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Application of Acoustic Delay-Line Based on Wedge Waves.

Po-Hsien Tung[1], Wen-Chi Wang[2], Che-Hua Yang[3]
(Inst. of Mechanical and Electrical Engineering, National Taipei Univ. of Tech.)

Abstract

The two bottlenecks of traditional probe measurement, one is hard to avoid noise from coupling agent and the other one is raise spatial resolution by reducing contact area. This study is focused on wedge waves with applications in delay-line. Wedge waves are guided acoustic waves propagating along the tip of a wedge. Wedge waves has large motion amplitude at tip with small truncation, the wedge wave's velocity is fixed weather frequency varied and low energy attenuation. According the characteristic of wedge wave and vibration direction of particle, using ultrasound transducer and wedge to develop a new acoustic delay-line type with high signal-noise-ratio, approximate point-like contact area, without coupling agent and in/out-plane signal detection by different contact angle.

Keywords : wedge delay-line, contact angle, in/out-plane signal detection

1. Introduction

This study is focused on wedge waves with applications in delay-line. The wedge wave is discovered by Lagasse and coworkers, in the early 1970's through a numerical study, wedge waves are guided acoustic waves that propagate along the tip of a wedge, and their energy is tightly confined near the apex [1]. Like Lamb waves, wedge waves with displacement fields anti-symmetric about the mid-apex plane are called anti-symmetric flexural (ASF) modes. Fig. 1 shows typical motion pattern of an ASF mode Wedge waves are propagating along the tip of a wedge. Wedge waves has large motion amplitude and low energy attenuation when tip with small truncation

Ultrasonic inspection is a type of nondestructive testing commonly used to find flaws in materials and to measure the thickness of objects. The Early ultrasonic inspection mostly use piezoelectric probe to generate/receive signal. The difficulty of traditional probe measurement is hard to avoid noise from coupling agent and to raise spatial resolution by reducing contact area. Therefore, in 1990 some scholars start against the variety method to reach approximate point contact to generate/receive signal. In 1993, Hsieh and coworkers formed one-point hertz contact between the sphere and the spherical depression in a buffer rod with a transducer to measure material property and surface defect of spherical analyze [2]. In 1995, Degertekin and coworkers polish quartz rod into cone shape at one end, and the piezoelectric transducer is connected to quartz at the other side to receive signal [3]. This research introduces a new signal-detection method based on wedge delay-line.

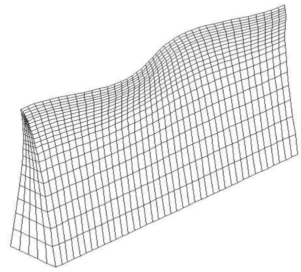

Fig. 1 Wave motion pattern of an ASF mode

2. Methodology

As shown in Fig.2, the experiment configuration consists of a 5MHz shear wave transducer and a wedge delay-line transducer for ultrasonic excitation and detection. The in/out-plane signal can be excited by rotating the generation source 90° about y axis. In this research, the wedge delay-line transducer is composed of a 2.25MHz shear piezoelectric transducer and an aluminum wedge with apex angle 70°. The truncation of wedge tip is controlled within 12μm to avoid dispersive. Also, the contact force between wedge delay-line and brass block is 5N by using force gage measuring. The signal is detected by oscilloscope with different contact angle (θ) between bisector of wedge's vertex angle and specimen surface.

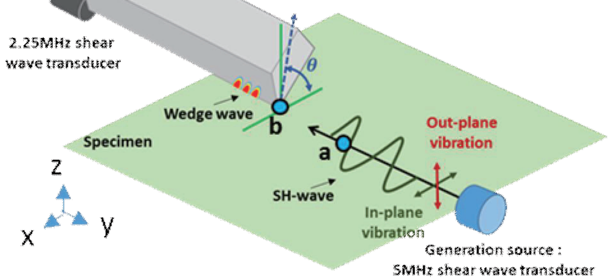

Fig. 2 The sketch is for wedge delay-line transducer

3. Results and Discussions

Fig. 3 shows the waveforms measured by wedge delay line transducer at different position A and B. The distance between point A and B is 20mm. The time of fight of A and B are 59.4μs and 69.5μs. Thus, the wave velocity can be calculated is 1981m/s. And the shear wave velocity of brass is 2030m/s. The in-plane shear wave signal can be captured by the equipment setup.

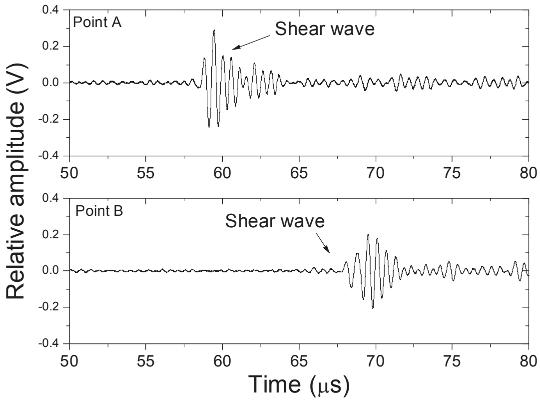

Fig. 3 TOF in different point

Fig. 4 and Fig.5 shows the waveforms of the in plane and out-plane signal measurement under contact angle start from 35° to 90° with an interval angle is 5°.

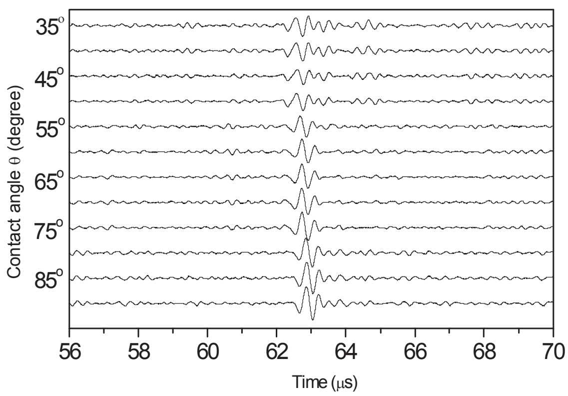

Fig. 4 In-plane signal at varied contact angle θ

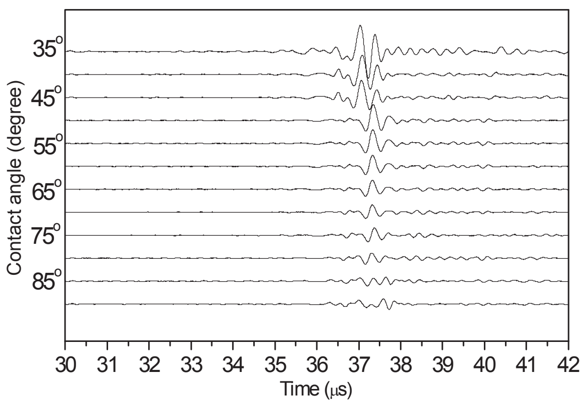

Fig. 5 Out-plane signal at varied contact angle θ

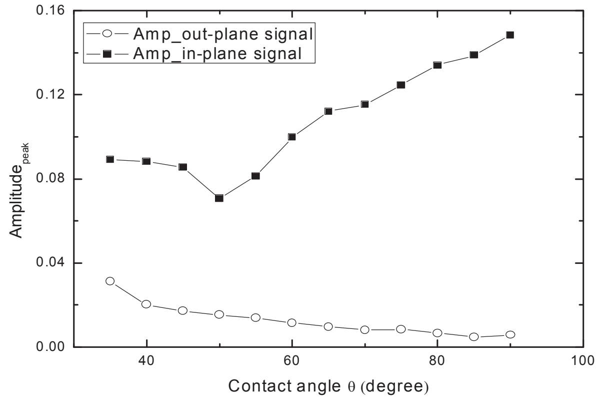

Fig. 6 Non-coated compare with coated

As shown in Fig. 6 is the contact angle (θ) corresponding peek of amplitude. The amplitude of in-plane shear wave is found to increase as the contact angle increases. The result shows when contact angle is approaching to 90°, the in-plane shear wave can be observed with better SNR.

For out-plane signal's measurement, the amplitude of out-plane signal is found to increase as the contact angle decreases. The result shows when smaller contact angle, the out-plane shear wave can be observed with better SNR. The feature can be regarded as the wedge delay-line with directivity by specific contact angle.

4. Conclusions

The wedge delay-line transducer are characterized experimentally. While the wedge delay line is in a configuration of contact angle near 90°, the detection for the in-plane shear wave is found to be very efficient. Advantages of wedge delay-line transducer include point-wise contact area, no coupling agent needed and directivity by specific contact angle. This research aims at the development of a new signal-detection method based on wedge delay-line.

Acknowledgment

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