Development of Methods to Measure Pipe Wall Thinning Using Guided Waves and Electromagnetic Acoustics Transducers

Background

Ultrasonic thickness meters are used now to measure pipe wall thinning in thermal and nuclear power generation plants. In order to detect and size pipe wall thinning, a conventional ultrasonic transducer, however, has to be moved axially and circumferentially. Moreover, couplant is absolutely necessary over detection area. Therefore, this technique is time-consuming and costly. Instead of this technique, a measurement technique is proposed based on guided waves and couplant-free electromagnetic acoustic transducers (EMATs) so as to measure pipe wall thinning more efficiently. In the proposed technique, guided waves are used to screen whether pipe wall thinning exists and to determine its position if it is detected, and EMATs are used to precisely measure the dimensions of pipe wall thinning. However, there are some difficulties in applying guided waves and EMATs, for example, it is difficult to apply guided waves to components whose thickness is more than 3 mm and SN ratio is quite low for EMATs.

Objectives

To solve the problems mentioned above, an efficient technique for pipe wall thinning measurement is developed. In this technique, guided waves＊1 are applied to determine pipe wall thinning location and EMATs＊2 are used to measure their wall thinning ratio (WTR).

Principal Results

1. Location measurement of wall thinning by guided waves

(1) Numerical analysis of wave propagation is performed for a specimen with thickness of 10mm, where different artificial defects are introduced to model local wall thinning. As shown in Fig.1, when transmitted waves impinge the wall thinning, they are reflected and the intensity of the reflected waves varies with WTR.

(2) A low frequency transducer is designed and manufactured according to the results of numerical analysis of wave propagation. The transducer is applied to transmit and receive guided waves on a square specimen whose thickness and side length are 10mm and 1m, respectively. Various artificial defects are introduced to model local wall thinning in the specimen. Experimental results show that 1) it is possible to detect local wall thinning that is 600 mm away from the transducer, and to determine its location with an error smaller than 12mm (Fig.2), and 2) the intensity of reflected waves from local wall thinning varies with WTR (Fig.3).

2. Height measurement of wall-thinning by EMATs

A sensitive EMAT is developed to measure specimen thickness based on electromagnetic ultrasonic testing. By means of electromagnetic shield on cables and EMATs, SN ratio is improved from 0.8 to 7.2 as shown in Fig.4. EMATs have equal accuracy in thickness measurement as conventional piezoelectric transducers, the maximum error for EMATs is 0.18 mm as shown in Fig.5.

3. Actual pipe wall thinning measurement

It is probably expected to measure wall thinning more efficiently by combing guided waves and EMATs together, which results in the reduction in cost. Guided waves are applied to actual pipes to determine wall thinning location remotely and EMATs are used to precisely measure WTR.

Future Developments

Optimize the configuration of transducers and measurement conditions, and apply them to actual pipes.

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Reference

S. Lin, et.al., 2006, “Development of Measuring Method of Pipe Wall Thinning Using Advanced Ultrasonic Techniques”, CRIEPI Report Q05006 (in Japanese)

＊1：A kind of ultrasonic wave which propagtes whole thickness of a specimen over a long distance.

＊2：A kind of ultrasonic wave excitation, where eddy current is introduced in a conductive specimen.

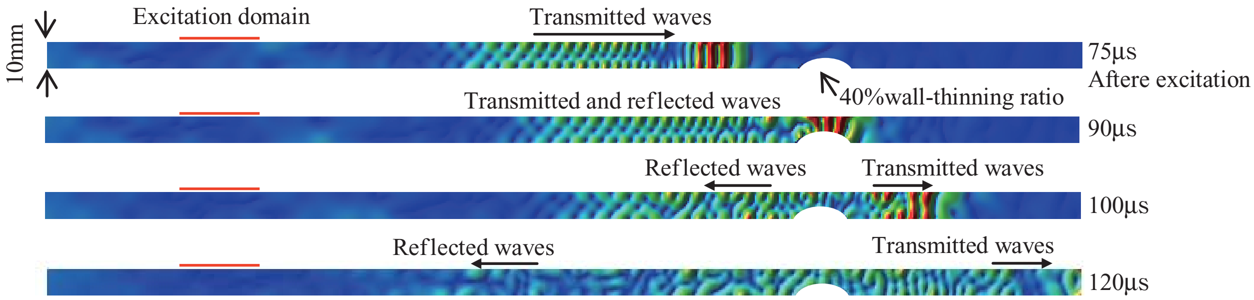

Fig.1 Wave propagation of guided waves (Numerical results)

Guided waves are excited by forces loaded in excitation domain. One part of the energy of transmitted waves goes through wall thinning, but the other waves are reflected at it. The information of the wall thinning is included in the reflected waves.

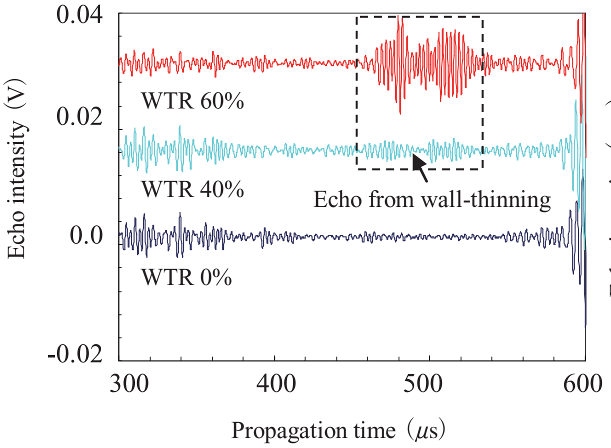

Fig.2 Echoes from different wall-thinnings

Echoes in dashed frame are from wall thinning, and they increase with WTR.

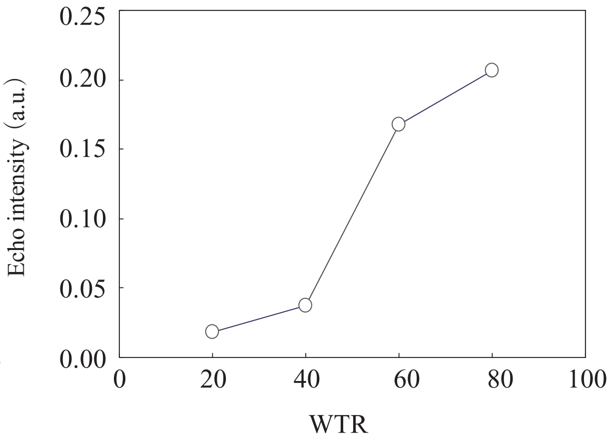

Fig.3 Relation between echo intensity and WTR

The intensity of echoes from wall thinning increases with WTR.

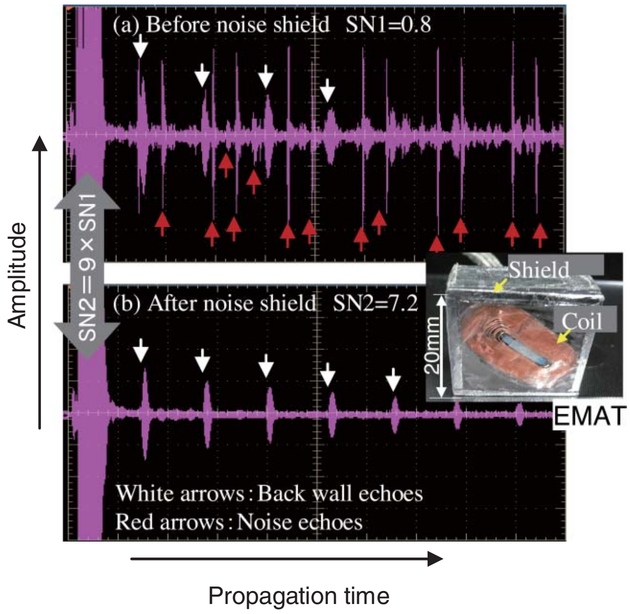

Fig.4 Enhance of SN in EMATs

By noise shield, noise echo reduces and SN improves greatly from 0.8 to 7.2.

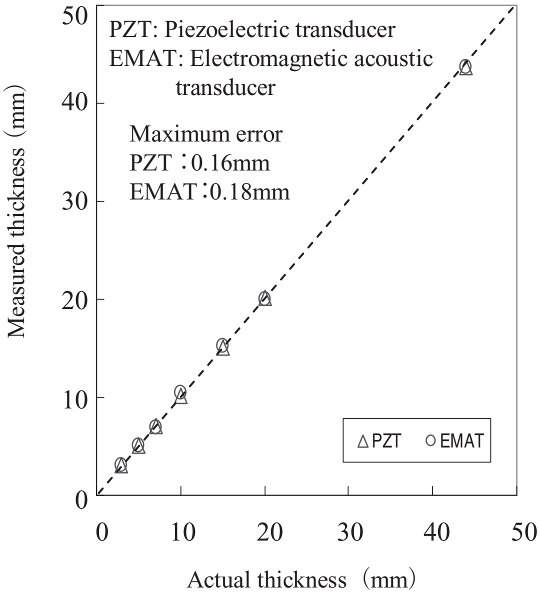

Fig.5 Comparison of thickness measurement

Specimen thicknesses are measured by EMATs with error of not larger than 0.18 mm.