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Development of Fousing Air Probes for High Sensitive Non Contact Air Coupled Ultrasonic Testing
高感度・非接触空中超音波検査用集束探触子の開発

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1. Introduction

We have developed non contact air coupled ultrasonic testing (here after called NAUT)using square burst waves[1]. This time we obtained high sensitive focusing air probes for NAUT. We experimented & calculated air probe's property such as sound field & beam width. We found that the very narrow sensitive beam was obtained by focusing probes, therefore the narrow beam made the clear & sharp image pattern. NAUT has many advantages such as no influence of coupling condition by conventional ultrasonic testing and the wave length in air is very short and suitable to make the desired beam [2]. We introduce focusing probe's property and its applications.

2. Sound Field by Focusing Probes

Kimura [3] reported a point focusing probe. We considered the sound field of point focusing probes in air. Fig.1 shows the calculated sound field and the directivity of 0.4K20N・R38.(normal frequency 400kHz, element size φ20mm, focusing distance 38mm). Fig.2 shows that of 0.8K20N・R20(normal frequency 800kHz, element size φ20mm, focusing distance 20mm). For 400kHz probe's beam width it is 1.92mm and 0.48mm for 800kHz probe at the focusing point. Fig.3 shows the measurement method and the result of measurement values for these two probes.

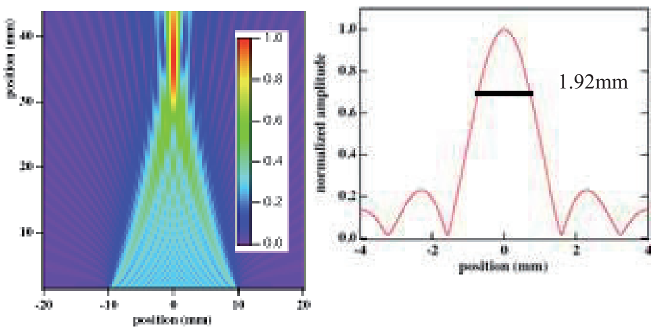


Fig.1 Calculated sound field & beam width for focusing air probe of 0.4K20N・R38.

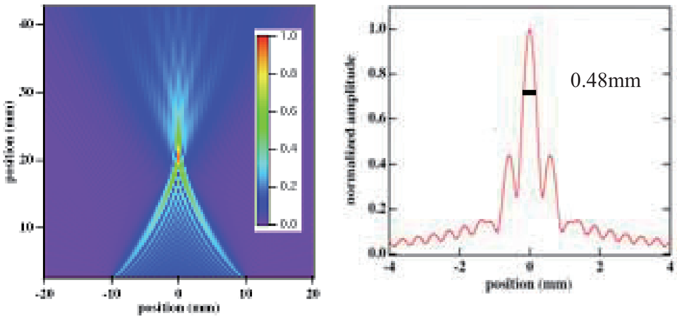
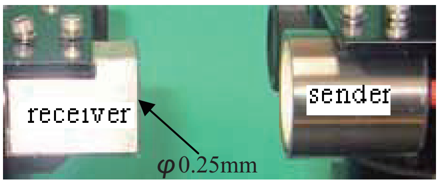
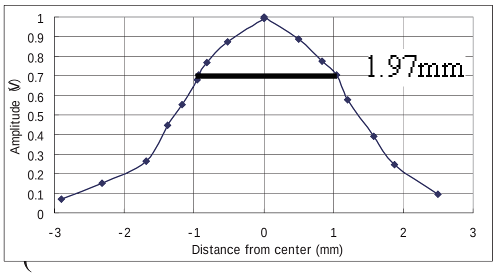


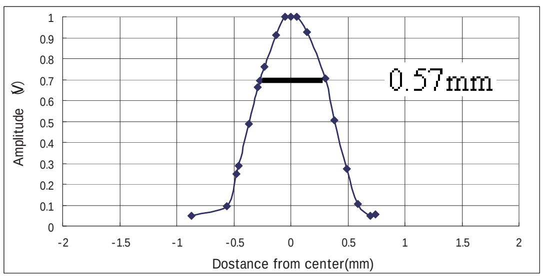
Fig.2 Calculated sound field & beam width for focusing air probe of 0.8K20N・R20



(a) Measurement method



b) Beam width of 400kHz's air probe



(c) Beam width of 800kHz's air probe

Fig.3 Measuring method of beam width & its value for focusing air probes

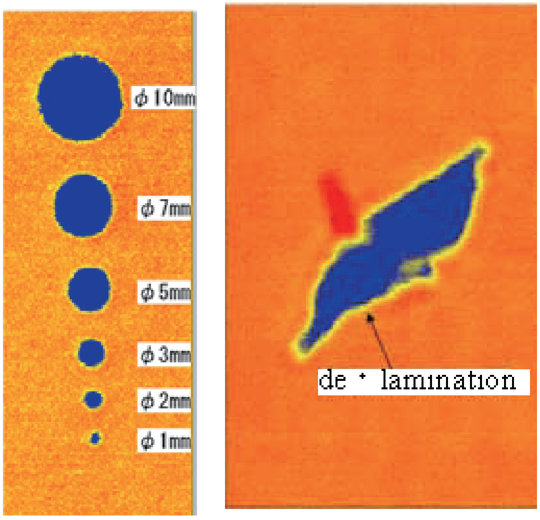
Fig.3(a) is a transmission method, the sender is a focusing probe, the receiver is a plane probe with the shadowing plate having φ0.25mm hole. We measured the receiving beam amplitude by moving receiver. For calculation of sound pleasure in Fig.1 &2, we used Rayleigh Integral of two dimensions. In focusing sound field, cylindrical plane waves emitted by minute area, each sound pleasure is summed up in considering phases & the element shape & surface. The calculation formula is shown in formula (1). ω, ρ, v_0, l, $H_0^{(2)}(kr)$ are angular frequency, density, particle velocity of element surface, position of element surface and second order Hankel function. Maximum value is normalized "1" in actual calculation.

$$p = \frac{\omega \rho v_0}{2} \int_l H_0^{(2)}(kr) dl \quad \text{-----------(1)}$$

The measurement value of the beam width(-3dB of one way, -6dB of echo height) by transmission method is 1.97mm for 400kHz's probe & 0.57mm for 800kHz's probe. The calculation value of Fig.1 &2 is 1.92mm for 400kHz & 0.48mm for 800kHz. Experimental value is in good agreement with calculation.

3. Application of Focusing probes.

Fig.4 shows the image pattern example of CFRP.



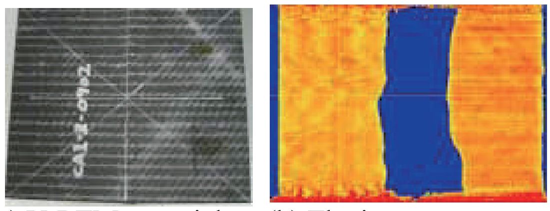
(a) Calibration of image pattern (b) De・lamination of image pattern

Fig.4 Image pattern of CFRP

Fig.4(a) is a calibration image pattern of acrylic disk fiber on CFRP specimen. φ1mm disk is enough clear by 800kHz's frequency. Fig.4(b) shows the de・lamination of CFRP and the boundary is very clear. Fig.5 shows the image pattern of 10mm thick CFRP produced by VaRTM

(Vacum assisted Resin Transfer Modeling).

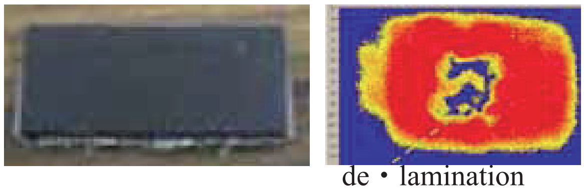
Even on 10mm thick VaRTM, the de・lamination is clearly detected.



(a) VaRTM material (b) The image pattern

Fig.5 The image pattern of 10mm thick CFRP

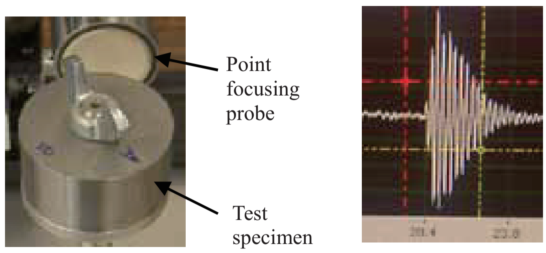
Fig.6 shows the image pattern of IC's chip and the de・lamination in center is observed



(a) IC's chip (b) Its image pattern

Fig.6 IC's chip & its image pattern

Fig.7 shows the example of surface opening defect detection by 1MHz's focusing probe. Its beam width is 0.4mm, and the beam hits the surface opening defect, the strong reflected echo is obtained from the defect.



(a) The testing method (b) Defect echo

Fig.7 The detecting method for surface defect

4. Conclusion

We have developed the focusing air probes for NAUT. Its property and applications are followings.

(1) Sound velocity in air is very low & the wave length becomes short, so it is easy to make the narrow sensitive beam for NAUT.

(2) The experimental beam width is in good agreement with the calculation.

(3) Very clear & sharp image pattern is obtained by using point focusing probes.

Reference

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