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Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 321-322
6-8 December, 2010

Measurement and Modeling for the Dispersion Behaviors of Porous Plates.

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Abstract

This research is focused on the dispersion behaviors of porous plates. A theoretical model of porous plate is built in this study. The investigated samples are 316L stainless steel plate with different porosity. Dispersion relations of porous plate are measured by laser generation ultrasound and transducer detection. The results are found that theory model of porous plates agree with the measurement as well. Therefore, this method can be applied to porosity of non-destructive testing in the future.

Keywords：Laser ultrasonic excitation, porous plate, porosity, dispersion.

1. Introduction

Porous materials used in filtration systems and purification, separation. Porous materials are also used in drinking fountains inside the filter cartridge and filter system in the industrial sector. In fuel cells, porous structure is also used as a cathode or anode. However, as the filter will use as much as the use of porous material, time, subject to environmental impact and make rate increase or decrease the pore, thus losing the filtering effect.

Porous materials can be divided into two structures of open-cell and closed-cell [1]. The former like a sponge, appearance or internal are full of holes, and holes in between and connected to each other. The latter is the distribution of surface without holes. More general as a filtration system is the use of porous perforated material.

In this research, using laser excitation ultrasonic and received by transducer. Obtain the dispersion curves of porous plates and establish the theoretical models of porous plates. Observe the relations of the pore plates of the wave propagation behavior of the dispersion.

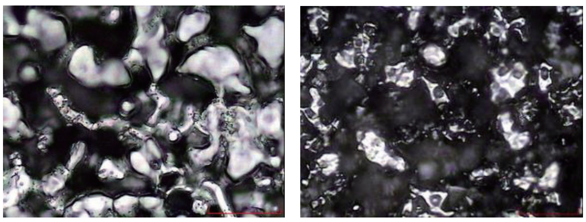
2. Theoretical model

The theoretical model has been derived from a 4 × 4 matrix by Boeckx published in 2005(1). To simulated the wave propagation under the pore of the porous plates. Operation the 4 × 4 matrix by LabView, then used Crawler to get the dispersion curves. The following formula is derived by the Boeckx mathematical model and the element parameters in accordance with its paper in 2005[2].

$$
\begin{vmatrix} -2jkp_1c_1 & -2jkp_1c_1 & (k^2+q^2)c_q & 0 \\ 2M_1s_1 & 2M_2s_2 & 0 & -2\phi P \\ 2N_1s_1 & 2N_2s_2 & j4N_skqs_q & -2(1-\phi)P \\ 2K_1c_1 & 2K_2c_2 & 2K_3c_q & 2\gamma e^{-\gamma H/2} \end{vmatrix}
\times \begin{vmatrix} -2jkp_1s_1 & -2jkp_1s_1 & (k^2+q^2)s_q & 0 \\ 2M_1c_1 & 2M_2c_2 & 0 & -2\phi P \\ 2N_1c_1 & 2N_2c_2 & j4N_skqc_q & -2(1-\phi)P \\ 2K_1s_1 & 2K_2s_2 & 2K_3s_q & 2\gamma e^{-\gamma H/2} \end{vmatrix} = 0 \qquad (1)
$$

3. Experimental Specimens

In this research, the investigated samples are 316L stainless steel plate with 19.1%, 27.1%, 37.4%, 39.2%, 42.1% and 46.5% porosity respectively. **Fig. 1** shows the micrograph of samples by optical microscopy.



(a) (b)

Fig. 1 Micrographs with (a)19.1% and (b)37.4% porosity.

4. Laser Ultrasonic Excitation

In this research, dispersion relations of porous plate are measured by laser generation ultrasound and transducer detection. As shown in **Fig. 2**, the experimental configuration consists of a pulsed laser for the generation of guided waves and a shear transducer for the detection. The excitation source is a Nd:YAG laser with a power of approximately 100 mJ, a 532 nm wavelength, and a pulse duration of 6.6 ns. The detection source is a shear transducer with 1MHz central frequency. Laser beam scans linearly on the plate by step motor combine with mirror set. A two-dimensional fast Fourier transform (2D-FFT), is used to obtain the dispersion relations.

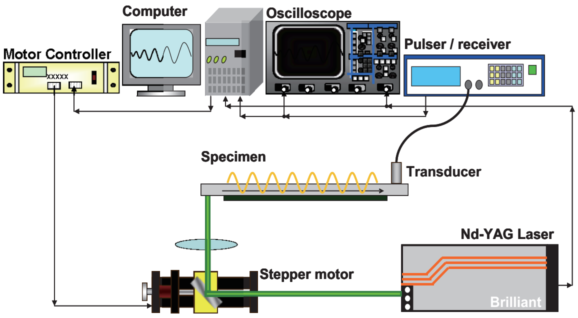


Fig. 2 Experimental configuration

5. Results and Discussions

Fig. 3 shows the theoretical and experimental dispersion curves of 19.1% porosity stainless steel plate. The measured dispersion relation of 19.1% porosity is agree with theoretical model as well. **Fig. 4** shows the theoretical and experimental dispersion curves of 37.4% porosity stainless steel plate. The measured dispersion relation of 37.4% porosity is also agree with theoretical model as well. **Fig. 5** shows the dispersion curves of A0 mode of Lamb waves with different porosity of stainless steel plate. As shown in **Fig. 5**, the phase velocity of A0 mode is found to decrease as the porosity of porous plate increasing. Because of high porosity of porous plate has low volume of plate and cause decreasing density of porous plate.

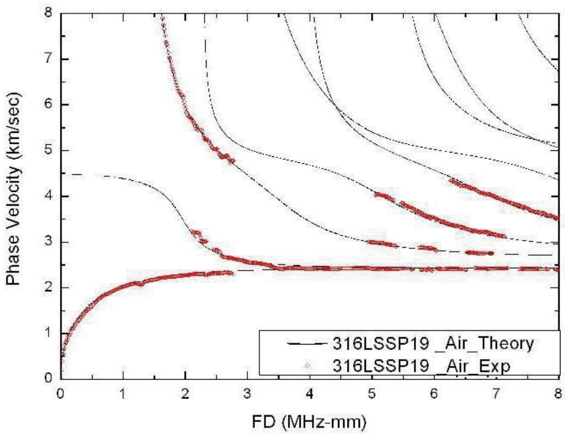


Fig. 3 Theoretical and experimental dispersion curves of 19.1% porosity

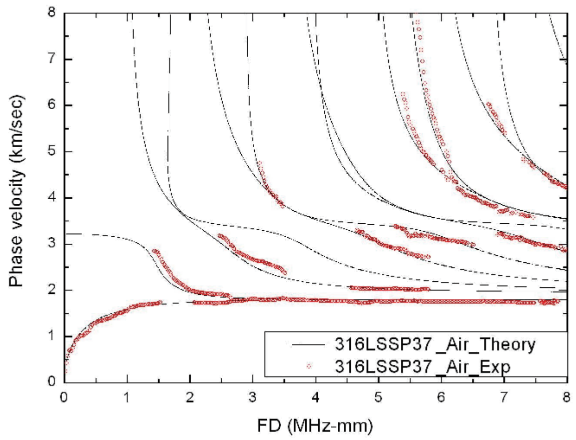


Fig. 4 Theoretical and experimental dispersion curves of 37.4% porosity

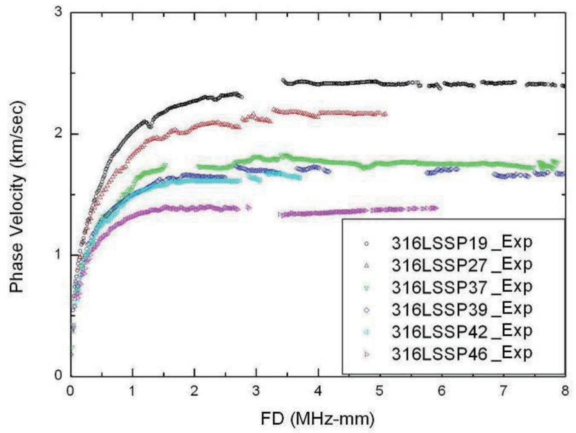


Fig. 5 Dispersion curve of A0 mode with different porosity samples

6. Conclusions

In this study, dispersions of guided waves propagating in porous plate are measured with a laser ultrasound excitation as well. The theoretical models are supported with the measurements. Because of high porosity of porous plate has low volume of plate and cause decreasing density of porous plate. The phase velocity of A0 mode is found to decrease as the porosity of porous plate increasing. This method is potentially useful to probe the porosity of porous plate in an nondestructive way.

References

1. M. A. Biot, J. Acoust, Vol. 28, No. 2, pp. 168-178, 1956.
2. Boeckx, P. Leclaire, P. Khurana, C. Glorieux, W. Lauriks, and J. F. Allard, J. Appl. Phys. 97, 094911, 2005.