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Removal of the Liquid in a Small Hole with Opened at Both Ends by High-Intensity Aerial Ultrasonic Waves

強力空中超音波による両端開放の細孔内に浸入した液体の除去

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1. Introduction

We had already verified that the liwuid which entered in a slit or any other elongated groove could be insatantaneously removed by irradiating it with a high-intensity aerial ultrasonic waves (at the frequency of 20 kHz)[1)-3)]. Here, the liquid which entered in an elongated hole with open ends was experimantally removed instantneously by using high-intensity aerial ultrasonic waves. By observing the detailed behavior of the liquid irradiated with the ultrasonic wave,we revealed the relationships between the intensity of the ultrasonic wave and the required time for removing effects of the ultrasonic wave.

2. Experimental equipment

Figure 1 shows the schematic view of the experimental device that we used. A point-converging ultrasonic source of stripe mode vibrating plate type[4)] (at the frequency of 20 kHz) was used to generate high-intensity aerial ultrasonic wave. The ultrasonic wave radiated by this ultrasonic source were converged on the circular section of 10mm in diameter which was placed 140mm distant from the opening of the ultrasonic source, and the source thus provided the high-intensity ultrasonic waves of about 5000 Pa at the supplied power of 50 W (in free field) .

In our experiments, we used cylindrical holes with open ends formed in acryl materials to introduce a liquid into them. The holes were 5 to 20 mm in length and 2 mm and 5 mm in diameter. As the liquid to be introduced in the holes, we used the pure water which was mixed with a very small amount of white watercolors so that the liquid could be easily observed. The behavior of the liquid entered in each hole during when it was irradiated with an aerial ultrasonic wave was observed in detail using a digital microscope with high-speed camera.

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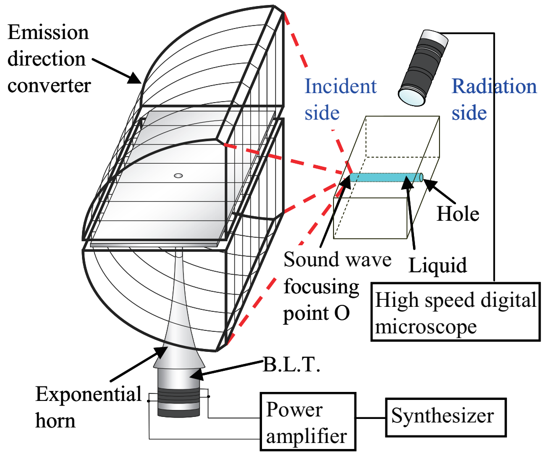

Fig. 1 Schematic of experiment

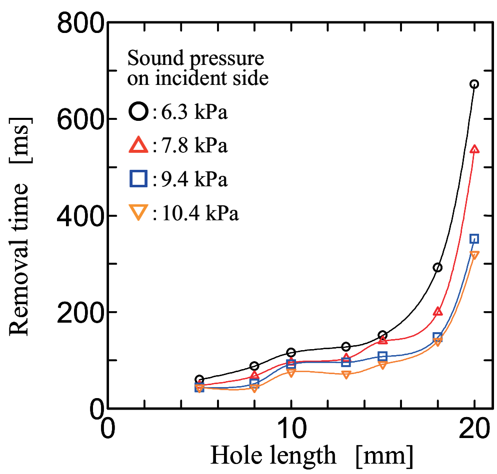

Fig. 2 Relation between hole length and required time of liquid removal

3. Measurement of the required time for removing the liquid

As shown in Fig. 1, the ultrasonic wave focusing point was aligned with the opening (on the irradiation side) of each hole with a diameter of 5 mm and length of 5 to 20 mm, and the time length from when the liquid was started to be irradiated with the ultrasonic wave (0 s) to when the liquid in each hole was removed was measured using the microscope with high speed camera.

Figure 2 shows the measured time lengths required to remove the liquid in each hole at the sound pressures of 6.3 to 10.4 kPa (at the supplied electric powers of 20 to 50W) acting on the liquid surface irradiated with the ultrasonic wave. As the hole was greater in length, the required time for removing the liquid was longer. For the hole with a length of around 20 mm, particularly, the required time for removing the liquid rapidly increased. **Figure 3** shows the relationship between the sound pressure of the ultrasonic wave and the required time for removing the liquid in a hole. The required time for removing the liquid decreased as the sound pressure of the ultrasonic wave increased, whatever was the length of the hole. The gradient was the power of -1, approximately.

4. Rate of liquid removal

For holes having different lengths, we measured the liquid removing effects of the ultrasonic wave on the liquid. The intensities of the ultrasonic wave emitted on the liquid surface were 6.3 to 10.4 kPa. The rate of liquid removal was determined by comparing the weight of the liquid before and after the irradiation. **Figure 4** shows the relationship between the length of the hole and the rate of liquid removal. The figure indicates that the liquid removal rates were 97 % to 99 % for all the holes at the electric power of 50 W supplied to the ultrasound source. It also reveals that the rate of liquid removal depended on the length of the hole, even if the intensity of the emitted ultrasonic wave was the same. Especially, the rate of liquid removal was low for the hole with a length of 8 mm. This was considered to be due largely to the standing ultrasonic wave field which was formed in the hole after the certain amount of liquid had been removed.

5. Conclusion

We examined the method of removing the liquid having entered in an elongated hole by using a high-intensity aerial ultrasonic wave (at the frequency of 20 kHz and the sound pressures of 6.4 to 10.4 kPa). As a result, we determined the required liquid removal time and the liquid removing effect of the ultrasonic wave emitted on the liquid in relation to the sizes (length and diameter) of the holes and the intensity of the ultrasonic wave. We also tried to remove the liquid having entered in the pore with a diameter of 2 mm. As a result, it was confirmed that the liquid was removed immediately after when it was irradiated with the ultrasonic wave. The required times for the pores with a diameter of 2 mm were almost the same as the ones for the pores with a diameter of 5 mm. The behavior of the liquid entered in each hole during when it was irradiated with an aerial ultrasonic wave was observed in detail using a digital microscope with high-speed camera.

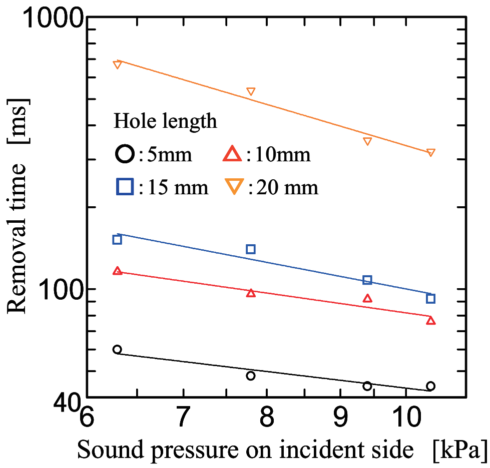

Fig.3 Relation between sound pressure on incident side and required time of liquid removal

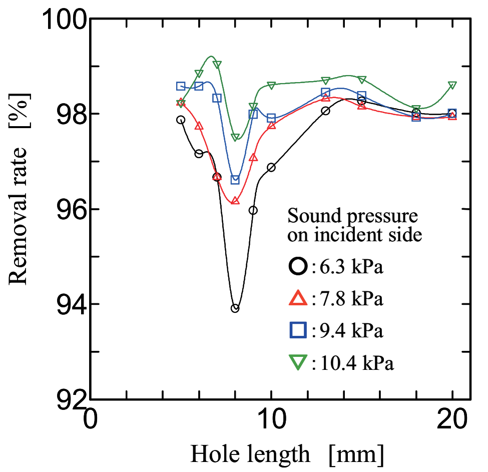

Fig.4 Relation between hole length and rate of liquid removal

References

1. Y. Ito and M. Kotani: Jpn. J. Appl. Phys. **43** (2004) 2840.
2. Y. Takeda and Y. Ito: Proc. National Spring Meet. J. Acoust. Soc. Jpn (1999) 873. [in Japanese]
3. M. Itabashi and Y. Ito: Proc. Symp. Ultrason. Electron. **26** (2005) 117. [in Japanese]
4. Y. Ito: J. Acoust. Soc. Jpn. **46** (1990) 383. [in Japanese]