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The NDT methods under high temperature service environment

ZHANG Zhen-guo，FENG Hui-xing ，ZHAO Wei-hua

Suzhou Nuclear Power Research Institute Co., Ltd., Suzhou Jiangsu, 215004,China

Abstract. Concerning the detective requirement of the equipment under high temperature running status, this paper summarizes the technical characteristics and related applications of several non-destructive testing methods(NDT), such as thermal infrared imaging technology in high temperature, ultrasonic testing technique in high temperature, pulsed eddy current technology in high temperature and magnetic powder flaw detection technology in high temperature, penetration testing technique in high temperature and indirect visual detection in high temperature and on-line monitoring system in high temperature.

1 INTRODUCTION

Many devices are operating under the service condition of high temperature in petroleum, chemical, electric power industries area, equipment in high temperature environment will inevitably produce the phenomenon such as oxidation, high temperature corrosion thinning. The equipment material itself also contains internal defects which will prone to extend in high temperature environment, and it is harmful to the safe operation of equipment. Effective testing and evaluation of these defects has been the target of engineer, because the non-destructive testing methods(NDT) methods does not produce damage for device, it get more and more attention of the researchers in recent years. Under the normal temperature of NDT methods currently applied widely, but the high temperature of NDT methods applications is relatively less, this paper summarizes several high temperature NDT methods applications and technical features.

2 THERMAL INFRARED IMAGING TECHNOLOGY IN HIGH TEMPERATURE

Thermal infrared imaging technology has the advantages of non-contact, quick scans the area and no harm to people, it is mainly used in pressure vessel and pipeline on-line detection in high temperature pressure.

Detecting pressure vessel can find its lining damage and the internal coking, congestion and other anomalies in time. Such as petroleum and chemical pressure vessel lining anticorrosion and thermal insulation materials is easy to damage in the long-term production process because of high temperature and high pressure high speed flow medium erosion. The use of infrared thermal imaging technology for pressure vessel can find the damage of the lining, and take remedial measures in time.

Infrared thermal imaging technology pressure has potential in on-line detection of pipeline internal corrosion in high temperature pressure. Shen Gong-tian et al. [1] through the experiment proved that the infrared thermal imaging detection technology can effectively detect the pressure pipeline internal corrosion and erosion defects, and the defect size meet the safety requirements of the minimum safe operation of the pipeline allowed size. At the same time, materials thermal conductivity, defect geometry size, and the thickness of the material are all the key factors for influencing the infrared thermal imaging detection sensitivity.

3 ULTRASONIC TESTING TECHNIQUE IN HIGH TEMPERATURE

Ultrasonic testing method is not restricted by material type, it has high detection sensitivity and fast detection rate. The high temperature ultrasonic testing technology is mainly used for pressure vessel, pipeline detection and the detection of weld.

High temperature ultrasonic testing technology original main research field is high temperature test of hot plate and forging materials, and developed a water-cooled ultrasonic probe and electromagnetic acoustic probe. JohnA. Brunk [2] studied the temperature slightly change on the influence of ultrasonic wave oblique detection. M. A. Mahmoud [3] studied the ultrasonic characteristics of different coupling agent. W. Morgne [4] studied ultrasonic longitudinal wave velocity and attenuation in forgings from room temperature to 800 degrees. The

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researchers began to study high temperature weld defect detection technology, including high temperature probe and the high temperature coupling agent, etc. Currently Sonavation company, Germany K.K, American (Panamatrics) companies in the United States, etc., has been selling commercial high temperature high temperature probe and coupling agent.

In recent years, some domestic research institutions and researchers began to study high temperature ultrasonic testing technology. He Fei general machinery research institute used high temperature ultrasonic technology for on-line detection and monitoring of pressure vessels and pipes under 450 ℃. Li Jin-gong [5] used guided wave screw methods to measure high pressure pipe wall thickness, the measurement results was good consistency with the wall actual thickness value. Lu Fang-long [6] combined with the characteristics of high temperature pipe weld ultrasonic testing technology, and used the laboratory simulation test, determined the technical parameters of pipeline weld ultrasonic flaw detection, and successfully applied in a power plant of high pressure gas of high temperature testing.

4 PULSED EDDY CURRENT TECHNOLOGY IN HIGH TEMPERATURE

Pulsed eddy current detecting technology has high detect speed, it don't need a coupling agent, and it don't contact client artifacts, it is suitable for conductive material surface and near surface defects detection. Ou Yang-qi et al.[7] analyzed high temperature casting billet surface defects of pulsed eddy current signals difference and time domain, extracted the defects of voltage peak and peak time, and summarized the defects influence of the detection signal, they proved that the feasibility of on-line inspection technology for high temperature continuous casting slab defect non-destructive technology. Some researchers used eddy current method successfully simulated dynamic detection of continuous casting slab surface defects above 1100 degrees, the probe and the equipment meet the need of the high temperature for a long time, and it have detection ability of surface defects for 10 * 1.5 * 3 mm size, based on signal processing, it can locate defects quantitatively.

5 PENETRATION TESTING TECHNIQUE IN HIGH TEMPERATURE

Under the normal temperature, the penetrant testing can be used in the material surface defect detection, it has simple equipment and easy to use under limited condition. Under the high temperature, the dye penetrant is vulnerable to damage, lead to disappear or fluorescence quenching, so it limited the use of penetration testing technique. At the present stage, using penetrant can only contact with high temperature artifacts for a short period of time without damage, therefore it requires the test speed is fast. In order to overcome this disadvantage, the main research focused on the developing a high temperature resistant penetrant materials.

6 MAGNETIC POWDER FLAW DETECTION TECHNOLOGY IN HIGH TEMPERATURE

Magnetic powder flaw detection can be used for ferromagnetic material surface and near surface defects detection, but at higher temperatures, magnetic powder can degaussing and cannot detect defects .ASME rules that when the magnetic powder reaches a certain requirement, it can be used in the detection below 315 degrees .The laboratory experiment and field test results showed that below 300 degrees, by choosing the appropriate magnetic powder and its applied mode, it can detect the ferromagnetic material surface and near surface defects, and the detection sensitivity is not less than the normal temperature detection sensitivity, it can solve the on-line detection in pipe.

7 INDIRECT VISUAL DETECTION IN HIGH TEMPERATURE

Indirect visual inspection on the surface of observation material defect has advantages of intuitive, real and good repeatability test results. Some researchers used machine vision technology and the corresponding test device, established the high temperature casting billet surface defects control model under the background of the CCD shutter, they also designed the algorithm for classifying defects, and test showed that the system could work continuously for a long time under high temperature, the maximum width of 3000 mm slab could be detected, and realized the online hot slab surface defect detection and classification.

8 OTHER HIGH TEMPERATURE NONDESTRUCTIVE TESTING TECHNOLOGY

Although some high temperature detection technology do not belong to the normal sense of the non-destructive testing method, but from a general point of view, because the method itself will not cause damage to equipment, it can also be classified as high temperature NDT methods. For example, creep deformation measurement method which is used by measuring deformation of material to predict material life, this method has been widely used in power plant and nuclear power plant steam pipeline life evaluation. Corrosion probe method is that by using electrical resistance probe to detect the metal corrosion loss under high temperature condition, its principle is that

a component of the same material with the detective component are exposed to the high temperature environment, the detective component is thinning constantly in the process of corrosion, its resistance value is increasing, through the resistance of the conventional measurement, you can get online corrosion rate of component. On-line monitoring system gets more and more widely used in power plant on the steam boiler, piping system, and the high temperature components. As the ERA of British company developed AMASS software system which is used for real-time monitoring of boiler tube .The ALIAS system which is developed by Germany, Britain and Spain, will monitor the results and combined with the on-line calculation and analysis, to predict the high temperature creep and fatigue damage of the piping components, but the high cost of restrict its further development.

9 SUMMARY

High temperature NDT methods meet the requirement of real-time, non-destructive testing for the equipment and materials under high temperature. It can effectively warning of high temperature material accidents in advance. With the further development of the science and technology, the method will play a more and more important role in the field of non-destructive testing.

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