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Electromagnetic Acoustic Evaluation of a Be/Cu Diffusion Bond Quality

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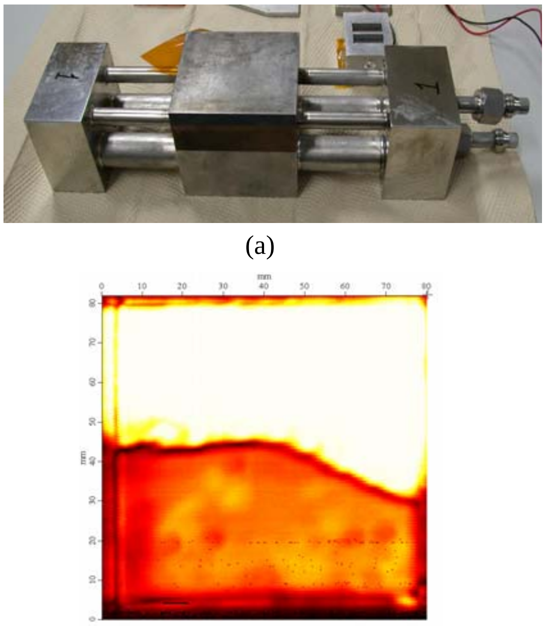
1. Introduction

EMAT (Electro-Magnetic Acoustic Transducer) is a non-contact transducer that generates and detects the ultrasonic waves in electrically conductive materials. As the coupling between the EMAT and the sample is electromagnetic, they are relatively insensitive to a wave when compared to the conventional ultrasonic method. However, EMAT technique has the advantages of a non-contact nature and an easy selection of the desired wave modes such as a Rayleigh wave, a Lamb wave and a shear horizontal (SH) wave. [1, 2]

The sample is a mock-up with beryllium (Be) which has a higher magneto-mechanical coupling factor than any other metal. The purpose of this study is to investigate the feasibility of an EMAT technology for an in-situ inspection of a Be/Copper (Cu) joining interface which is for the first wall of an ITER under a high temperature and high radiation environment.

2. Sample Preparation

Mock-up for the first wall of an ITER was fabricated by a Hot Isostatic Pressing (HIP) with Be of a S-65C grade, CuCrZr and SS316L. Dimensions of the mock-up is 80mm long, 80mm wide and 85mm thick including 10mm of Be tile and 22mm of Cu alloy. This mock-up was tested under high heat flux (HHF) and damaged. To confirm the delaminated Be tile, ultrasonic immersion test was applied. A photograph of mock-up and an ultrasonic test result of Be/Cu interface was shown in Figure 1. Large delaminated defect indicated as the white image was found at the upper side of the square area. A Red image at the lower side could be evaluated to be a good bond region. [3]



(a)

(b)

Figure 1 Photograph (a) and Ultrasonic C-scan image (b) of the sample

3. EMAT Measurement of the Be/Cu diffusion bond

EMAT transducer consisted of a permanent magnet with 300 mT and a printed coil with 8 kW tone burst signal if the maximal output power is required. EMAT measurements were performed with an ITER first wall mock-up using a high power ultrasonic gated amplifier system RPR-4000.

A typical EMAT waveform was shown in Figure 2, representing shear horizontal waves into the target material through a surface movement for wall thickness measurement of a 10 mm Be plate at a good bond position.

For the purpose of comparison, Figure 2 also showed the waveform obtained from the same sample at a delaminated position.

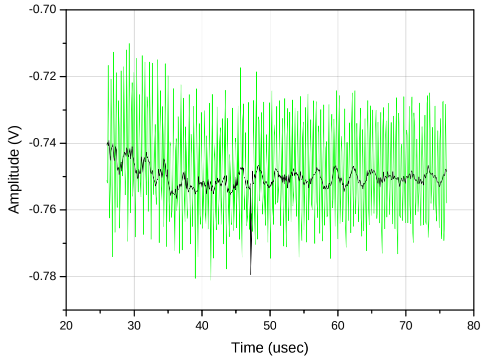


Figure 2 Typical zoomed waveforms at a good bond position (black line) and a delaminated position (gray line)

This signal showed the higher amplitude and many high frequency components than that of good bond and was processed by Fast Fourier Transform in order to obtain the signal spectrum as shown in Figure 3.

Several thickness mode resonances were occurred with 430 kHz interval which was related to the Be thickness of 2.3 μ sec. And a peak of 351 kHz was revealed in signal spectrum at a good bond as well as at a defective bond, which might come from EMAT itself.

From this result, a SH wave can provide a effective decision criterion in order to detect the debonding because the SH wave has a feature of the full transparency of the interface,

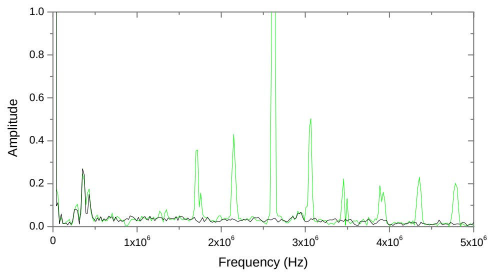


Figure 3 Signal Spectrums at the good bond and delaminated position

4. CONCLUSIONS

The Lorenz force type EMAT is a convenient inspection method for a Be/Cu diffusion bond test if a couplant or water is not permitted. The EMAT can produce a SH wave which provides a good penetration for a flawless bond and some reflections for a delaminated bond. It is possible to conclude that EMAT can be applied in the inspection field for ITER even if it has an inferior energy conversion efficiency and spatial resolution to a conventional ultrasonic method.

Acknowledgements

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