1P2-26

Proceedings of Symposium on Ultrasonic Electronics, Vol. 34 (2013) pp. 87-88
20-22 November, 2013

Detection of Second Harmonic Ultrasonic Wave Generated from Weld Defect
溶接欠陥から発生する 2 次高調波超音波の検出

Tatsuya Sugiura[1‡], Makoto Fukuda[1], and Kazuhiko Imano[1] ([1]Graduate School of Engineering and Resource Science, Akita Univ.)
杉浦竜也 [1‡], 福田誠 [1], 今野和彦 [1] ([1]秋田大学　大学院工学資源学研究科)

1. Introduction

Welding has been widely used in construction or auto industry. If the weld defect including closed crack is exist in weld zone, it may be lead to destruction or breakdown. Therefore, the early detection of closed crack is being required.

Recently, nonlinear ultrasonic (second-harmonic or sub-harmonic) waves have been studied for detection of closed crack. Nonlinear ultrasonic waves are generated in nonlinear vibrations of closed crack, which is known as contact acoustic nonlinearity (CAN)[1,2]. As regards detection of weld defect using nonlinear ultrasonic wave, useful method used sub-harmonic components have been reported[3]. However, sub-harmonic components method is not easy, because generation of sub-harmonic components method need large power compared to that of second-harmonic components method. Lamb waves have been applied in the nondestructive evaluation fields[4]. Lamb waves are a kind of plate waves having smaller attenuation, and propagated long distance. Therefore, second-harmonic components of Lamb waves is being expented as a new method for detection of weld defect.

In this study, Lamb waves are transmitted into the carbon steel plate with weld defect, and second-harmonic components generated from closed cracks are detected.

2. Experimental method

The experimental set-up is shown schematically in Fig. 1. Transmitting signals were generated using an arbitrary function generator and their amplitudes were amplified up to 140 V_{p-p} with a bipolar amplifier. These signals were applied to the transmitter transducer. Ultrasonic burst pulses of 235 kHz were transmitted through the carbon steel plate via the polymer polystyrene wedge. The second-harmonic components of the Lamb waves were generated by nonlinear vibrations of the closed crack and were received by the receiver transducer. The resultant pulse were passed through

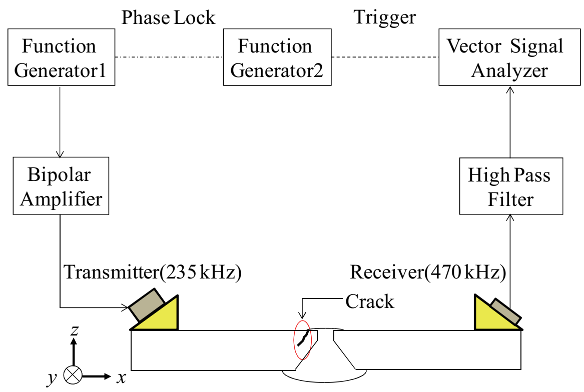


Fig. 1　Experimental set-up.

high pass filter (cut-off frequency f_c = 1.0 kHz). Finally the received pulse waveform and spectrum were captured by a vector signal analyzer, and the second-harmonic components could be observed in real time using FFT function of the vector signal analyzer. In this system, the pulse inversion averaging (PIA) method was applied to enhance the second-harmonic components. PIA method involves the time averaging of received wave to cancel out their fundamental and odd-components[5]. In this study, Lamb waves are transmitted along x-axis and y-axis, respectively.

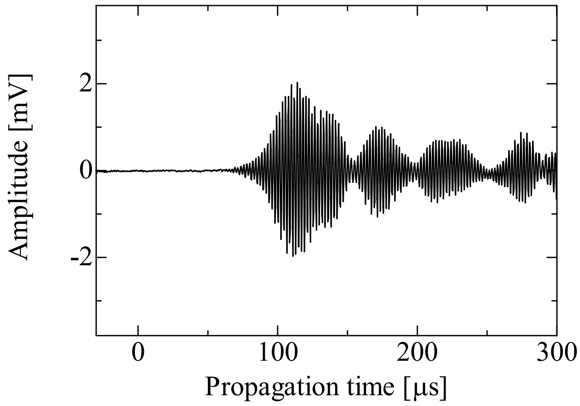
The carbon steel plate used in this study is a 100 × 200 mm standard test piece for the nondestructive evaluation (Sonaspection company, PL 18399).

3. Results and discussion

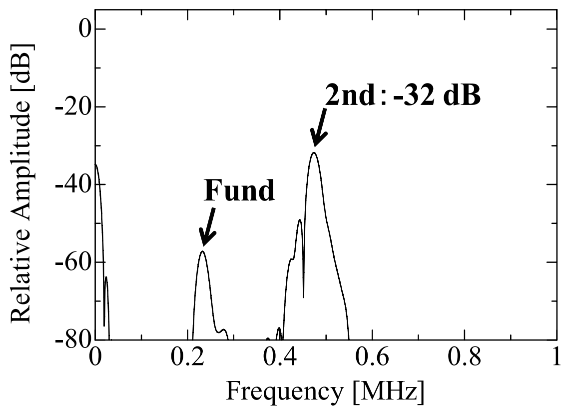
The received waveform and spectrum after PIA are shown in Figs. 2(a) and 2(b), respectively, where Lamb waves is propagated along the x-axis at the position of y = 20 mm. Figures 3(a) and 3(b) show detected second-harmonic components when transducers are moved at 20 mm intervals along x-axis and y-axis, respectively. Moreover, the distribution of second-harmonic components in the carbon steel plate is shown in Fig. 4.

In Figs. 3, second-harmonic components in x = 60 - 80 mm and y = 20 mm were increased compare with other measurement points. Closed crack is

----
imanoken@ee.akita-u.ac.jp

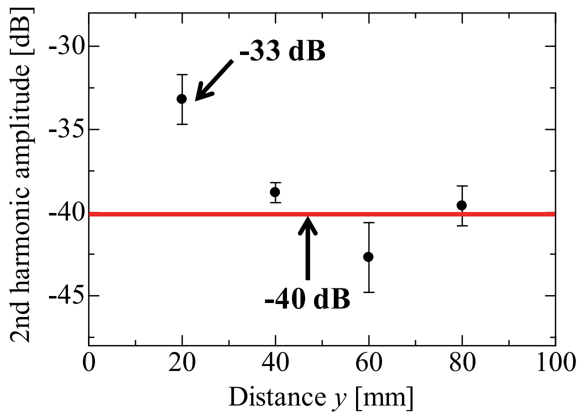


(a) Received waveform by the 470 kHz transducers

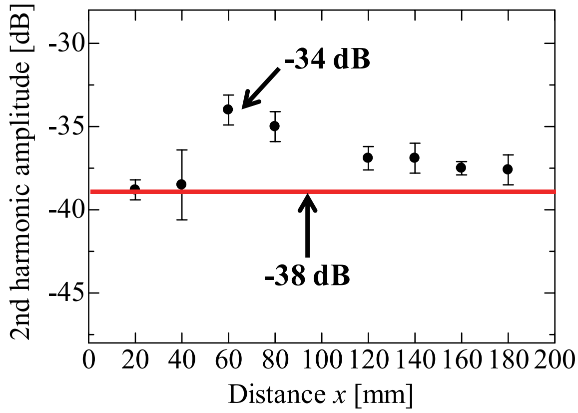


(b) Spectrum of waveform (a)

Fig. 2 An example of experimental.



(a) Propagation for x-axis direction



(b) Propagation for y-axis direction

Fig. 3 Second harmonic components distribution both x and y direction.

located in this area[6]. Therefore, increasing differences of second-harmonic components should be generated from the closed crack. As shown in Fig. 4, it is confirmed that closed crack exist in x = 60 - 80 mm and y = 20 mm. Therefore, the possibility for the detection of closed cracks in the weld defect, by our method was demonstrated.

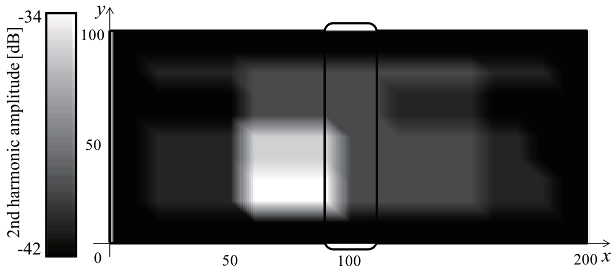


Fig. 4 Distribution of second-harmonic component.

4. Conclusions

Lamb waves were transmitted into the carbon steel plate with weld defect, and second-harmonic components generated from closed cracks were defected. Consequently, by existing of closed crack, in area x = 60 - 80 mm and y = 20 mm, which second-harmonic components were increased compare with other measurement area. Therefore, the possibility for the detection of closed cracks in the weld defect, by our method was demonstrated.

In the future, Lamb waves through the weld defect propagation will be analyzed to confirm our experiment.

References

1. I. Y. Solodov: Proc. IEEE Ultrasonic Symposium. (1994) 1279-1283.
2. K. Kawashima, R. Omote, T. Ito and H. Fujita:Ultrasonics, **48** (2002) 611-615
3. S. Horinouchi, M. Ikeuchi, Y.Shintaku, Y. Ohara and K. Ymanaka: Jpn. J. Appl. Phys **51** (2012) 07GB15-01-05.
4. M. Fukuda, M. Nishihira and K. Imano: Jpn. J. Appl. Phys. **51** (2012) 07GB06-01-05.
5. M. Fukuda, M. Nishihira and K. Imano: Jpn. J. Appl. Phys. **45** (2006) 4556-4559.
6. http://www.sonaspection.com/SonaCatalog.pdf