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THE NEW WAYS IN NDE AND STRUCTURE INTEGRITY

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Abstract

This paper deals mainly with some new ways in NDE and structure integrity. The ways are a. the inspection by ultrasonic and strain distortion, b. the observation of safety valve leackage by acoustic emission and strain measuring, c. the application of vibration—induced neutron noise and diagnostic method for control rod vibration, d. the fatique testing methods of tube—type structure in hot cell or in high temperature and pressure. Some new points about LBB ES will be also discussed in this paper.

1. INTRODUCTION

Today, Integrity research and NDE technology provide a powerful tool to prevent from the failures of structures. NDE must be done correctly for product safety and reliability, quality assessment, life assessment, fatique life prediction and set right of the structure which were designed or constructed incorrectly or degraded by operation conditions and environment. The concept of "design by analysis" was described in the ASME code and other codes of the same knid. It is not only one of the important guarantees for the safety of a plant, but also is very important to decrease its total cost. The NDE technology and integrity research provide a important tool for design by analysis. They arisen with the development of SMIRT and became important branch in it. Some new NDE techniques have been focused expert's attention on. In this paper, the new ways are

a. the inspection of pressure vessel with defect by ultrasonic, strain distortion measuring and FEM,

b. the observation of safety valve leackage by acoustic emission monitoring and strain measuring,

c. the application of vibration—induced neutron noise and diagnostic method for control rod periodic and random vibration,

d. the fatique testing techniques of tube—type structures in hot cell or in high temperature and pressure.

will be discussed.

The LBB ES is a new kind of important tool for pressure component integrity. LBB criteria should be brought into pressure vessel code such as ASME. LBB ES was developed in MPA. A new system proposed may be NDE—LBB ES which is composed by putting NDE and material date base, failure pattern base, knowledge base, analytical tool base and computer system. The system can be used for design, operation maintenance and safety assessment. There are some new points about NDE—LBB ES will be discussed briefly.

2. THE NEW WAYS IN NDE AND INTEGRITY

2.1 The inspection by ultrasonic, strain distortion and FEM

The ultrasonic is important one of the NDE methods. The Inservice Inspection machines (MIS) which was input from CEA of French was respectively used for the inspection of the RPVs built in China in 1986 and from Japan in 1990 in Qin Shan NPP. The semi—automatic ultrasonic inspection system which was developed in NPIC of China has be used for the inspection of pressure components. Some results of the examination can be found in[1]. The B scan picture by NIPC system are two—dimentional. The three—dimention picture of defect could be obtained by assembling them. It can be used for doing the safety assessment of the vessel with defect, if the defect size, shape and position is exact.

How can I know the defect size, shape and position are exact or not? Strain distortion measuring is one of the new technique. Strain measuring is very familiar with mechanic experts and engineers. It can be used to measure not only the strain on the surface of the structures without any defect, but also the strain distortion on the surface of the structures with crack. The strain distortion feild can be obtained by photo—elastic painting and strain gages. The residual strain feild can also be obtained for the structure destroied or during fatique damage. Fig. 1 shows that there is a cat—ear curve of strain on the surface of the intermediate section and a mountain curve in the longitudinal section of a cylindrical modle with 2D crack in vertical and horizontal section seams respectively. Fig. 2 shows the distortion curves measured in 104D welding seam by means of FEM or not. [2] The distortion patterns are quite different from each other. The results can be obtained by strain gages just in some points. The distortion patterns obtained from testing data derectly may be incorrect. The FEM can show the full strain feild in the section with defect. NDE is a kind of inverse problems. So is very difficult. It is easy to calculate the strain distotion by using FEM for structure with defect in which the size, shape and position are known and helpful to predict the measuring points which are sensitive to the defect.

A new example in NPIC testing loop is very useful to interpret the prediction function of strain distortion for existing of defect or damage. The Inspection of the pressurizer in this loop has been done by ultrasonic and strain measuring in 1992. The strain distortion by strain measuring showed engineers the part with defect which hasnt been done by ultrasonic. To make up for a loss, the examination added shows that the vessel was cracked in the cladding and base material, the total lenth of crack is over 9mm.

2. 2 The leackage observation by acoustic emission monitoring and strain gages

The Integrity of the pressure components is not ensured if there is some leakage which is over the standard in them. The acoustic emission has been used for detection of the crack extention and also for the leackage and discharge observation to some safety valve. In French the monitoring of the observation is by AE frequency spectrum, but in China just by energy rate which is very easy to be used. Look at the Fig. 3.

The strain measuring has been also used to the determination of the discharge time of the safety valves. The discharge is a shock to the discharge pipe and valve itself. The strain gages used shows the shock response in Fig. 4. The discharge time is easy to be obtained by the open and close shock peaks.

2. 3 The application of vibration—induced neutron noise

The general inspection can not be used for the reactor internal during operation. The neutron noise technology is very useful for the diagnostics of PWR control rod and other internal components vibrations. In Li and Gu's paper" Neutron Noise Diagnostics of PWR Rod Vibrations" the neutron noise arising from absorber (control,safety, regulating and shim rod) vibration is investigated. The frequency — dependent Langevin equations are derived based on two—and multi—group diffusion theory and the adjoint function to neutron flux technique is applied to obtain the fluctuations to neutron flux Using the Galanin modelling of absorber rod, the formula is constructed which represents the relationship between absorber vibration and the signal of neutron detectors. The one and two—group frequency response functions to absorber vibration are studied analytically, it shown that the frequency response have a plateau region roughly between 0. 15HZ and 16HZ in a typical PWR.

In order to get effective CPSD expressions of displacement components, a simple two — dimensional vibration model of control rod is proposed, according to random forced vibration model hypotheses. Some results given by this model are in good agreement with experiment.

A diagnostic method suitable for periodic and random control rod vibration is developed. This method is applied to Paks — Ⅱ ,which is a PWR in Hungary, where a control rod mechanical fault was reported. The relevant results by this method are in good agreement with the report data, Fig. 5 shows one pllotting localization curve picture.

2. 4 The fatique testing techniques of tube—type structures in cell or in high temperature and pressure

The fatique is a important pattern of the structure damage. The fatique times of the components, especially the residual fatique times of the components over loaded or radiated are difficultly given correctly by analytical method. Maybe the testing techniques are good ways to overcome the difficulty, the reason is that there is not correct results if there is not correct constitutive relation of the materials damaged. Unfortunately, it is too difficult to obtain the data which is needed for establishment of the constitutive relation.

First new fatique testing device has been set up and used for fuel cladding in NPIC in 1989, and the second one for pulsed reactor fuel cladding in 1992. Fig. 6 shows one part of the strain fatique control curve for pulsed reactor. The strain amplitude is 3000 $\mu\varepsilon$. and the temperature is 570℃.

The fatique times is over 7500 at this strain amplitude and temperature, and it indicates that the heat treatment is applicable for the cladding material.

3. SOME NEW POINTS ABOUT NDE—LBB ES

The LBB criteria should be brought into pressure vessel code such as ASME for reactor safety and economy. The LBB ES is a new kind of powerful tool for pressure component integrity, it was developed in MPA. [4] It is still in developing. There are some new points about it which maybe are helpful for its development. A new system proposed is NDE—LBB ES which is composed by putting NDE and material base, failure pattern base, analytical tool base, knowledge base and computer system, and is one part of structure safety expert system. The system can be used for design, operation maintenance and safety assessment. The new points are

a. The NDE data should be included into data base and the relevant analytical technique into analytical tool base which is able to draw a conclusion about the defect size, shape and position from the NDE data.

b. The LBB criteria must be comprised into knowledge base and the relevant computer codes into analytical tool base which is able to draw a conclusion about the surface area of fracture and leackage rate of plane of rupture from the loading condition and the structure.

c. The function of relevant computer code are solution to large strain plastic dynamics of shell structures, fatique times with new constitutive relation and strain distortion of the structure with defect and damage.

d. Failure and damage pattern base is a new kind of Artificial Intelligence (AI) data base, which as a bench mark can be used for comparison in knowledge base.

e. Testing is still a useful tool when the analysis met with the difficulty, especially for the structures radiated or over loaded.

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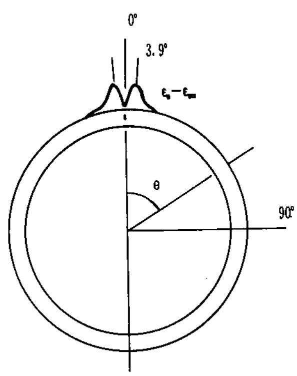

Fig. 1a cat—ear curve of strain ε_θ

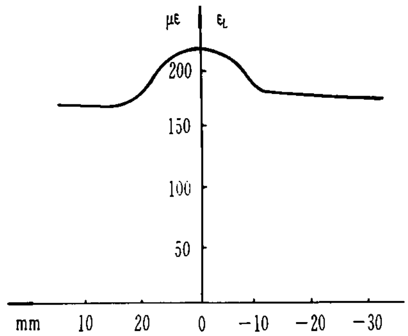

Fig. 1b mountain curve of strain ε_l

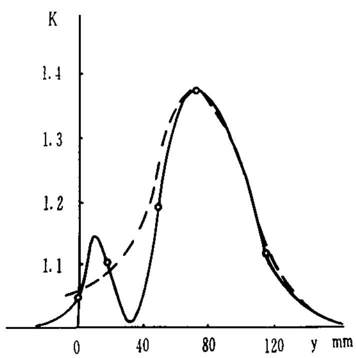

Fig. 2 strain distortion curves in 104D

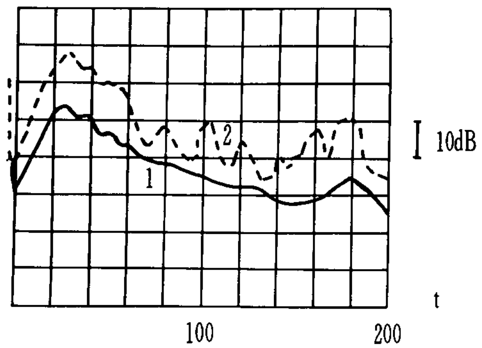

Fig. 3a AE frequency spectrum

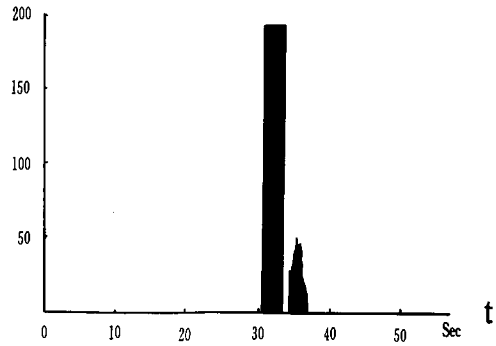

Fig. 3b energy rate picture

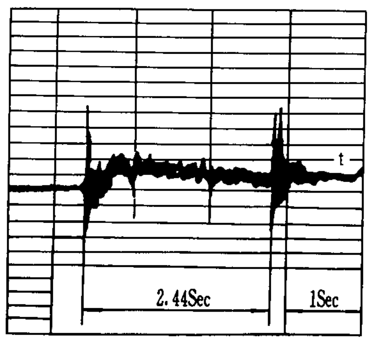

Fig. 4 strain response of discharge

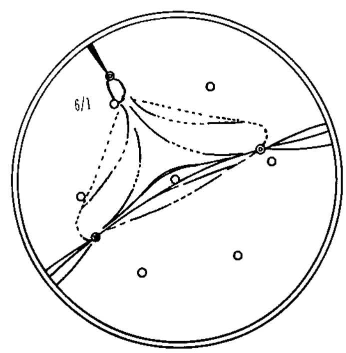

Fig. 5 pllotting localization curve picture

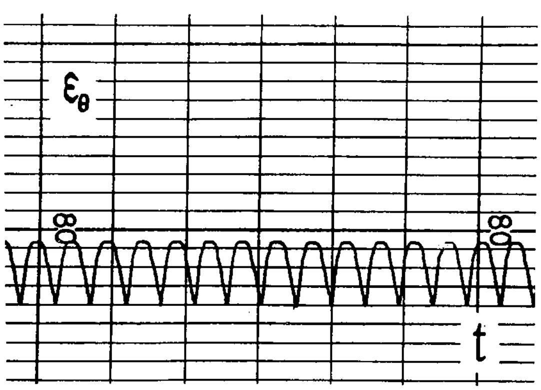

Fig. 6 strain fatique control curve