# Pipe Wall Thickness Monitoring Using Dry-Coupled Ultrasonic Waveguide Technique

Yong-Moo Cheong [a*], Ha-Nam Kim[a] and Hong-Pyo Kim [a]
[a]*Nuclear Materials development Div., Korea Atomic Energy Research Institute, Daedukdaero 1045, 305-353 Daejeon, Korea*
[*]*Corresponding author: ymcheong@kaeri.re.kr*

## 1. Introduction

In order to monitor a corrosion or FAC (Flow Accelerated Corrosion) in a pipe, there is a need to measure pipe wall thickness at high temperature.

Ultrasonic thickness gauging is the most commonly used non-destructive testing technique for wall thickness measurement. However, current commonly available ultrasonic transducers cannot withstand high temperatures, such as above 200°C. It is therefore necessary to carry out manual measurements during plant shutdowns. The current method thus reveals several disadvantages: inspection have to be performed during shutdowns with the possible consequences of prolonging down time and increasing production losses, insulation has to be removed and replaced for each manual measurement, and scaffolding has to be installed to inaccessible areas, resulting in considerable cost for interventions.

It has been suggested that a structural health monitoring approach with permanently installed ultrasonic thickness gauges could have substantial benefits over current practices.

The main reasons why conventional piezoelectric ultrasonic transducers cannot be used at high temperatures are that the piezo-ceramic becomes depolarized at temperature above the Curie temperature and because differential thermal expansion of the substrate, couplant, and piezoelectric materials cause failure.

In this paper, a shear horizontal waveguide technique for wall thickness monitoring at high temperature is investigated. Two different designs for contact to strip waveguide are shown and the quality of output signal is compared and reviewed. After a success of acquiring high quality ultrasonic signal, experiment on the wall thickness monitoring at high temperature is planned.

## 2. Methods and Results

### *2.1 Experimental Method*

Two attachment methods were investigated: attaching transducer on the surface of waveguide and transducer on the edge of the waveguide. Two strip-type of waveguides are clamped to the plate. A 12.5-mm diameter ultrasonic shear transducer was coupled to the far end of the waveguide to excite and receive the shear horizontal mode. It was coupled by shear couplant with its face onto 1) the surface or 2) cross section of the strip. It was ensured that the polarization direction of the transducer was parallel to the width of the strip.

It was found that a shear-horizontal-type guided wave shows no dispersion characteristics and thus the ultrasonic signal in time domain is sharp and clear. A clamp that could attach two parallel strip waveguides with separation of 1 mm to the plate was manufactured (see Fig. 1).

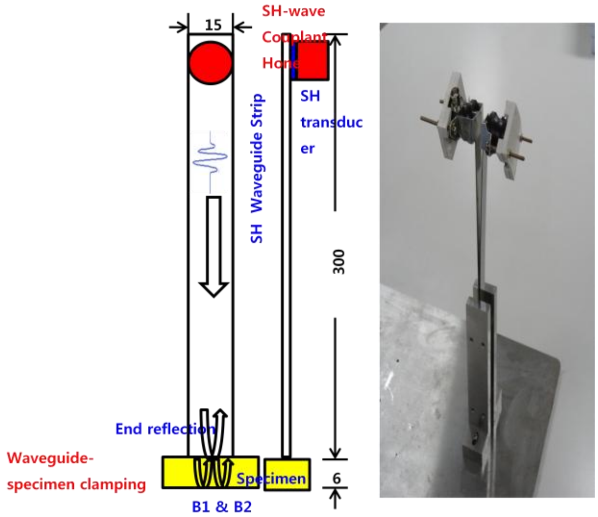


Fig. 1 Schematic drawing shows flight distance and reflection from end of strip waveguide and specimen.

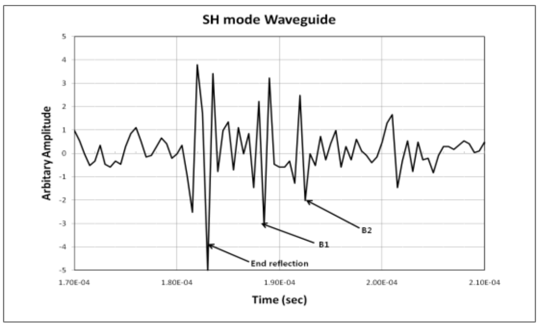


Fig. 2 A time domain signal shows echo from the end of waveguide, 1st back-wall and 2nd back-wall (freq=2.25 MHz).

### *2.2 Results and Discussion*

The shear wave velocity of Stainless Steel is approximately 3,250 m/sec, the flight time to reflect from a 300 mm long strip waveguide is estimated as 180 μsec. The flight time between first back-wall and second back-wall of the 6 mm thick plate is estimated as 3.7 μsec.

Using the clamp it was possible to test waveguides in pulse-echo mode and pitch-catch mode. Fig. 2 shows the pulse-echo mode signal collected form a strip waveguide with the transducer attached on the surface of the strip.

The pulse-echo signal is dominated by the end reflection signal, followed by long train of low amplitude signals. Coupling through the clamped junction is poor and therefore signals from features within the plate are weak and are hidden within the arrival of low amplitude strip modes due to imperfections in the transduction system or the waveguide/plate junction. Because of the acquired ultrasonic signal reveals a relatively low S/N ratio, it is attempted the second approach, the transducer with its face on cross section of the strip was performed.

Fig. 3 shows the schematic drawing and photos. The signal received in pitch-catch mode on the strip clamped adjacent to the sending waveguide is shown in Fig. 4. The signal amplitude is quite high and therefore S/N ratio also high. This is because the receiving strip only receives signals that have been transmitted into the plate specimen, which reduces their amplitude but avoids pollution from unwanted strip modes that are excited upon reflection from the strip end. It can be therefore noted that signal clarity and transmission through the joint without considerable distortion is much more important than the transmitted amplitude.

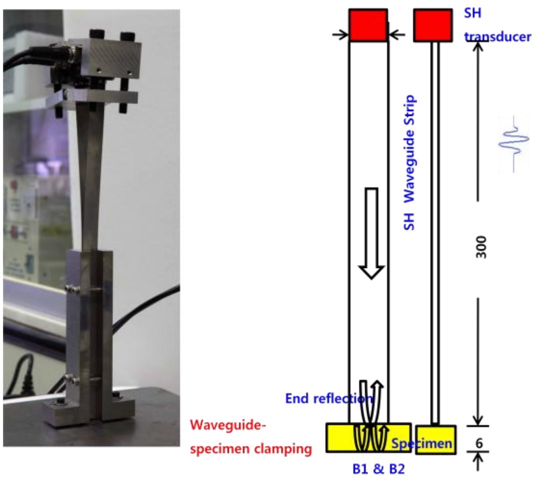


Fig. 3 Schematic drawing shows flight distance and reflection from end of strip waveguide and specimen

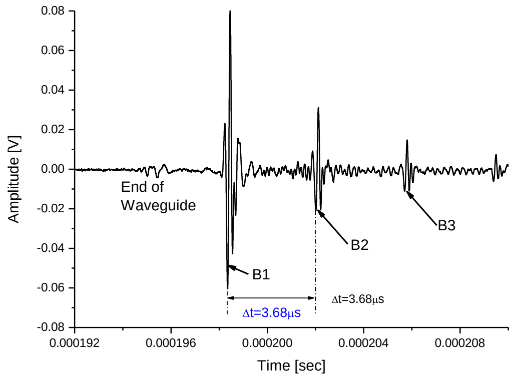


Fig. 4 A shear-horizontal mode signal by pitch-catch method shows a low amplitude of end-reflection and very high amplitude signal from back-wall (Pitch-catch mode, frequency = 5 MHz, instrument = UT340) .

### 3. Conclusions

A shear horizontal waveguide technique for wall thickness monitoring at high temperature is investigated. Two different designs for contact to strip waveguide are shown and the quality of output signal is compared. The configuration of the ultrasonic transducer with its face on the cross section of the strip and pitch-catch mode on the clamped to the plate shows high signal amplitude and S/N ratio. The experiment on the wall thickness monitoring at high temperature will be carried out before installation to the actual piping mockup.

### Acknowledgement

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