1P2-4

Ultrasonic Visualisation by Simulator and Application for Array Probe
シミュレータによる超音波伝搬の可視化とアレイ探触子への応用

Yuusuke Tanaka[1†], Kazuyuki Kikuchi[1], Katsumi Ohira[1], and Yukio Ogura[1] ([1]Japan Probe Co., Ltd.)
田中雄介 [1†]，菊池和幸 [1]，大平克己 [1]，小倉幸夫 [1]([1]ジャパンプローブ株式会社)

1. Introduction

When ultrasonic propagates, reflects, refracts and longitudinal wave and shear wave are caused. Ultrasonic is invisible, so ultrasonic visualiser is needed in order to observe ultrasonic propagation. This device can not be used for opaque material such as steel. We have developed ultrasonic propagation simulator "SWAN21" with Finite Integration Technique: FIT, ultrasonic propagation was visualised[1]. Using this simulator, visualising ultrasonic propagation from a flaw was reported in non-destructive inspection[2]. And visualising puncture in medical ultrasonic was reported[3]. In this paper, visualising ultrasonic propagation is reported using simulator. Phased array in different materials and behaviour of the grating lobe were visualised.

2. Phased array

Phased array probe was simulated using the model of Fig. 1. Width of transducers was 0.9 mm, pitch was 1.0 mm, ten elements of an array probe were placed acrylic wedge with 20 degree angle. Wedge was placed on top of the steel, focal point of phased array was set near hall of steel. Each material constants shows table I. Probe was driven by 5 MHz.

Figure 2 shows the results of simulation. When ultrasonic entered steel from wedge, ultrasonic longitudinal wave and shear wave were separated. And longitudinal wave was focused to near hall of steel. Behaviour of phased array ultrasonic in different materials using simulator are obserbed, and it is useful for design of probe.

3. Grating lobe

Grating lobe of phased array scanning was visualised. In phased array scanning, condition of grating lobe arises informally when the pitch d of the probe satisfies

$$d < \frac{\lambda}{1+\sin\theta} \qquad (1).$$

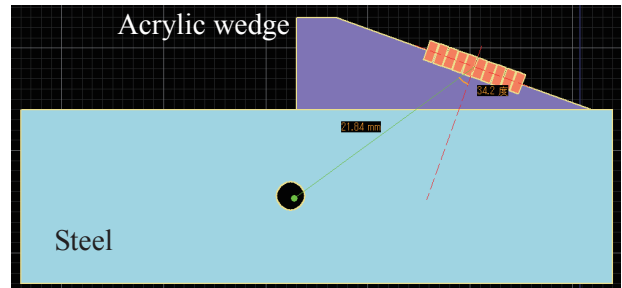λ is the wavelength, θ is scanning angle of phased

Fig.1 Phased array simulation model

Table I Material Constants

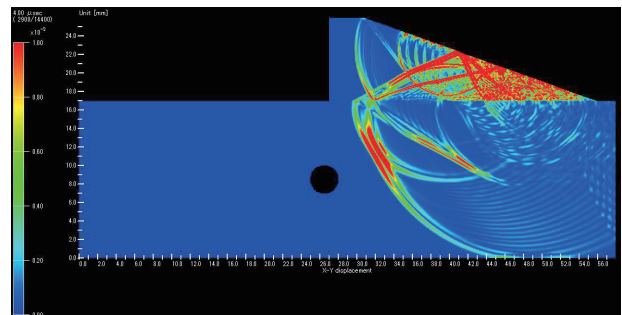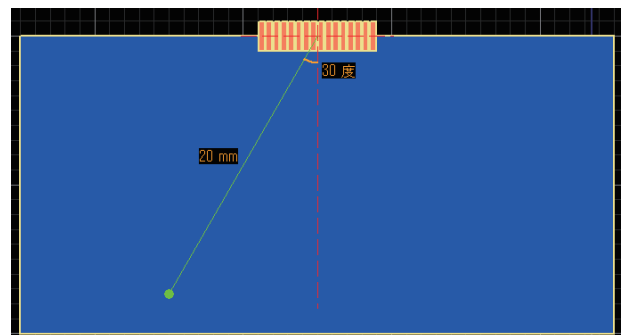|	Density[kg/m³]	Longitudinul wave velocity[m/s]	Shear wave velocity[m/s]
Acrylic resin	1200	2730	1460
Steel	7800	5920	3230

Fig.2 Result of simulation

Fig.3 Grating lobe simulation model

array probe. Figure 3 shows simulation model. Sixteen elements array probe with 0.4 mm width of elements, 0.5 mm pitch was placed on top of the water. Driving frequency was 5 MHz. Density and

---

yuusuke.tanaka@jp-probe.com

velocity of water was 1000 kg/m^3, 1500 m/s. Input signal was sin wave with 1 to 8 cycle waves. And inputting continuous wave was simulated. Scanning angle was set 30 degree in order to generate grating lobe. Figure 4 shows simulation results of continuous wave, figure 5 shows simulation results of 1 cycle wave. In both figures, ultrasonic wave was propagated to direction of A. In the case of continuous wave, grating lobe arise directions of B and C. Grating lobe intensity of direction of C was smaller than direction of B. Grating lobes of B or C in figure 4 were not generated on top of ultrasonic, these grating lobes generated after second waves. Therefore wave cycle was changed to 5 or 8, and ultrasonic propagation was simulated. Simulation results show Fig. 6 and Fig. 7.

When wave cycle was 5, grating lobe was generated direction to B in figure 6. Moreover, when wave cycle was 8, grating lobe that has same intensity of direction to A was generated. When wave cycle was 2 or 3, intensity of grating lobe of direction B was not so large.

Next, grating lobe of direction C was examined. Figure 8 shows what the wave cycle was 8, and the scale of intensity was changed in figure 7. Grating lobe arise direction C. In this case, when wave cycle was below 5, graging lobe hardly arises, intensity of grating lobe was smaller than grating lobe of direction B.

Therefore, grating lobe was generated by overlap after second wave and its earler wave. And intensity of grating lobe becames larger as wave cycle increases. Reducing wave cycle is effective in order to reduce intensity of grating lobe in phased array.

4. Conclusion

Phased array in different materials and grating lobe were visualised using ultrasonic propagation simulator. Grating lobe is generated by overlap after second wave and reducing wave cycle can reduce intensity of grating lobe were examined by simulator.

References
1. S. Mikami, Y. Tanaka, K. Ohira, Y. Ogura: Proc. 34th Symp., Ultrasonic Electronics, 9 (2013).
2. Y. Tanaka, K. Ohira, Y. Ogura: Proceedings of the 21th Symposium on Ultrasonic Testing, 89 (2014).
3. Y. Tanaka, K. Ohira, Y. Ogura, K. Tanaka, H. Shiomi, Y. Kurumi, T. Tani: Jpn. J. Appl. Phys. 53, 07KF26 (2014).
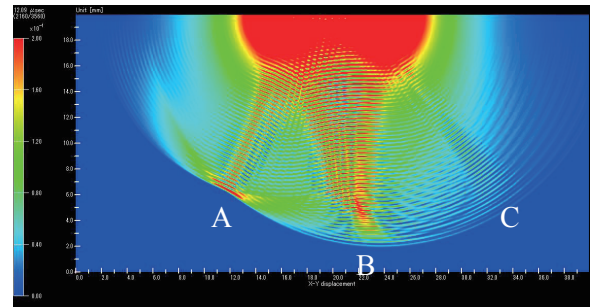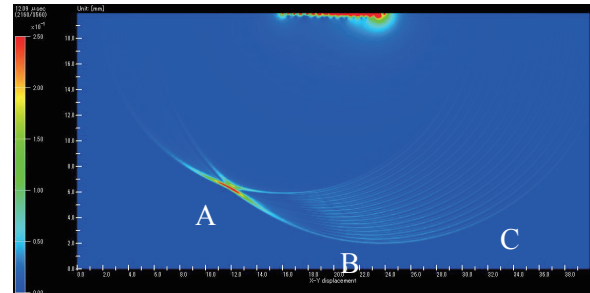
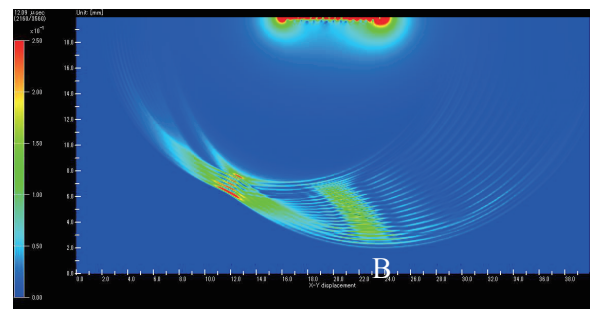Fig.4 Result of continuous wave

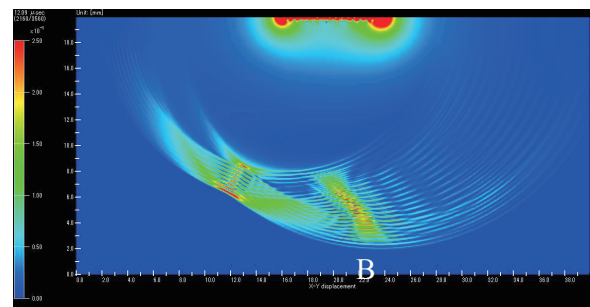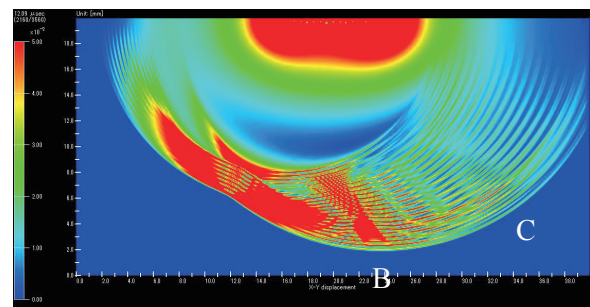Fig.5 Result of 1 cycle wave

Fig.6 Result of 5 cycle waves

Fig.7 Result of 8 cycle waves

Fig.8 Result of 8 cycle waves