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Exfoliation and Guidance of Adhered Fine Particles Using High-Intensity Aerial Ultrasonic Waves with Narrow Pipe

細いパイプを併用した強力空中超音波照射による付着微粒子の剥離と誘導

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1. Introduction

We had already verified that the fine particles which adhered to the surface of an object instantaneously were peeled off from the surface of the object and scattered in the air, by irradiating high-intensity aerial ultrasonic waves (at a frequency of approximately 20 kHz).

In the previous study, we examined a method which removes fine particles by irradiating high-intensity aerial converging ultrasonic waves directly[1)]. As a result, the fine particles irradiated the ultrasonic waves dispersed into a random direction. Thus, we have proposed a new method to capture fine particles by controlling the direction of the scattering the particles by irradiating high-intensity aerial converging ultrasonic waves through a narrow pipe. In this report, we examined the behavior of the fine particles upon carrying out guidance and control of fine particles scattered by using two types of pipes.

2. Experimental setup and method

Figure 1 shows a schematic view of the equipment used in our experiment. The equipment consists of an ultrasonic source for producing high-intensity aerial ultrasonic waves, a pipe (Pipe1) for propagating the ultrasonic waves, a pipe (Pipe2) for guiding fine particles, and a digital microscope with high-speed camera. A point-converging ultrasonic source with a stripe-mode vibrating plate[2)] (frequency of 19.6 kHz) is used to generate high-intensity aerial ultrasonic waves.

Fig. 1(b) shows a schematic view of the method to carry out guidance and control of fine particles scattered by using two types of pipes. As shown Fig. 1, this device guided the fine particles into the direction of arrow marks in the figure by using Pipe1 and Pipe2. In experimental device, opening end of narrow pipe (inside diameter: 4 mm) was set to coincide with sound wave converged point, and ultrasonic waves were incident in the pipe. Near the other end of pipe, a glass plate coated with fine particles was equipped. The fine particles used in the experiment is the Al_2O_3 particles having an average diameter of 14 μm. The ultrasonic waves passed through the pipe

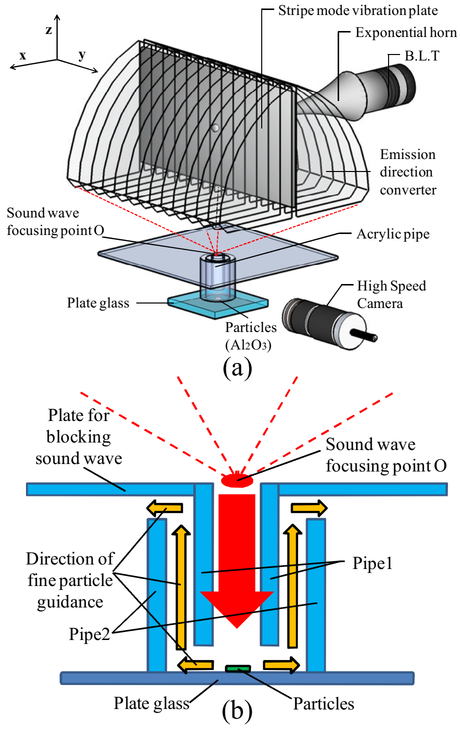

Fig. 1 Schematic of experiment device.

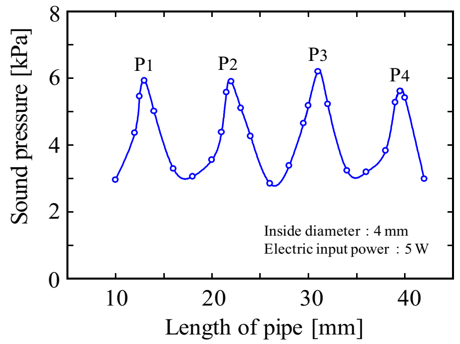

Fig. 2 Relationship between sound pressure on the surface of plate and length of pipe.

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were irradiated to the fine particles on the glass plate. Pipe2 (inside diameter: 12 mm) was set on the glass plate, as shown Fig. 1(b). By using the experimental apparatus, we examined the effect of removing fine particles by irradiating ultrasonic waves. In addition, the behavior of the fine particles irradiated ultrasonic waves was observed in detail using a digital microscope with high-speed camera. The sound pressure distribution on the glass surface was measured when the distance of between the glass surface and the open end of the pipe was 1.0 mm.

Figure 2 shows the measurement result. As a result, the sound pressure varies as the length of the pipe, the period is equal to the length of 1/2 of the acoustic wavelength.

3. Behavior of fine particles

3.1 Behavior of fine particles irradiated by ultrasonic waves

Figure 3 shows one example of the results obtained by observing the behavior of fine particles by using a digital microscope with a high-speed camera, when the fine particles were irradiated ultrasonic waves directly. As shown the figure, particles rose up into vertical direction immediately after ultrasonic irradiation and dispersed widely into the random direction.

Figure 4 shows one example of the results obtained by observing the behavior of fine particles by using the digital microscope with a high-speed camera, when the fine particles were irradiated ultrasonic waves with Pipe1. The length of the pipe used in the experiment is equivalent to P4 in Fig. 2, the length is 39.5 mm. In Fig. 4(a), the particles rose up into vertical direction immediately after ultrasonic irradiation, and in Fig. 4(b), particles moved radially from between opening end of pipe and glass plate.

3.2 Behavior of fine particles irradiated by ultrasonic waves (with Pipe1 and Pipe2)

Figure 5 shows one example of the results obtained by observing the behavior of fine particles by using the digital microscope with a high-speed camera, when the fine particles were irradiated ultrasonic waves by using Pipe1 and Pipe2. In Fig. 5(a), particles rose up into vertical direction immediately after ultrasonic irradiation, and in Fig. 5(b), particles moved radially from between opening end of pipe and glass plate, and then moved to the direction of arrow marks.

4. Conclusion

We examined a method to control and trap fine particles by irradiating high-intensity aerial converging ultrasonic waves with a narrow pipe.

As a result, it was shown that it is possible to use the method described above, to move the dispersed particles in the guiding direction by using this method.

Therefore, it is possible to control and trap the dispersed fine particles by the method.

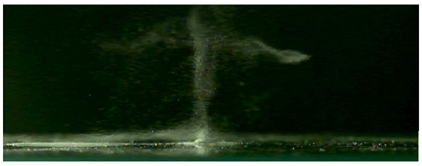
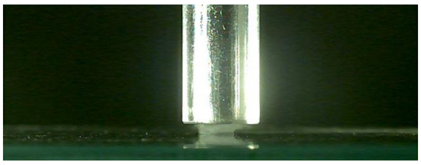
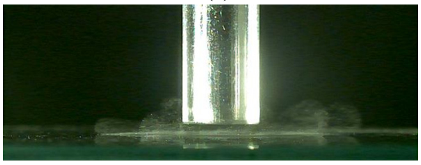


Fig. 3 Behavior of fine particles irradiated by ultrasonic waves (without pipe).

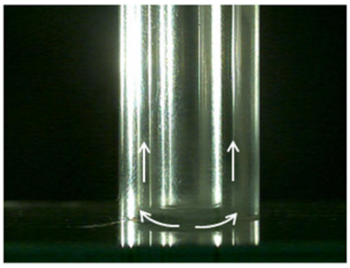


(a)

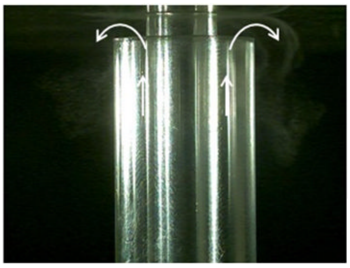


(b)

Fig. 4 Behavior of fine particles irradiated by ultrasonic waves (with pipe).



(a)



(b)

Fig. 5 Behavior of fine particles irradiated by ultrasonic waves (with Pipe1 and Pipe2).

References

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