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Material characterization of duplex stainless steel with ultrasound Techniques

Yu-Wei Hsu[1] ,Che-Hua Yang[2]
(Institute of Manufacturing Technology, National Taipei University of Technology)

Abstract

This research focused on nondestructive laser ultrasound Technique of thermal aged CF-8 duplex stainless steel treated at 723K for 1200 hours. Laser ultrasound technique (LUT) is employed to measure the behavior of guided wave. Based on experimental data, it shows that the phase velocities of CF-8 duplex stainless steel aged at 723K for 1200 hours is faster than unaged treatment caused by microstructure transformation and make the material strength harder.
Keywords: Nondestructive, Dispersion curve, Thermal aging, CF-8 duplex stainless steel, Laser ultrasound technique

1. Introduction

Duplex stainless steel possesses high yield strength, high corrosion resistance and high fatigue resistance due to the composition itself, which is composed of ferrite and austenitic.

Most of the parts are made of stainless steel and CF-8 duplex stainless steel inside the nuclear plant. But δ-ferrite will transform into chromium-rich (α'-phase) and iron-rich (α-phase) as temperature increased above 573K which causes the material embrittle. The degradation is called thermal aging brittle which causes the material embrittle, thus the ductility and toughness decreased as well[1] [2].

Nondestructive laser ultrasound technique is essential for inspection of duplex stainless steel made parts inside nuclear plant. There are many works focus on the measurement for cast duplex stainless steel and which can be divided into destructive and nondestructive measurements, impact test, microhardness test, small punch test [3] and tensile test [4] which fall into destructive measurement while electrochemistry [5], SQUID [6] and ultrasound technique [7] fall into nondestructive measurement.

There are different modes of plate wave and which differs from characteristics of materials. Thus, this research is based on this principle for further measurements.

2. Experiment

2.1 Material and Sample

CF-8 duplex stainless steel which belongs to cast austenitic stainless steel with normal chemical composition(wt%) of 0.08 carbon ,18-21 chromium, 8-11 nickel, 2.0 silicon, 1.5 manganese and includes 5-20%vol of δ-ferrite[4] , while in this experiment the composition of δ-ferrite is 6%vol.

Fig. 1 represents the unaged and aged samples individually. The aged sample is aged at 723K for 1200 hours.

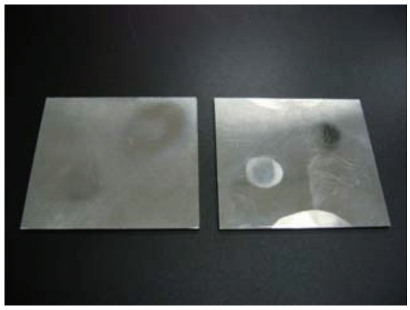

Fig. 1 CF-8 duplex stainless steel specimen

2.2 Laser Ultrasound Technique

A laser ultrasound technique is used for the measurement of dispersion spectra of the bi-layer system. **Fig. 2** shows the experimental configuration consisting of a pulsed laser for the generation of ultrasonic waves and a laser-based optical detector to detect the generated waves.

In order to obtain the dispersion, a B-scan scheme is used, followed by a two-dimensional fast Fourier transform (2D FFT) scheme to extract dispersion curves.

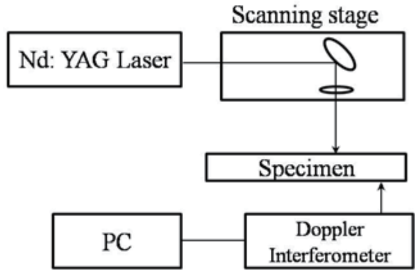

Fig. 2 A schematic showing the measurement system

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[1]E-mail: t8568032@ntut.edu.tw

3. Results and Discussions

Fig. 3 shows the dispersion curves of aged and unaged CF-8 duplex stainless steel, it shows the phase velocity of thermal aged sample is faster than the unaged sample. The aged sample is treated at 723K for 1200 hours. From **Fig. 3**, the A0 mode of aged sample shifts to high velocity and high frequency. The phenomenon in **Fig. 3** is resulted in changes of aged conditions lead to the material embrittle and harden.

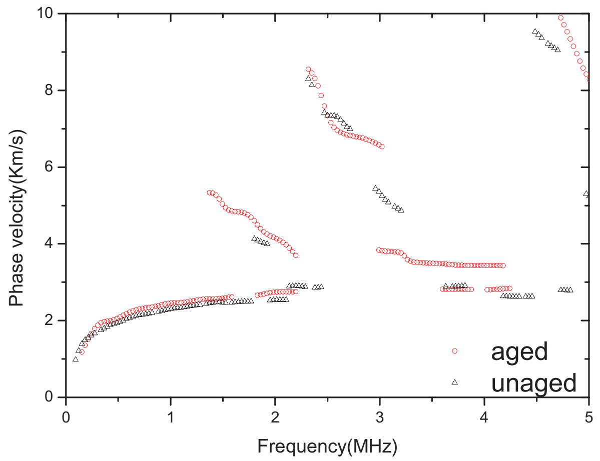

Fig. 3 Dispersion curve of both samples

4. Conclusions

Dispersion relations of guided waves propagating in unaged and thermal aged CF-8 duplex stainless steels are successfully measured in this research. For results, dispersion relation curves in Fig. 3 represents that the phase velocity of aged treatment sample is faster than the one without aging treatment sample. We assumed that the result is due to the aging treatment which causes the material embrittle and harden.

This study successfully measured by LUT to investigate the behavior of guided wave propagating in the CF-8 duplex stainless steel during various aging conditions.

Acknowledgment

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