1P2-18

Proceedings of Symposium on Ultrasonic Electronics, Vol. 34 (2013) pp. 71-72
20-22 November, 2013

Reflection coefficients of the A_0- and S_0-mode Lamb waves at precisely fabricated 2 dimensional incremental defects
精密に形成した２次元漸増欠陥における A_0 及び S_0 モードラム波の反射係数

Hikaru Kaneshima[1‡], Yuta Watanabe[1], and Hideo Nishino[1]
([1]Institute of Technology and Science, The Univ. of Tokushima)
金島　光 [1‡], 渡邉雄太 [1], 西野秀郎 [1]([1] 徳島大・院)

1. Introduction

The Lamb wave inspection is one of the rapid and efficient techniques for defect detections in plates. Although it is very useful for estimating efficiently the defect locations, quantitative measurements of depth and/or shape of defects are relatively poor comparing to the conventional ultrasonic testing (UT). Several effective approaches [1,2] have been carried out to reveal the quantitative relation between reflection coefficient and shape of defects, however the reflection phenomena have not yet understood well.

In this paper, reflection coefficients of the A_0- and S_0-mode Lamb waves at several incremental defects that were created precisely by the milling machine were carefully measured. Reflection phenomena were also discussed comparing with a calculation model [3,4] which was defined as reflections depended on the difference of cross-sectional areas. It was confirmed previously that the model estimated excellently reflection coefficients of axisymmetric defects in a pipe [4].

2. Experiments

Figure 1 shows the experimental setup. Al (c_l = 6400 m/s, c_t = 3120 m/s) plates were prepared for the specimens. Two longitudinal wave transducers (f_c = 500 kHz) were used as the water-coupled transmitter and receiver, respectively. That is, each of the transducers was immersed in a water bath (c = 1500 m/s) and was set to be the critical angles for the S_0- and A_0-mode Lamb waves. The phase velocities and their critical angles of the S_0- and A_0-modes at 500 kHz for a plate (thickness = 2 mm) are theoretically 5250 and 2300 m/s, and 16.6˚ and 40.8˚, respectively. A 10-cycle tone burst was used as the signal source. Three types of incremental defects were prepared, as shown in **Fig. 2**. The depth of both the step-down and triangular defects were gradually increased up to 1 mm depth with 0.1 mm step. In the arc-shaped defect, the width was gradually increased during the experiment. The milling machine (Yamasaki Giken YZ-500WR) was used to create precisely the incremental defects.

----
e-mail address: kaneshima@me.tokushima-u.ac.jp

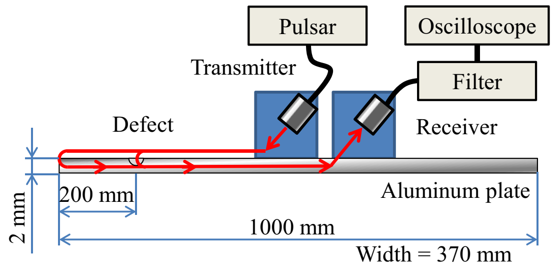
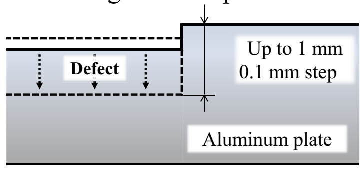
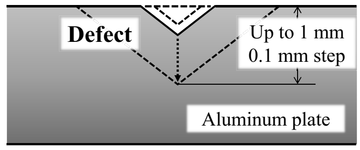


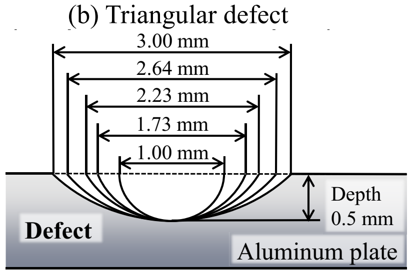
Fig. 1 Schematic diagram of experimental arrangement



(a) Step-down defect



(b) Triangular defect



(c) Arc-shaped defect

Fig. 2 Gradual increasing defects

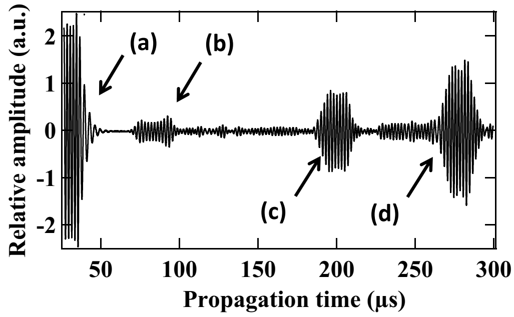


Fig. 3 Example of RF time domain signal

3. Result and Discussion

A typical RF time domain signal (the triangular defect with 0.8 mm in depth) was shown in **Fig. 3**. The wave packets (a), (b), (c), and (d) indicate the crosstalk of the input signal, the back propagating Lamb wave generated spuriously at the water bath of the transmitter, the defect signal, and the plate-end signal, respectively.

Figures 4, 5, and 6, respectively, shows the reflection coefficients of the step-down defect, triangular defect, and arc-shaped defect. The closed circles indicate the experimental results and the lines are the calculation results, respectively.

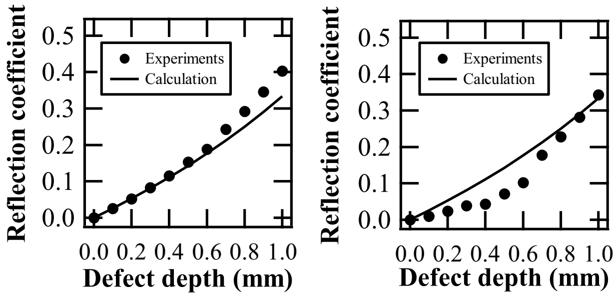
In the step-down defect, the experimental results of the S_0-mode were coincided excellently with the calculations and those of the A_0-mode were coincided well with the calculations. In the triangular defect, the experimental results of the S_0-mode were agreed well with the calculations; however, those of the A_0-mode were much different from the calculations. In the arc-shaped defect, similar results to the triangular defect were found, namely, the experimental reflection coefficients regarding the S_0-mode agreed fairly well with the calculations and those regarding A_0-mode were different from the calculations.

In all the experimental results regarding S_0-mode, the experimental results agreed fairly well with the calculations, but in those regarding the A_0-mode, they disagreed with the calculations except the step-down defects. The simple particle displacement of the S_0-mode (comparing to the A_0-mode) might be one of the main reasons of the phenomena. Conversely, the relatively complex particle displacements of the A_0-mode must be the main reason of the disagreement between the experiments and the calculation model. Anyway, it was confirmed that the S_0-mode together with the calculation model was fairly useful for the quantitative evaluation.

As shown in Fig. 5(b), the experimental reflection coefficients were not monotonically increased with an increase of the defect depth in the A_0-mode. Careful data handlings will be needed if the A_0-mode will be used in actual situations because plural defect depths take the same reflection coefficient. Almost same caution can be seen in the arc-shaped defect. That is, Fig. 6 shows that the reflection coefficient changes in spite of the same defect depth (1 mm).

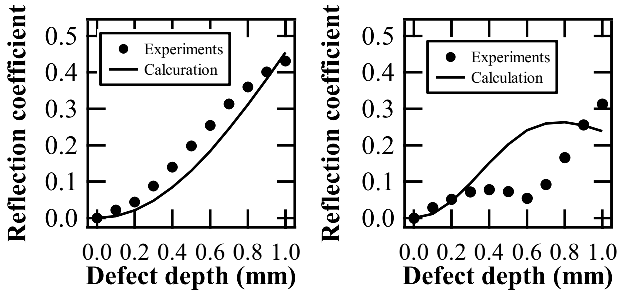
4. Conclusions

Reflection coefficients of the A_0- and S_0-mode Lamb waves at the several incremental defects created precisely by the milling machine were carefully measured. In all results regarding S_0-mode, the experimental results agreed fairly well with the calculations, but in those regarding the A_0-mode, they disagreed with the calculations. The S_0-mode together with the calculation model was fairly useful for the quantitative evaluation. It was shown that the particle displacements of the Lamb waves might be the main reason of the agreements and disagreements between the experiments and the calculation model. In the future work, quantitative evaluations as to whether the simpler particle displacement makes the better coincidence between the experiments and the model are going to be carried out.



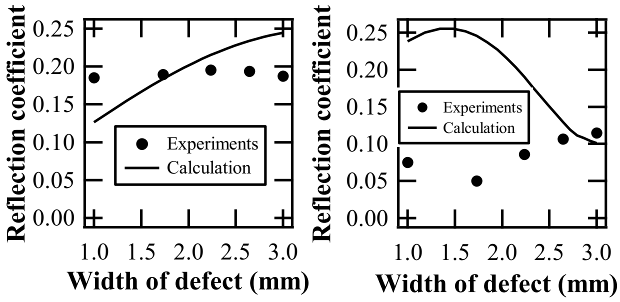
(a) S_0-mode (b) A_0-mode

Fig. 4 Reflection coefficients of Step-down defect



(a) S_0-mode (b) A_0-mode

Fig. 5 Reflection coefficients of Triangular defect



(a) S_0-mode (b) A_0-mode

Fig. 6 Reflection coefficients of Arc-shaped defect

Acknowledgment

This work was supported by the Research group (type II) of the Iron and Steel Institute of Japan. The authors thank the technical staffs for their kind instructions on the milling machine to create the incremental defects.

References

1. R. Carandente et al, JASA **127** (2010) 3440.
2. M.J.S. Lowe et al, JASA **12** (2002) 2612-2622.
3. Y. Nagashima et al, QNDE **28** (2009) 1583.
4. Seam Song et al, JSNDI UT Symp. (2012) 65-68.