1P2-30

Proceedings of Symposium on Ultrasonic Electronics, Vol. 34 (2013) pp. 95-96
20-22 November, 2013

Detection of cracks using laser scanning PVDF transducer
レーザ走査型 PVDF トランスデューサを用いたクラックの検出

Kazuki Nakata[1†], Takaharu Kitamura[1], and Mami Matsukawa[1] ([1]Doshisha Univ.)
中田和樹 [1†]，北村暁晴 [1]，松川真美 [1] （[1] 同志社大　波動セ）

1. Introduction

Ultrasonic pulse techniques have been used to detect cracks. However, some cracks remain difficult to be detected because they are often closed at the tips. Recent interesting solutions to evaluate closed cracks in solid materials is the nonlinear techniques[1,2].

We have proposed a simple system for detecting crack tips, especially, the distribution of crack tips in a thin plate. In our former studies, we combined two techniques. One is a pulsed laser, which enables us to generate ultrasonic pulse waves by the thermoelastic effect. The other technique is a PZT transducer, viblating large amplitude and low frequency longitudinal ultrasound, or symmetric mode Lamb waves[3,4]. We have used a handmade hollow cylindrical PVDF transducer which enables transmission and reception of waves at one surface.

In this study, we introduce a laser scanning PVDF transducer. First, we discuss fundamental characteristic of this transducer. We have attempted to detect distribution of crack by focusing on the reflected wave from the crack by using two parallel sensors in the transducer.

2. Experiment

2.1 Sample

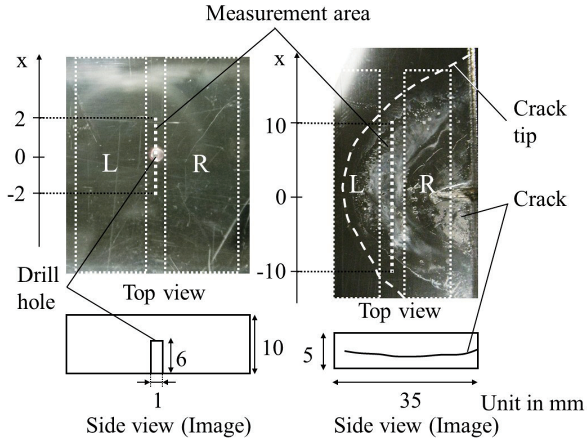
To check the crack positions by eye, we have used an acrylic resin sample. We have evaporated thin aluminum film on one surface of the acrylic plate sample to generate pulse ultrasound by the thermoelastic effect. **Figure 1** shows samples with a drill hole (sample A: **Fig. 1(a)**) or a plane crack (sample B: **Fig. 1(b)**).

2.2 Laser scanning PVDF transducer

Figure 2 shows a schematic view of self-made laser scanning PVDF transducer. This transducer is composed of two separate rectangle shape PVDF sensors (thickness 40 μm, Kureha) (left (L) and right (R)). The sensors were placed parallel and we introduced laser beam into the gap.

2.3 Experimental system

Nd-YLF pulse laser (R2-VS5-104Q, Spectra physics, wavelength 1047 nm, pulse energy 80 μJ, pulse width 5 ns, repetition time 1 ms) was irradiated to a sample surface through the gap of the PVDF sensors. Induced pulse ultrasound was generated at the surface by the thermoelastic effect. The induced pulse ultrasound propagated in the sample, and reflected at the reverse side or crack. The ultrasound received at the PVDF sensor was amplified (46 dB) and observed at an oscilloscope (54852A, Agilent). We scanned the pulse laser irradiation area with a step of 0.1 mm (**Fig. 1**).



(a) Sample A. (b) Sample B.

Fig. 1 Measured sample.

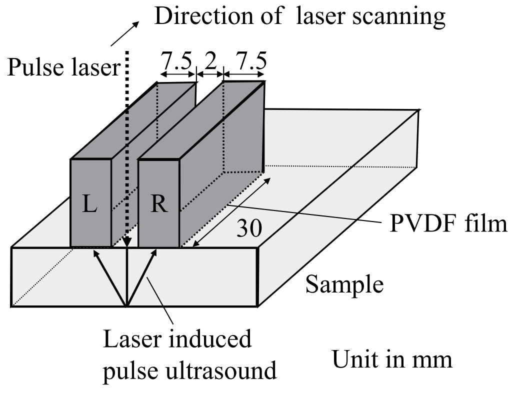


Fig. 2 Laser scanning PVDF transducer.

---

mmatsuka@mail.doshisha.ac.jp

3. Results and Discussion

Figure 3 shows waveforms obtained from sample A. The laser irradiated the sample surface on the drill hole (x=0). The waveforms around 0.2 μs show waves which propagated on the sample surface and were received at the PVDF sensors. In addition, we can see reflected waves from the drill hole (around 2.8 μs), and the reverse side (around 7.5 μs). This arrival time of reflected wave from the reverse side is comparable to the depth of 3.99 mm. At the L and R sensors, these waveforms were observed almost at the same time. **Figure 4** shows the arrival time of the reflected wave from the hole at L sensor. From x= -1 to 1, the arrival time was almost same in spite of diameter of drill hole was 1 mm. This indicates the large directivity of laser induced pulse ultrasound, which is around 20 degrees[5]. However, the amplitude of reflected wave from the drill hole showed maximum on the hole and decreased due to the distance from the hole as shown **Fig. 5**. From the amplitude and arrival time information, we can estimate the position of the small hole.

Next, to evaluate the plane crack in sample B, we have focused on arrival time of reflected waves from the crack. **Figure 6** shows estimated depth of the crack (**Fig. 6 (a)**) and amplitude variation of the reflected wave from the crack (**Fig. 6(b)**) observed at L and R sensors. Here, one should note the large directivity of the radiated ultrasound, however, the change of amplitudes may give us information of crack surface condition.

4. Conclusion

Using a laser scanning PVDF transducer, defects in the acrylic resin sample were evaluated. The structure of this transducer is very simple and convenient for the detection of defects from one surface of the sample. The introduction array sensors will give us more valuable data.

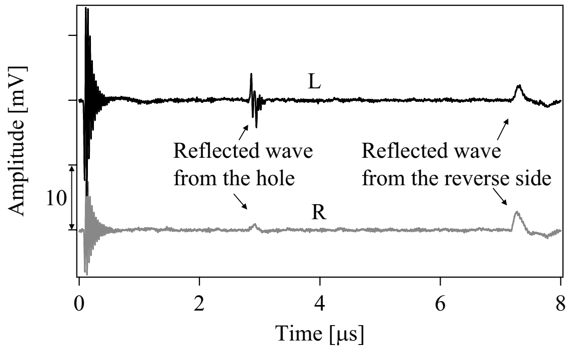


Fig. 3 Observed waveform on x=0 in sample A.

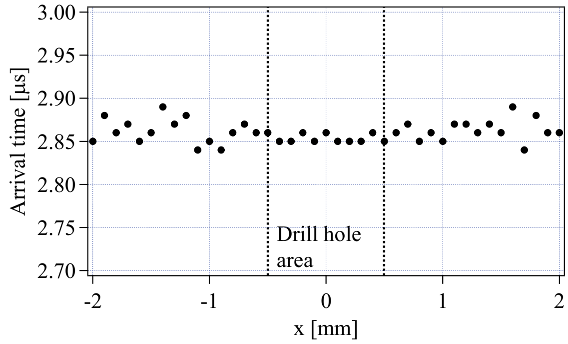


Fig. 4 Arrival time of reflected waves (L) from drill hole.

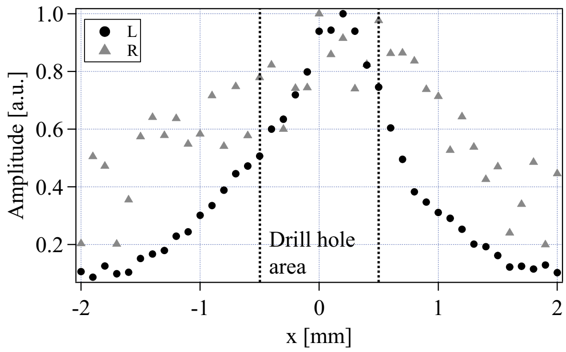


Fig. 5 Normalized amplitudes of reflected waves from the hole.

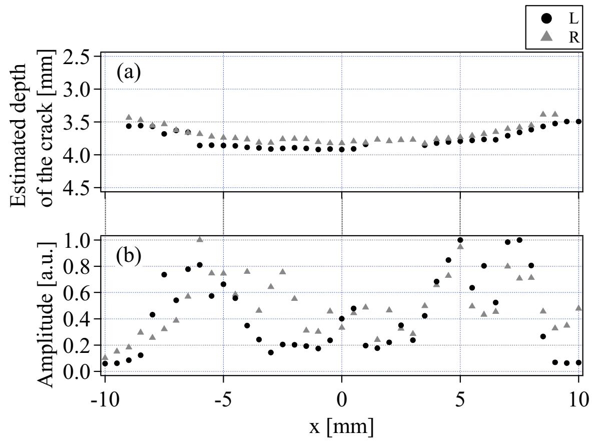


Fig. 6 Estimated depth of the crack (a) and normalized reflected wave amplitude (b) in sample B.

References

1. S. Horinouchi, M. Ikeuchi, Y. Shintaku, Y. Ohara, K. Yamanaka, J.J.A.P., 51 (2012)07GB15-1-5.
2. Y. Ohara, T. Mihara, R. Sasaki, T. Ogata, S. Yamamoto, Y. Kishimoto, K. Yamanaka, Appl. Phys. Lett.,90, (2007) 011902.
3. R. Nakase, K. Nakata, M. Matsukawa, J.J.A.P., **51** (2012) 07GB16.
4. A. Miyamoto, M. Matsukawa: Proc. 2009 IEEE Int. Ultrason. Symp. (2009) 2793.
5. C. B. Scruby, L. E. Drain: *Laser Ultrasonics*