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Reduction of false detection of multiple reflections caused by attached seashelles in ultrasonic non-contact thickness gauging

非接触式超音波肉厚測定における付着物による多重反射誤検出の低減

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1. Introduction

Thickness gauging of steel sheet piles used in harbor facilities is necessary to inspect performance degradation due to shape changes such as damage and deterioration[1]. Contact-type thickness gauging requires removal of deposits. This operation is very time consuming and has a problem of arising enormous costs for disposing of the removed deposits. Therefore, a non-contact ultrasonic thickness gauging instrument that can measure even in attached such seashells has been researched. However, when measuring the thickness of steel pipe piles with many deposits, multiple reflected waves may be erroneously detected due to the effects of deposits. In this study, an accurate multiple reflection detection method in the steel plate attached seashells are described. The proposal method is possible to reduce false detection of multiple reflections caused by attached seashelles in ultrasonic non-contact thickness gauging. By changing the detection range of multiple reflections and the plate thickness calculation method, false detection of non-contact thickness measurement attached seashells has been reduced.

2. Method

In previous study, the largest amplitude wave was decided reflection wave from surface of the steel plate[2]. The thickness of the steel plate was calculated from the time difference of multiple reflected waves. The estimated receive time of multiple reflection waves was calculated from the sound speed of the steel plate. **Figure 1** shows an example of a received waveform. The beginning of the detection range was a value obtained by subtracting the pulse width of the transmission signal from the multiple reflection theoretical value, and the end of the detection range was a multiple reflection theoretical value + 5%. The thickness of the steel plate is obtained by the time of flight method shown in Eq. (1).

$$D = \frac{1}{2i} \cdot c \cdot \Delta T_i \quad \cdots (1)$$

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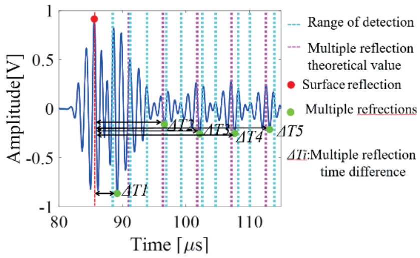


Fig. 1 Received waveform

D is the thickness of the steel sheet, c is the longitudinal sound velocity of the steel plate, ΔT_i is the time difference between the surface reflection wave and each multiple reflection wave, and i is number of multiple reflection wave.

3. Experimental setup

Figure 2 shows a schematic diagram of this experiment and a specimen of the steel plate with seashells in this experiment. The height of steel plate is 200 mm, width is 200 mm, and thickness is 16 mm. Oyster's shell covered the a half of the vertical area of the steel plate. The transmission signal is five wavelength of sinusoidal wave at 1 MHz. The reflected wave was received at $z = 0$ mm by scanning the transducer horizontally. The thickness of steel plate was measured at 201 points in 1 mm increments.

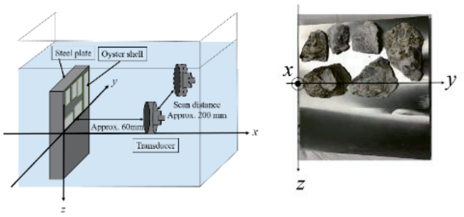


Fig. 2 Schematic diagram of this experiment and specimen.

4. Results

Figure 3 shows the received waveform by scanning the transducer horizontally. As shown in Fig. 3, the amplitude of surface reflection wave received at 80 to 90 μs is uniformly. It can be seen that the amplitude of the reflection from the surface and the reflection from the seashell is about the same.

Figure 4 shows the detection of multiple reflections at a thick shell. As can be seen from Fig. 4, the proposal method improved the multiple reflection detection accuracy for the 3rd, 6th and 7th waves even with the same waveform by changing the detection range. **Fig. 5 (a) and (b)** show the relative error of the measurement result. Since the first wave of multiple reflection is difficult to detect, the error is too large. It can be seen that the proposal method can detect multiple reflections after the 3th multiple reflection wave with an accuracy of within ± 5% even if attached seashells at steel plate. If the influence of the seashells is small, it can be said that multiple reflected third waves can be measured with high accuracy. However, proposal method has a problem that an error occurs in the plate thickness measurement result when the thickness of the steel plate is thinner than the original thickness due to deterioration. It cannot be detected correctly if the decrease of steel plate's thickness is 2 mm over. For the improvement of the proposal method accuracy, it is necessary to change the multiple reflection estimate value to a deteriorated thickness.

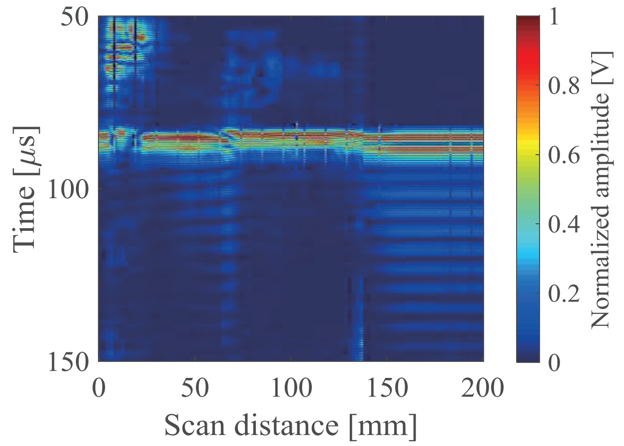
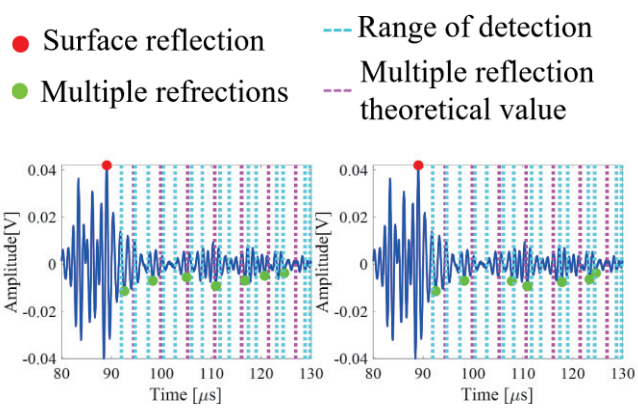
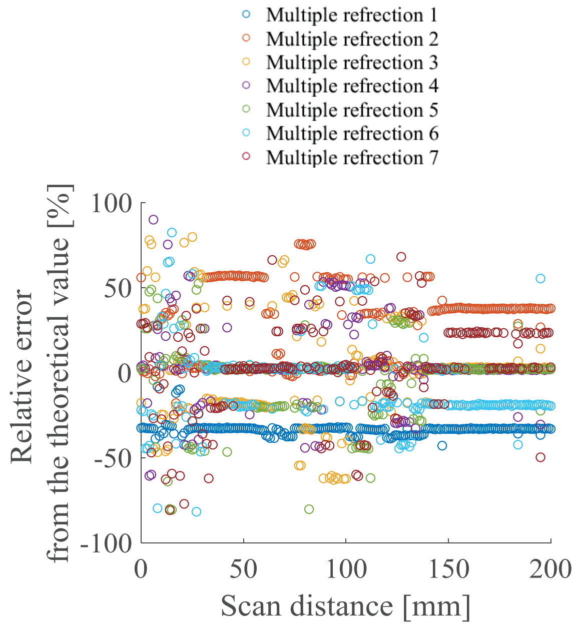


Fig. 3 Received waveform.

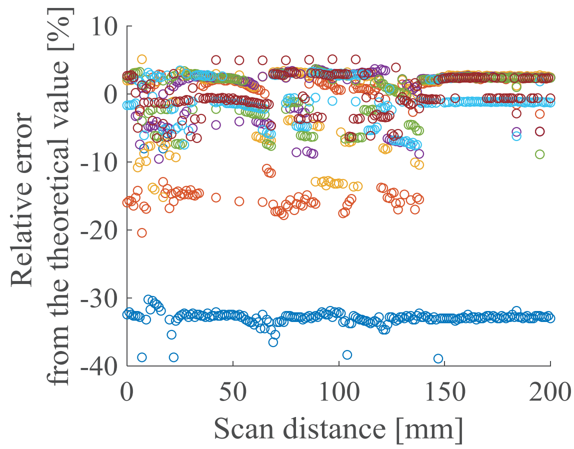


(a) proposed method (b) conventional method

Fig. 4 Multiple reflection detection points.



(a) conventional method



(b) proposal method

Fig. 5 Relative error from the theoretical value.

5. Conclusion

In the proposed method, the thickness of the steel plate attached seashells obtained from the 4th to 7th waves of multiple reflection can be obtained with high accuracy if the thickness of the deteriorated steel plate and the multiple reflection theoretical value are the same. In future research, we will investigate the improvement of plate thickness measurement accuracy when shells are attached in a denser state.

References

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