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Water Level Gauging in a Tube by Using a Special Ultrasonic Shoe in an Immersion Tank

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1. Introduction

An ultrasonic pulse travels through the thickness of a material, then finally it is reflected by the back or inside surface, and it can be returned to a transducer. In most applications this time interval is only a few microseconds or less. The measured two-way transit time is divided by two to account for the down-and-back travel path, and then multiplied by the velocity of the sound in a test material. The result is expressed by a well-known relationship as equation (1):

$$d = V * t/2 \qquad (1)$$

where d = the thickness of the test piece
V = the velocity of the sound waves in the material
t = the measured round-trip transit time

2 Ultrasonic Measurement Methods

In this experiment, a residual water level measurement in a bellow tube is obtained by using an immersion ultrasonic technique and a special UT probe attachment. This system was designed and fabricated for a convenient control in a water tank, which has a combination of a sensor and a position control function. The shoes are specially made with Lusite material which has the same shape as the bellows tube and then the immersion transducers are controlled by a 3-axis position control system, and it can be operated within a moving distance as small as 0.5mm. Certain specialized applications such as an underwater testing require a long cable between the transducer and the ultrasonic gauging target in an immersion tank.

2.1 Preparation of the Immersion Ultrasonic Measurement

The immersion ultrasonic measurement & the position system are controlled by a 3-axis position control system, and it can be operated within a moving distance as small as 0.5mm using a manual method. An ultrasonic module assembly, available in different frequencies and sensing ranges, easily plugs into the system, thus optimizing the sensing range for a specific application and allowing for an easy and inexpensive modification of the system for other requirements. The shoes are made with Lusite material which has the same shape as the bellows tube and then the immersion transducers are controlled by a 3-axis position control system, and it can be operated within a moving distance as small as 0.5mm. The scanner which means the 3-axis position control system is used to carry out an ultrasonic immersion testing of the centered bellows tube. The scanning distance has a 50mm x 70mm x 60mm range. The scanning is done by providing the following ranges to move the probe.

2.2 Design of the Shoes

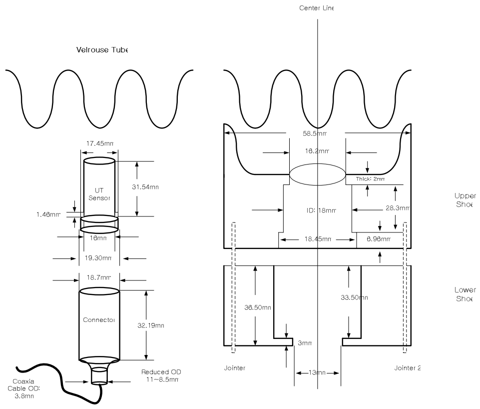

Fig. 1 Shoes design drawing-I(side view)

Figure 1 shows shoe design drawing-I (side view) and shoe design drawing-II (volume view). To enhance the contact efficiency of the transducer, transducer shoes in the shape of the outside of the bellows tube were designed, and the applied design recommendations.

3. Procedure for the Measurement

In this experiment, as the procedures for the water level measurement, the first one and the second one are the reference glass tubes from which we could obtain the reference information for the real level thickness data.

3.1 Reference glass tube-I

The dimensions of the first reference glass tube were 65.3 ㎜ in diameter and 2 ㎜ in thickness, when the water level was defined as 47.9 ㎜ and 50mm. The measured signals were obtained from the first reference glass tube. Figure 2(a) shows a signal for the 47.9mm water thickness measured from the first reference glass tube at the 15 MHz transducer. Figure 2(b) shows a signal for the 18 ㎜ water thickness from the second reference glass tube at the 25MHz transducer. In the case of using the 25 MHz transducer, S/N ratio has been enhanced more so than that for the 15 MHz transducer. As a result, it is able to measure a reliable signal at a 25 MHz frequency because of a signal which can be classified by the glass thickness signal and the measured water level signal between the initial echo and the first echo

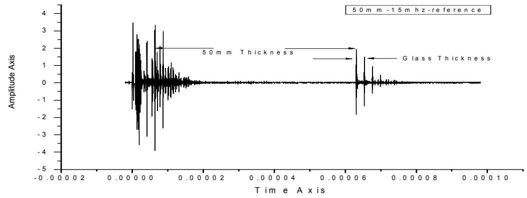

Fig. 2(a) Signal for the 47.9mm water thickness measured from the first reference glass tube (at 15MHz transducer)

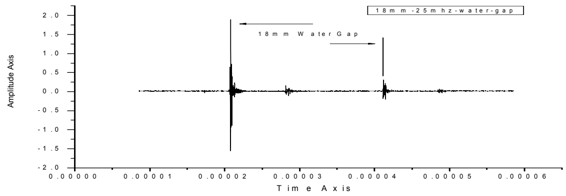

Fig. 2(b) Signal for the 18 ㎜ water thickness from the second reference glass tube (at 25MHz transducer)

3.2 Bellows tubes

The bellows tube in the water tank was attached by a supporter at both sides. The dimensions of the bellows tube were each 250 ㎜, and 280 ㎜ in diameter and the thickness could be ignored because of a very thin thickness, when the measuring a water level is defined as 3.7 ㎜, 4.1 ㎜, 7.1 ㎜, 17.2 ㎜, 27.2 ㎜, 37.2 ㎜ and 48 ㎜ in thickness. The reference signals were obtained from the first reference glass tube and then we are able to obtain the water thickness signals from the second bellows tube. Figure 3(a) shows a signal for the 4.1 ㎜ water thickness measured from the bellows tube by the 15MHz transducer. Figure 3(b) shows a signal for the 4.1 ㎜ water thickness measured from the bellows tube by the 25MHz transducer..

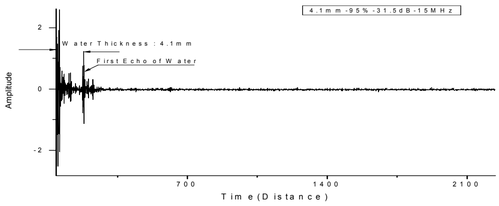

Fig. 3(a) Signal for the 4.1 ㎜ water thickness measured from the bellows tube. (at the 15MHz transducer)

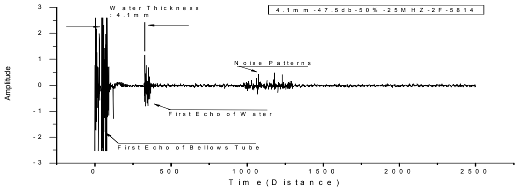

Fig. 3(b) Signal for the 4.1 ㎜ water thickness measured from the bellows tube. (at the 25MHz transducer)

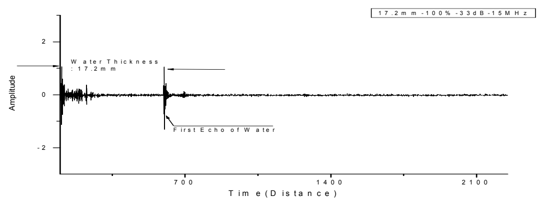

Fig. 4(a) Signal for the 17.2 ㎜ water thickness measured from the bellows tube. (at the 15MHz transducer)

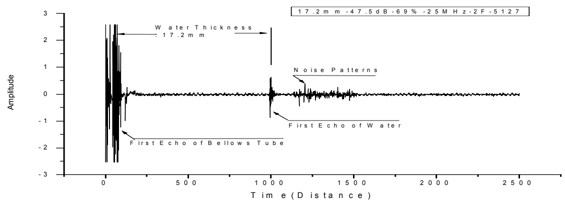

Fig. 4(b) Signal for the17.2 ㎜ water thickness measured from the bellows tube. (at the 25MHz transducer)

Figure 4(a) shows the measured signal from the bellows tube with a 17.2 ㎜ thickness by the 15MHz transducer. Fig. 4(b) shows a measured signal from the bellows tube with a 17.2 ㎜ thickness by the 25MHz transducer.

4. Conclusions

In order to obtain clean multiple echoes for a water thickness measurement, a focused immersion transducer should be operated at considerably shorter than the focal length of 1 inch. By using an immersion ultrasonic inspection, the developed system was aimed at measuring the water level in a bellows tube. In this experiment, as the procedure for the water level measurement, we obtained reference information from a reference glass tube. The dimensions of the first reference glass tube were 65.3 ㎜ in diameter and 0.4 ㎜ thick, when the water level was defined as a 47.9 ㎜ thickness with 15 MHz, and an 18 ㎜ thickness with 20 ㎒. The resulting signals were obtained from the first reference glass tube by using the Mode 1 method.

ACKNOWLEDGEMENT

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REFERENCES

[1] K. M. Koo, S.B. Kim, I. C. Im, C. M. Sim, Y. M. Jeong and C. S. Park, "*Water Thickness Gaging in a Bellows Tube using the Special UT Shoes & an Immersion Ultrasonic System*", Key Engineering Materials Vols. 321-323, pp. 468-471, (Aug. 2006).

[2] K. M. Koo, J. H. Kim, S.B. Kim, H. D. Kim, and D. Y. Ko, "*Ultrasonic Thermometry System for Measuring Very High Temperatures Using High Resolution Signal Processing*", Proceeding of the ICEIC 2000, pp. 229-232, (Aug. 2000).