Proceedings of Symposium on Ultrasonic Electronics, Vol. 32 (2011) pp. 509-510
8-10 November, 2011

Removal of Liquid in a Partially Bent Pore Using High-Intensity Aerial Ultrasonic Waves

強力空中超音波による曲がりのある細孔内に浸入した液体の除去

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1. Introduction

If an object is irradiated with ultrasonic waves, an acoustic radiation force is produced on the surface of it. We have considered the method of removing the liquid entered into a long pore using this phenomenon, that is, by irradiating the liquid with high-intensity aerial ultrasonic waves (at the frequency of 20 kHz)[1)-4)]. This report considers the experiments made on the method of removing the liquid entered into an L-type pore with open ends by irradiating the liquid with high-intensity aerial ultrasonic waves.

2. Experimental equipment

Figure 1 shows the schematic view of the experimental equipment used. A point-converging ultrasonic source equipped with a striped-mode vibrating plate[5)] (at the driving frequency of 19.7 kHz) was used to produce high-intensity aerial ultrasonic waves. This ultrasonic source radiated and converged ultrasonic waves into a circle cross-section of about 1cm at the point about 14cm distant from the opening of the ultrasonic source to produce ultrasonic waves having a high intensity of about 168dB at the supplied power of 50W. The samples used for experiments were L-type pores with open ends. The pores had the constant central axis of 20mm, and the linear sections of three acryl samples had different lengths from each other. **Table I** gives the detailed information on the samples. The cross-sections of the pores were square with 2mm sides. As the liquid in the pore, we used pure water, in which a trace of a white water paint was mixed to observe the liquid more easily.

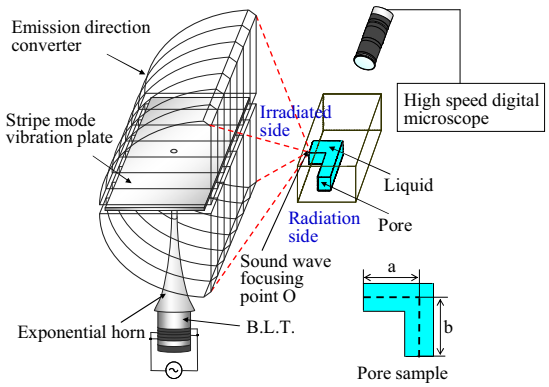
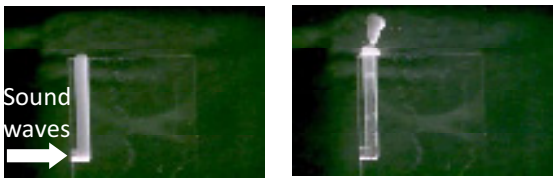


Fig. 1 Schematic of experiment

Table I Detailes of samples

Sample	I	II	III	IV
Length a [mm]	10	6	2	20
Length b [mm]	10	14	18	-

(a) Sample I



(b) Sample III

Fig. 2 Behavior of liquid irradiated with ultrasonic waves

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3. Effect of ultrasonic waves on removal of liquid from a pore

As shown in Fig. 1, the behavior of a liquid in the pore when the liquid was irradiated with the ultrasonic waves by making an opening (on the irradiated side of the sample) coincident with the convergent point of the ultrasonic waves was observed by using a digital microscope with a high-speed camera.

Figure 2 shows an example among the results of the observations. The left arrays as shown in Fig. 2 indicate how the liquid in the pore was slightly pushed out in a convex state from the pore opening irradiated with ultrasonic waves. The right arrays indicate how the almost all the liquid in the pore was pushed out of the pore.

For each sample, the required time to remove the liquid from the pore was determined by using the digital microscope. Here, the time required to remove the liquid from the pore is defined as the time between when the irradiation of the ultrasonic waves starts and when almost all the liquid in the pore is removed from the pore. **Figure 3** shows the relationship between the electric power supplied to the ultrasonic source and the liquid removal time. For each sample, the liquid removal time was shorter as the supplied power was increased. The L-type samples I and II and the linear sample IV presented similar characteristics. For the sample III, however, the liquid removal time was obviously longer than those for the others. The reason can be considered as that the sound field formed in the sample III was different from others.

We considered the relationship between the electric power supplied to the ultrasonic source and the liquid removing rate. **Figure 4** shows the results. For each sample, the liquid removing rate was calculated from the measured weights of the entered liquid before and after the irradiation of the liquid with ultrasonic waves. There were slight differences in the liquid removing rates for each sample. For the samples I and III, the liquid removing rates were about 97% at the supplied power of 50W (with the radiated ultrasonic waves of about 168dB). For the samples II and IV, the liquid removing rates were about 95%.

4. Conclusion

We made experiments to remove the liquid entered into the L-type pores with open ends by irradiating them with high-intensity aerial ultrasonic waves (at the frequency of about 20 kHz). As a result, it was found that removal of the liquid was possible. It was also observed that the liquid removing rate was at least 95%, and that the liquid removal time was as short as about 120 to 180 ms.

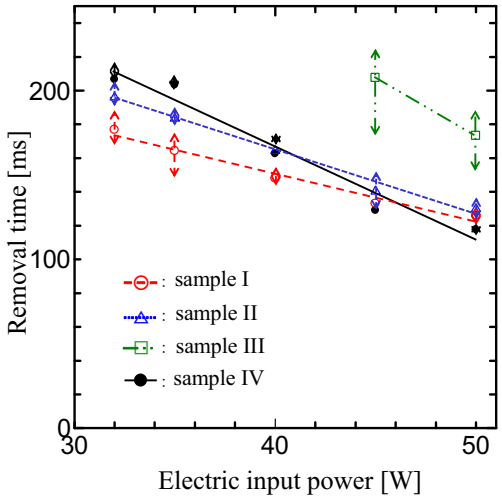

Fig. 3 Relationship between time required to remove liquid and electric input power

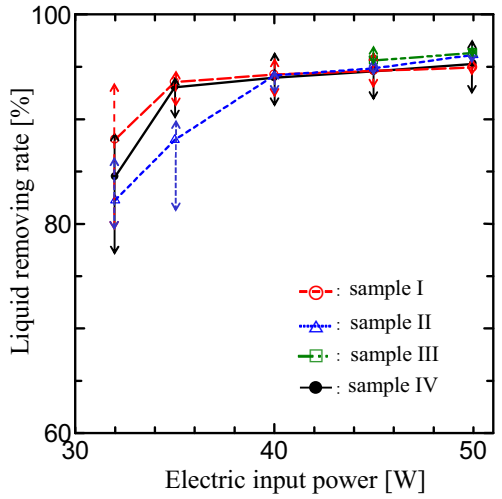

Fig. 4 Relationship between liquid removing rate and electric input power

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