in motion with restrictions, its centre of mass will change with the change of its posture. And human body moment of inertia will change with its change of posture no matter what. By using the high-speed digital camera, the position of human body segment articulation point (marker) and its joint angular change could be captured. Given the basic inertial parameters of the model and of its standard anatomical position, through the joint angle and the transformational matrix, the human inertial parameters and the center of mass position at any posture can be obtained[8]. The force platform system can indicate the changes of human body constraints and then the momentum theorem can tell how the external force can affect the human motion when it has some restrictions.

INVESTIGATION ON ANALYTICAL METHOD OF FATIGUE LIFE PREDICTION

Luo Hongyun* Wang Hongwei Zhong Qunpeng

It is difficult to predict the life of mechanical components on random overloading which is valuable for the finite life design. An analytical method to predict fatigue life of components with no need of measuring working load was discussed in this paper. The analytical method can be used at the beginning of design without need of fatigue experiments.

INTRODUCTION

The finite life design of mechanical strength is an important breakthrough. This technology first uses in this century 70's in England which has already took the acceleration of mechanical product update. The life prediction is the key step for the finite life design of the automobile. An analytical method to predict fatigue life of mechanical components on random overloading and design load spectrum, the calculating test can be carried out which is very helpful for the product design and the fatigueexperiments.

STRUCTURAL DURABILITY ASSESSMENT FOR OLD CONCRETE BRIDGE USING TIME VARIABLE RELIABILITY ANALYSIS

Zhou Taiquan Hua Yuan*

Concrete structural durability of old concrete bridge is vital for structure integrity assessment at service state. The influence of the concrete carbonation and the induced rebar corrosions and the resistance force function degradation with time elapsed were studied. The structural resisting force as a function of service was investigated. The time-variant reliability analysis was proposed for structural integrity assessment. The OpenSees reliability analysis module was applied in the analysis. The FORM was used to derive the reliability index in each service time. The evolution of the reliability was obtained. The proposed method was applied in an old concrete bridge time variant reliability analysis.

1. INTRODUCTION

The concrete bridge is exposed to outdoor environment. The concrete carbonation decreases the concrete strength. The induced steel rebar corrosion gives rise to the concrete member bearing capacity degradation. The capacity that the concrete bridge completes the prescribed performance function decreases with the service year increasing. The need for the application of time-variant reliability methods to bridge life-cycle prediction is becoming increasingly recognized in the United States. Obviously, the reliability of a reinforced concrete bridge is a time-variant property, which is dependent on the history of both the applied loads and the remaining strength of the structural members. The aim of this paper is to investigate the durability of an existed frame arch bridge submitted to concrete strength degradation and steel rebar corrosion due to concrete carbonation.

ANALYSIS OF ULTIMATE LOAD CAPACITY FOR REINFORCED CONCRETE STRUCTURES BY DEGENERATED THREE-DIMENSIONAL SOLID VIRTUAL LAMINATE ELEMENTS

Wu Guangyu[*], REN Peng[*], WANG Jinfeng[#], XU Xing[#]

The method that ultimate load capacity of reinforced concrete structures is analyzed by degenerated three-dimensional solid virtual laminate elements is presented. Considering the influence of geometrical and material nonlinearity, the computing of ultimate load capacity for reinforced concrete structures was programmed by the elements. By this program, the experiments for the failure of reinforced concrete box girders and reinforced concrete biaxial flexural beams were simulated. By the analysis, computational results tally with experimental results very well. Moreover, computational results show that the number of needed elements in the analysis model can be greatly decreased as well as the computing efficiency can be greatly improved. The method that is applied to analysis of ultimate load capacity for large and complex reinforced concrete structures has great advantages.

INTRODUCTION

At present, the traditional spatial element is often used in analysis of ultimate load capacity of reinforced concrete structures. For large and complex reinforced concrete structures, using the traditional spatial isoparametric solid element to analyzing ultimate load capacity is not very suitable obviously. So shell element (Yang and Che [1], Razaqpur et al. [2] and, Zhou and Zhu [3]) or beam segment element is mostly used in the analysis.

However, using shell element has a number of difficulties: (1) The computation efficiency may be very low if using shell element to analyze the structures that are formed by many shells or plates, while considering the influence of geometrical and material nonlinearity. (2) Considering the influence of shear deflection, shell element based on *Mindlin* plate theory is often used in the analysis. However, when the shell element is very thin, shear locking will become an outstanding problem. (3) If using shell element, steel bars need to be replaced with steel layers in the structure, which may cause divergent analysis result.

Using beam segment element has also a number of difficulties: (1) Ameliorative beam segment elements must be constructed, while considering the influence of

torsion, buckling and distortion. Because the assumption mode of torsion deflection and the conception of neutral axis are introduced, the universality of the elements is not good. (2) Ameliorative beam segment elements need to increase degrees of element, so the computation efficiency is lower. (3) The geometry decri-

ption of beam segment element is one-dimensional, so the effect of transverse reinforcements is not considered. However, the effect of transverse reinforcements is often crucial for the structures of shear failure.

Owing to above difficulties, the method that ultimate load capacity of reinforced concrete structures is analyzed using degenerated three-dimensional solid virtual laminate elements is presented by this paper.

ASSESSMENT ON REMAINING STRENGTH OF SPIRAL WELDS OF IN-SERVICE PIPELINES

Qingshan Feng[1,2], Kewei Gao[2], Lijian Zhou[1], Hongsheng Cui[3], Weibin Wang[1], Xiaoming Han[1], Yi Li[1], Xianjun Tan[1], Mao He[3]

Reliability of a weldment plays an important role in a pipeline safety in oil and gas industry. The existence of defects in a weldment limits the carrying capacity of a pipe. In the present work, the mechanical properties of a spiral welded pipe with an incomplete penetration defect were investigated after the pipe transported oil for more than thirty-five years in North China. FEM numerical simulation was performed to determine the relationship between the depth of the incomplete penetration and the carrying capacity of a welded joint with the incomplete penetration, in order to evaluate the remaining strength of the in-service pipe.

INTRODUCTION

Limited technical condition in construction period brought about many welding defects, such as incomplete penetration, unfitness or convex, existed in the pipeline with welds in China, which gave rise to a certain amount of pipeline accidents. At present, most of these pipelines are under repairing time, evaluating the remaining strength of the given defects will provide definite guiding sense to determine whether the defects need to be repaired and which repairing method should be chosen.

Investigations about the welded pipeline have been carried out in the past

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several decades. In order to optimize the welded-joint anticorrosion ability, the chemical composition, microstructure, mechanical properties, heat treatment conditions of the welded joint and heat affected zone have to be considered. The corrosion mechanism in selective weld corrosion is attributed to formation of protective layers, e.g., when a zone of the weld is attacked, this part is not covered with any layer while the adjacent areas are protected [1]. The lowering of C content less than 0.01mass% and the increasing of Mo content from 2.0mass% to 2.5mass% in the weldable super 13Cr stainless steel could improved the sulfide stress cracking resistance in the heat affected zone[2,3]. The presence of H_2S in oil and gas transmission lines could introduce the potential problem of hydrogen-assisted stress corrosion cracking (SCC), and it had been proven that the welded joints in ferritic steels were susceptible to hydrogen-induced stress corrosion cracking because of the local hardening. Normally the cracking occurred at the area with maximum hardness [4]. In practice, most plant undergoes load fluctuation, there had been reported that the propagation of a corrosion fatigue crack in the girth weld exhibited dependence on both frequency and stress intensity factor range [5,6].

Incomplete penetration, unfitness and convex are the main welding defects for a long distance pipeline. The presence of these defects changes the framework continuity of the pipeline resulting in stress concentration and decreasing the carrying capacity of the welding zone. Besides, due to the preferential weld corrosion of carbon and low alloy steels used for pipelines in CO_2 containing media, the thickness reduction caused by general corrosion or localized corrosion will also decrease the mechanical properties of the welding zone. Assessment if defects in pipeline, especially in the welded joints is very important to an integrity management plan, however, up to now, there is few investigations about the effect of incomplete penetration, unfitness and convex on the weldment reliability, especially when aggressive environment exists.

In the present work, the studied pipeline with a spiral weld came from an oil field in North part of china which has been in service for more than thirty-five years. The mechanical properties of the welded joint and parent metal were determined by tensile test. The fracture behavior of the welded joint with incomplete penetration defect was investigated by three points bend test. The remaining strength of the welded joint with defects was evaluated by Finite Element Method (FEM) numerical simulation.

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DYNAMIC RELIABILITY ASSESSMENT OF NON-LINEAR STRUCTURES UNDER EARTHQUAKE LOADS

Zhang-Jun Liu[*1,2], Jie Li[2]

A newly developed probability density evolution method is presented for dynamic response analysis and reliability assessment of non-linear structures. In the method, a completely uncoupled one-dimensional governing partial differential equation is derived first with regard to evolutionary probability density function of the stochastic response of non-linear structures. For the dynamic reliability problem, a virtual stochastic process associated to the extreme value of the studied stochastic process is firstly constructed in such a way that the extreme value equals the value of the virtual stochastic process at a certain "instant of time". The probability density evolution method is then employed to evaluate the instantaneous probability density function of the virtual stochastic process. After that, dynamic reliability could be evaluated from the extreme value distribution, instead of the level-crossing process theory. An example, of which deals with a nonlinear frame structure subjected to ground motions, is illustrated to validate the proposed method.

INTRODUCTION

Structural dynamic reliability has been one of the basic aspects in structural design theory for decades since researchers and engineers recognized that uncertainties are unavoidably involved in loads and structures. The diffusion-process-based theory has relatively rigorous theoretical basis but its application to multiple degree-of-freedom system needs prohibitive computational efforts and therefore actually unfeasible [1]. On the other hand, the out-crossing-process-based theory may be easier in implementation provided that the joint probability density function of the target response and its velocity are available and the information on properties of the out-crossing events is known [2]. However, the two problems are usually far from easy to be solved for practical problems.

In recent years, a family of probability density evolution method (PDEM), which is capable of capturing the instantaneous probability density evolution (PDF) and its evolution of the response of structures involving random parameters, has been developed and used successfully in linear and nonlinear dynamical systems [3,4]. In the present paper, the PDEM is employed as a basis. Using the approach for evaluation of the extreme-value distribution of a set of random variables and /or a stochastic process and the idea of equivalent extreme-value event [5], the structural system reliability could be evaluated requiring neither the joint PDF of the response and its velocity, nor the assumptions on properties of the level-crossing events. An example which nonlinear structures subjected to earthquake loads is studied to exemplify and validate the proposed approach.

CONCRETE EROSIVE WEAR AND CAVITATION EROSION MECHANISM AND PROTECT METHOD

Wang qian * Zhang zhe*

Erosive wear and cavitation erosion is one of the most ordinary disease, which influence the operational safety of the water conservancy hydroelectric equipment. In order to length the service life of the large water conservancy hydroelectricity project and ensure it operate safely, the higher durability of hydraulic concrete material is required. Especially, under the condition of high-velocity flow have stronger resistant ability of erosive wear and cavitation erosion. The paper discusses the concrete erosive wear and cavitation erosion mechanism. On the basis of the discussion, considering from different aspects, it introduces the concrete protective methods. Including adding silica powder and high-efficiency water reduce, adding latex and carbon fibers, adopting concrete with suitable strength, adding steel-fiber to improve the concrete durability, replacing the Poland cements with calcium aluminate cements and improving the abrasion resistance of the concrete lime substratum by replacing fine aggregate with Class F ash.

INTRODUCTION

With the development of the water resources and hydropower construction projects, more and more construction of large water conservancy and hydropower project is going on. Aside from the normal load, the concrete of hydraulic structure is subjected to the erosion of the environment water, the freeze-thaw erosion, erosion of flow and the cavitation corrosion. In this case, the better durability and corrosion resistance of concrete is more important than the strength of concrete.

This paper introduces the concrete erosive wear and cavitation erosion mechanism and some typical and advanced protection method.

EROSION BEHAVIOUR AND MECHANISM OF CONCRETE

Denudation is a term which is used to indicate the loss caused by the liquids with solid particles. When the liquid with solid particles contacts with concrete, the collision, sliding and rolling motion of the solid particles abrade the concrete surface. Denudation usually occur in hydraulic structures such as tunnel lining, spillway and water pipe. The porosity and strength of concrete, the number, size, shape, density, hardness and velocity of moving particles influence the surface exfoliation rate.

Studies show that the velocity of flow is the key factor of concrete abrasion. The limited

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current velocity which can't lead to obvious abrasion is 10~12m/s. When the current velocity exceeds 16~20m/s, the abrasion is obvious. In the abrasion procedure, there is a high correlation between the mass loss of concrete and the kinetic energy of abrasive particles. With the increase of the sediment concentration, the collision between the back particles and the anterior ones lead to the loss of the kinetic energy of abrasive particles. So, the mass loss of concrete reduces with the increase of the sediment concentration.

INHERENTLY SAFER DESIGN RELIABILITY ANALYSIS AND ASSESSMENT INDEXES

Fan Xiaohua[1], Wu zongzhi[1, 2,] Li Qiu-jin[1], Yang Yu-sheng[1]

Chemical industry is a main part of national economy. Chemical product includes techniques and high risks, product features are high temperature or pressure, flammability, explosive, corrode, toxicity, and accident prone industry. These years, there are many serious accidents in world; people realized the important and emergency of chemical product process. Inherently Safer Design is a way of thinking about the produce process of chemical processes and plants that focuses on the elimination or reduction of the hazards, rather than on management and control. This paper discusses reliability and costs of inherently safer design, and relations of complexity and reliability in process risk management strategies. This paper gives inherently safer design assessment indexers about reliability, economy, safety and compatibility.

As technology improving, human have control abilities to change nature and create unprecedented wealth. But a series of Major accidents in chemical industry have occurred world-wide. For example: in 1976, a major accident in Seveso, Italy, which resulted in an immediate contamination of some ten square miles of land and vegetation. In 1984, MIC leakage accident occurred in Bhopal, and so on. Major accidents express paroxysmal, calamitous, interruptive and socialization. Reliability and safety are paid more attention in society. Reliability and safety engineering had been preferential developed in 21 century for developed and developing countries, which improve products' acceptability for tone up nation industry competitiveness.

RESEARCH ON ROBUST CONTROL SYSTEM OF FATIGUE TESTER SYSTEM BASED ON INTERNAL MODEL CONTROL

Tang Zhiyong, Ma Jungong, Pei Zhongcai, Peng Zhaoqin

Because of the uncertain parameters and disturbing force of fatigue tester, the traditional control algorithm can't achieve good effect. So the robust control system based on IMC is adopted on analysis mathematic model. It represented the good robustness and stability that were proved by simulation.

INTRODUCTION

With the rapid development and promotion of the society, more and more new materials and new machines are used in productions and lives. And the fatigue tester is used to research different materials and parts, it is a system with the large variation of the object parameters, redundant force, deformation of the c and the disturbance caused by the frictional moment. But the parameters setting of traditional PID arithmetic depend on the precise mathematic model, so it can't achieve good robustness and control accuracy. In order to improve the robustness of system, the control method based on IMC (Internal Model Control) was adopted.

DESIGN AND STRESS ANALYSIS OF A NEW TYPE SIMPLY SUPPORTED TO CONTINUOUS T BEAM

CHEN Guo-fang, ZHANG Zhe, QIU Wen-liang

Based on the study of the structure system of simply supported to continuous, a new construction technique was put forward. A finite element model considering construction stage was set up to study the mechanical behavior of the new technique compared with the old one. The result shown that in the case of same span and loading capacity, the quantity of anchor and the sum of prestress tendon are reduced, the influence of shrinkage and creep to this structure system is smaller than the traditional one as well as the camber.

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INTRODUCTION

The instant development of the freeway and high speed railway improve the speed of the construction of the bridge. High speeding and better comfort requires the bridge has the favorable mechanical behavior and lesser movable joint. The construction method of simply supported to continuous was applied to solve the problem of the speed of bridge construction, so the system of simply supported to continuous was formed. Since 1960s many scholars at home and abroad studied it. In recent years, some meaningful advances have been achieved [1-7]. Shang [1] has proved the rationality of the system of the simply supported to continuous, and pointed out that the best type was setting tendon at the place of the wet joint. Sheng [2] indicated that the structure stiffness of the system was reduced by the fatigue, the fatigue load aggrandized the strain of the concrete, especially for the place of the wet joint. Yan [3] did the experimental study on static and dynamic load, the results showed that the wet joint was the weakness of the structure; the crack coefficient was smaller than the theory. Wu [4] analyzed the parameters which influence the creep, and put forward the corresponding mended approach to design this type bridge based on the analyzing result. Yu [5] briefly introduced the characteristic and computing method of the structural design of simply supported to continuous. Amri et al [7] put forward the precast beam's concatenation could be realized by setting the continuous steel bar and the concrete diaphragm of the precast beam end of internal bearing. The research of this system in aboard not only focused on the construction technique of aft continuous, mechanical behavior and reinforcement of beam end of aft continuous, but also concentrated on the influence of the shrinkage and creep [6-9]. Two connection techniques, connected the two beam end in America, were merely adapted to the condition with only one beam in the direction of cross bridge. In this paper, a new construction technique, called aft stretching the continuous long bundle, is applied. The research for the influence, resulting from the shrinkage and creep of concrete, was investigated, compared with the traditional fashion (aft-continuous short bundle). The efficiency and practicability of the new technique is proved.

AUTOMATION OF MODE ANALYSIS FOR THE SOLAR WING

Song Shunguang, Wang Chunjie*

The automation of mode analysis for the solar wing was studied in this paper. Mode analysis is crucial for designing the structure of the solar wing. It is inconvenient to implement the analysis manually due to the complexity of the

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structure. Furthermore, some solar wings have the same configuration, and only vary in size and categories of the parts. To acquire the mode results conveniently and swiftly, by programming with PCL (Patran Command Language), the automation of mode analysis for the solar wing was carried out. Parameterized modeling, automatic analysis and final results output of the solar wing were then realized. The achievement is significant for improving the efficiency and lowering the cost in the design.

INTRODUCTION

The energy required for spacecrafts running in the orbits is in general provided by the solar cell array. One of the most universal structures adopted for the solar array is the folding solar wing. It is primarily composed of panels that support the solar cells as well as their circuits, the yoke that joins the solar panels to the spacecraft, locking and releasing devices, deployment hinges and the driving mechanism (Yuan Jiajun [1]).

One of the most important tasks in the design of the solar wing is to satisfy the mode requirements. The solar wing stows when launched into the space by the rocket initially, and deploys when it runs and begins to work in the orbit. Mode analysis of both stowed and deployed solar wings are necessary. Due to the complexity of the structure of the solar wing, mode analysis is usually implemented with the help of finite element analysis software, such as MSC.Patran/Nastran. Some solar wings have the same configuration and only vary in size and categories of the parts. To utilize the modeling and analyzing approaches that have been accumulated before, and to avoid the duplication of work, the automation of mode analysis was achieved by programming with PCL (Patran Command Language). On this basis, the designers could complete the configuration design and performance analysis of solar wings conveniently and swiftly. So the efficiency of the design was improved.

FRACTURE EVALUATION OF POLYMER COMPOSITE MATERIALS BY ULTRASONIC WAVE PROPAGATION CHARACTER

Junjie Chang* and Chengxin Lin**

The use of ultrasonic wave technology was anticipated as an important technology in health monitoring of composite materials and/or structures. However, the propagation of ultrasonic wave becomes very complicated in

polymer-based composite materials due to reflection, transmission, dispersion and other behavior, which may occur at the interface of the matrix and within the reinforcements. Therefore, in this paper, the elastic wave motion equation is evaluated by using newly developed time domain finite element analysis; the ultrasonic wave motion and its characteristics in a single composite material with/without debonding failure was numerically elucidated. Particularly, the ultrasonic wave mode conversion in the media body and the influences of the fiber/matrix interface and the debonding failure on wave propagation process were clarified. The visualization of both longitudinal and transverse wave during the wave propagation is conducted, and its effectiveness for identifying the complicated wave characteristics is confirmed.

INTRODUCTION

Composite materials, such as glass fiber reinforced plastics (GFRP), have been applied practically in a variety of fields, such as aircraft, space and other structural fields, because of their excellent characteristics of light-weight, high rigidity ratio and so on. Despite the outstanding characteristics of composite materials, the damages, such as cracks in matrix, fiber breakage and debonding between fiber and matrix are easy to occur in practical use. These damages are difficult to be detected directly by visual inspection technologies from the material surface, and they have limited the wider applications of these materials. Thus, the technology of health monitoring for composite materials and/or structures is indispensable in order to ensure the reliability as well as safety of these materials in engineering use. Among the health monitoring technologies, the ultrasonic technology attracts lots of attentions in recent years for its valuable information, such as the characteristics of reflection, transmission, and dispersion, obtained during wave propagation. In this paper, as a basic investigation of ultrasonic wave in composite materials, the single fiber composite, which is one important model composite for understanding the mechanical mechanism of reinforcement, is used. The characteristics of ultrasonic wave propagation in the single fiber composite are investigated and the influence of debonding failure at the fiber/matrix interface on the wave propagation was discussed.

ASSESSMENT OF THE DAMAGE IN CARBON FIBER REINFORCED CONCRETE BY ACOUSTIC EMISSION AND RESISTANCE MEASUREMENT METHODS

Zhao Jiao, Xu Zhihong*

In this paper, the change of the resistance and AE signals in concrete beams under bending load were tested simultaneously. The tests show a good correlation among the changing of resistance and the AE signal counting intensity. These two methods certificate each other that they are valid and effective in monitoring damage in CFRC.

INTRODUCTION

Short carbon fiber reinforced concrete (CFRC) exhibits both electric conductivity and higher mechanical strength and a new method of detecting the damage of CFRC by electrical resistance measurement (RM) has been developed in recent years [1] [2] [3].

Acoustic emissions (AE) are the stress waves produced by the damage of material caused by the changes in the internal structure such as the propagation of the micro cracks and the breakage of the fibers in composite material. AE sensors can receive the signals of stress waves on the structure surface. AE parameters such as amplitude, counts, energy, which provides information about the damage in concrete structure, can be obtained by mathematical process. AE technology has being widely used in non-destructive test (NDT) [4] [5] [6].

In this paper the damage and breakage process of short carbon fiber concrete beams under three points bending test were studied both with RM and AE detection, the resistance and the AE were measured simultaneously. From the test results, it is found that the damage detected by the RM method was consistent with that detected by the AE method. These two methods certificate each other that they are valid and effective in monitoring damage in CFRC. The details about the preparation of the CFRC, the test setup, test results and discussions are described in the following sections.

MECHANICAL PROPERTY OF SILICA XEROGELS ESTIMATED BY MERCURY

Fei He[1], Xiaodong He[1], Mingwei Li[2]

Mercury cannot penetrate the pores, and the pressure increase induces an isostatic pressure on aerogels. According to this phenomenon, several authors have shown a new way to estimate the mechanical properties for brittle aerogels, based on a power law between the mechanical modulus and the bulk density. Two step acid-base catalyzed silica xerogels which had integrated structure were prepared through sol-gel and ambient pressure drying. Silica xerogels powder, TiO_2 powder and short fibers were added as the additives in order to improve the mechanical properties of silica xerogels. The porous structure was estimated by the means of mercury intrusion porosimetry (MIP). Five exponent values with different additives were determined from MIP curves according to the theoretical model of R. Pirard. The results show that there is the coherence between microcosmic measure of MIP and macroscopical method of classical mechanical properties. The mechanical property of silica xerogels is increased by adding different additives.

INTRODUCTION

Aerogels are low density nano-porous solid materials, and have continuous random network structure which often exhibits a fractal character. The unique properties of aerogels are related to their nano-size particles and porous distribution, and a striking number of applications have developed for them by scientists [1]. Adding different additives is one of methods to improve the properties of xerogels [2, 3], such as mechanical, thermal and optic properties, et al.

Aerogels consist of two continuous phases: the solid skeleton that is typically made up of bars or chains of particles that form a 3D network, and the open pore space [4]. Due to the shrinkage of aerogels under mercury pressure, the network is compressed by the mercury intrusion and the pores collapse gradually, which leads to the change of pore size distribution possibly. MIP usually is used to estimate the bulk modulus of the network [5, 6]. The relationship between Young modulus E and bulk density ρ of aerogels is presented by a power law as $E = E_0(\rho/\rho_0)^m$, where the

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index 0 denotes an arbitrary reference. The classical theory based on intrusion of mercury is not used to exhibit the mechanical properties of aerogels because of the shrinkage under mercury pressure. A coefficient K', defined as $\Delta P = -K'(\Delta V / V)$, and the density ρ are also linked by a power law as $K' \propto \rho^{\alpha}$ using the method of mercury intrusion porosimetry (MIP). Although there is a conceptual difference between classical interpretation and MIP, the difference in the measured exponents between m and α is surprisingly small.

The purpose of this paper is to investigate the effect of the different additives on mechanical property of silica xerogels obtained from the sol-gel method with acid and base catalysts and non-supercritical drying using fractal theory.

DRY SLIDING WEAR OF MICRO-ARC OXIDATION COATINGS ON A356 ALUMINUM ALLOY UNDER DIFFERENT CONDITIONS

CUI Shihai[1], TANG Hongtao[1], LI Jianyu[1], HAN Jianmin[2], LI Weijing[2]

The dry sliding wear resistance of micro-arc oxidation (MAO) ceramic coatings on A356 aluminum alloy was investigated in this paper. It was found that there was hardly no wear loss but weight increase of MAO coatings while the wear rate of the uncoated aluminum alloy was 4.3×10-5mm3/(N·m) at a speed of 0.52 m/s and a contact pressure of 0.1MPa.Even at the highest contact pressure of 0.7MPa, no collapse of MAO coating took place and the wear rate of the MAO coating was still less than 8×10-6 mm3/(N·m). With the increase of the contact pressure, the wear mechanism of MAO coatings turned from oxidative wear to abrasive wear.

INTRODUCTION

The relatively low hardness and poor wear resistance of aluminum alloy compared to that of steel material restricts its applications especially under wear

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conditions. Applying ceramic coating on aluminum alloy is an effective way to improve the wear resistance of aluminum alloy. Micro-arc oxidation (MAO) method as presented in reference [1,2,3] has been recently developed as a rapid and effective way to fabricate a thick, hard ceramic coating on aluminum alloy. This method is developed on the basis of conventional anodic oxidation and it also primarily involves an anodic polarization of aluminum alloys in aqueous electrolyte solutions. Micro-plasma discharges occur on the anode surface when the electrolytic voltage exceeds a critical polarization potential. Conventional oxidation layer can be converted to ceramic coatings with the help of plasma assisted electrochemical reaction in the aqueous electrolyte solutions. The electrolytes used in MAO method are usually weak alkaline solutions and are friendly to environment. Furthermore, the constituents of the ceramic coatings can be changed by using different electrolytes solutions. Coatings fabricated on aluminum alloy by MAO method exhibit high micro-hardness, good corrosion and wear resistance, excellent adhesion to the substrate and high electric insulation resistance, etc. Therefore, the protection of aluminum alloys by applying micro-arc oxidation coatings is currently of great interest. In this work reported here, ceramic coatings were fabricated on A356 casting aluminum alloy by MAO method. The dry wear resistance of MAO coatings under different conditions was investigated detailedly.

SHAPED CHARGE JET PENETRATION INTO MULITILAYER METAL TARGETS WITH LARGE INTERVAL

Cheng Wang*, Jianguo Ning, Tianbao Ma

At long standoff, a shaped charge with small cone angle will produce a jet with a high tip velocity and a low tail velocity, causing it to stretch and break up, so its penetration ability into multilayer metal targets is very weak, while the penetration depth of explosively formed projectiles (EFP) is too low to penetrate into multilayer metal targets. On account of this, the large cone angle shaped charge, whose internal cone angle is about 100 degree, is proposed and designed in the paper. The sensitivity of penetration effect into targets to the cone angle of the liner is investigated by experiment. The results reveal that the shaped charge penetration into multilayer metal targets with large interval is more optimistic than that of the shaped charge with small cone angle and explosively formed projectiles. In numerical simulation, based on MOCL (Marker on cell line) algorithm to track material interfaces, jet penetration into metal targets is simulated in a two-dimensional multi-material Eulerian code. The numerical results are in good agreement with the experimental ones and

also indicate the MOCL algorithm has much better resolution for moving interfaces, especially effective for large deformation.

INTRODUCTION

Since World War II, shaped charge jet has been used for penetration of targets such as steel, concrete and rock. Today, it is widely employed for both military and civilian purposes [1]. In order to attack different targets, various forms of liners such as conical and hemispherical liners are designed. Among them, typical and mostly used ones are small cone angle liner and large cone angle liner. Due to large velocity gradient, the jet formed by shaped charge with small cone angle sharply stretches before it reacts with targets, and its effect of penetration into targets is very weak at long standoff, so it is hard to satisfy the requirements of penetration into multilayer targets. Though explosively formed projectiles can meet penetration requirements at long standoff, its penetration depth is slightly small, and furthermore its capacity of penetration into multilayer targets with large interval will drop. For this reason, in order to penetrate into multilayer metal targets as deep as possible, this paper employs explosive forming principle and designs shaped charge with large cone angle. In combination with numerical simulation, penetration into multilayer metal targets for the various shaped charge is investigated by experiments. The results demonstrate that, the penetration capability of shaped charge with large cone angle is superior to that of jet and explosively formed projectiles.

TIGHTNESS PREDICTION OF BOLTED FLANGED CONNECTIONS WITH ELASTIC WASHERS

GU Boqin[*], CHEN Ye[*], ZHANG Yu[**], ZHU Ruisong[**]

Bolted flanged connections are commonly used in industrial equipment and pipeline, and their failure is mainly caused by leakage. Elastic washer is a kind of elastic compensating element. It can effectively compensate creep deformation and relaxation of gaskets, bolts and flanges, thus improve the tightness of the joints operating at elevated temperature. The concept of the tightness of bolted flanged connections was proposed. The deformation compatibility equation of the joints was established, and the tightness prediction method of the joints with elastic washers at elevated temperature was proposed. The research results have been applied to the bolted flanged connections in some petrochemical plants, and the tightness of these joints was obviously improved.

INTRODUCTION

Bolted flanged connections are commonly used in industrial equipment and piping system. Although most bolted flanged connections were in general operated satisfactorily, their tightness has proved that the leakage is still a major concern. In fact, the leakage is the main failure in chemical and petrochemical plants. Therefore, it is imperative to improve the tightness of the joints.

In the design methods of bolted flanged connections in the current codes [l, 2], the pretightening and operating loads of bolts are calculated based on some factors unrelated to leakage behavior of gaskets, and the structural strength of joints is mainly taken into consideration, while the tightness of them has not been interpreted demonstrably.

Physically, there exists no absolute tightness [3]. Tightness should be measurable like other physical quantities and indicates the leakage state of joints. The result of tightness assessment of joints is related to leak detection method and allowable leakage rate. After introducing the conception of leakage rate, the tightness of a joint can be defined as follows: under given operating conditions, the joint is tight when its leakage rate, which should be measured by a prescribed method with enough measurement precision, is smaller than the allowable one; otherwise, it is not tight.

Many researches have been conducted on gasket performances, test procedures of gasket performances and design criterion of bolted flanged connections, and they have largely improved traditional design and tightness evaluation methods of flanged joints. However, little progress has been made in predicting and controlling leakage rates of the joints subjected to large deformation caused by gasket relaxation and bolt creep at elevated temperature. Elastic washer is a kind of elastic compensating element developed especially for bolted flanged connections in recent years. It can effectively compensate the creep deformation and relaxation of gaskets, bolts and flanges, thus improve the tightness of joints. In this paper, on the basis of the research results of the behaviors of gaskets, bolts and elastic washers, the deformation compatibility equation of bolted flanged connections was established, and the tightness prediction method of the joints with elastic washers at elevated temperature was put forward. Furthermore, some applications of the research results were also presented.

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DEFINITION OF MAIN FACTORS AFFECTING RISK ASSESSMENT QUALITY OF OIL AND GAS PIPELINES

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On the basis of understanding acting mechanism, mode and consequences of human factor, and substantial factor, project operation factor and management factor affecting risk assessment quality of oil and gas pipelines, how to identify the main factors affecting risk assessment quality of oil and gas pipelines and then to focus on controlling them is the key that raises agreement with the conclusions of risk assessment of oil and gas pipelines. Evaluation index system of factors affecting risk assessment quality of pipeline is established in this paper, then the quantitative and sensitivity researches for this index system are progressed, so that the key factor affecting risk assessment quality of oil and gas pipelines — project operation factor is defined. This will make up the defects of existing risk assessment method of pipelines, improve risk assessment technology of pipelines, meanwhile key factor affecting risk assessment quality of oil and gas pipelines can be effectively controlled.

INTRODUCTION

Risk assessment of oil and gas pipelines is a multi-factor comprehensive evaluation process, and the applying research practice at home and abroad shows that the more comprehensive factors causing pipeline accidents are considered in the process of risk assessment, the higher the accuracy of risk assessment results. And because the objective existence of numerous uncertainty factors, the structure integrity of oil and gas pipelines has been inherently reduced and the effectiveness of protective measures weakened to some extent, however, among the current foreign general semi-quantitative risk assessment basic model of pipeline, analysis and evaluation to these factors are not fully considered. Clearly, the current risk assessment system of pipeline still exists obvious defects, so that the scope and magnitude of severity of these defects will have a direct impact on reliability of risk assessment quality of pipeline, and decide on the credibility and recognition degrees to final assessment results as well as. Just based on this, the idea that the risk assessment quality of oil and gas pipelines was evaluated have been presented by the author [1], then the cause in occurrence of the various affecting factors, such as the human factor, the substantial factors, project operation factors and management factors, and the likely impact model of these factors to risk assessment quality have been analyzed in detail [2]. Based on this, the evaluation index system for factors affecting the risk assessment quality of oil and gas pipelines is established here, then fuzzy comprehensive evaluation about sensitivity is performed, making an effort to

define main factor which plays some key role in the risk assessment quality of oil and gas pipelines from many affecting factors.