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Ultrasonic atomization using circular vibrating plate with a small gap

微小間隙を持つ円形たわみ振動板を用いた超音波霧化法の基礎検討

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1. Introduction

Atomization of liquids is crucial in a wide range of applications such as applying fertilizer and coatings, spray drying food, humidification, insecticide sprays, and kerosene fan heaters [1]. Ultrasonic atomization is used industrially in droplet separation and concentration. This method has the advantage of greatly reducing energy consumption compared with distillation.

In this study, we develop a device to improve atomization efficiency, and investigate a new ultrasonic atomization method. In this method, water is atomized through a small gap [2] created by the difference in the vibration of a circular vibrating plate with a hole and a vibrating uniform rod. In this work, we observe the atomization and the size of the atomized particles.

2. Ultrasonic sound source

Figure 1 shows a schematic of the ultrasonic sound source. The ultrasonic vibration source consists of a vibrating uniform rod (duralumin, length 155 mm, diameter 55 mm) connected to a 20 kHz bolt-clamped Langevin transducer. A circular vibrating plate with a hollow (duralumin, diameter 55 mm) is attached to the tip of the uniform rod. **Figure 2** shows a sectional view of the plate and the rod. The plate consists of a ring (thickness 4.8 mm, width 3 mm) and the part for transmitting the vibrations (diameter 10 mm, thickness 5 mm). A gap is formed between the ring and the uniform rod that atomizes the water.The vibrating plate also contains a reservoir (thickness 2 mm). The hole (diameter 1.2 mm) for supplying water is 13.8 mm from the center. Water is fed to the hole by a narrow tube (external diameter 1.2 mm, inner diameter 0.94 mm).

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3. Vibration amplitude of the circular vibrating plate

The vibration amplitude was examined with and without the circular vibrating plate. The vibration amplitude of the radius of the uniform rod and the circular vibrating plate was measured. The input power was set to 1 W, and water was supplied

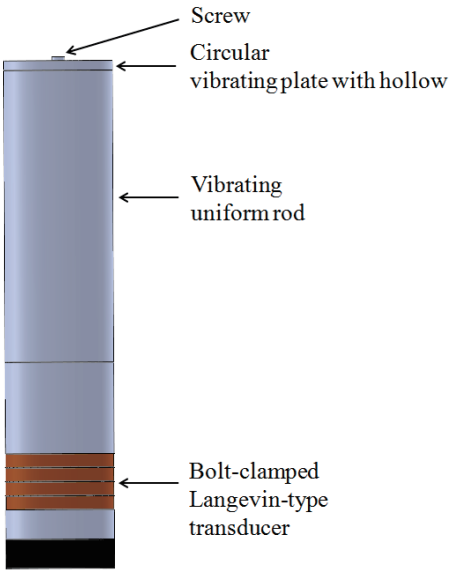

Fig.1 Schematic of the ultrasonic sound source.

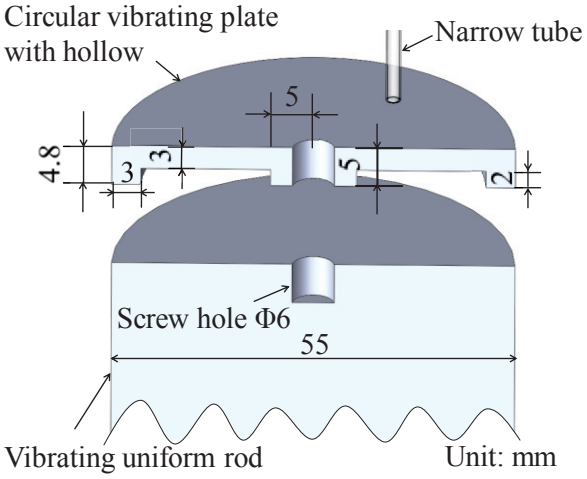

Fig.2 Sectional view of the vibrating plate.

at 100 mL/h. **Figure 3** shows the results. The horizontal axis is the distance from the center, and the vertical axis is the vibration amplitude. Without the vibrating plate, the vibration amplitude was constant, whereas with the vibrating plate, the vibration amplitude had one node. At the circumference, the vibration amplitude of the vibrating plate was larger than that without the vibrating plate.

4. Water atomization

The atomization of water was observed. The space was filled with water and the input power was set to 5 W to allow visualization. **Figure 4** shows the setup for atomizing water. The atomized water is visible as the white spray on either side of the circular vibrating plate. Atomized water escaped from several sections of the gap.

5. Measurement of atomized particle size

The size of the atomized particles was measured to obtain the particle size distribution of the atomized water. The water was supplied at 100 mL/h and the input power was set to 3 W. The atomized particles were collected on a petri dish coated with silicone oil (KF-96-1000cs, Shin-Etsu Chemical; kinematic viscosity: 1000 cSt). Atomized and scattered particles were collected on a petri dish. The particles were observed under an optical microscope, and a scattered area of 6 × 60 mm was photographed.

The atomized particles were extracted using image analysis software, and the particle diameters were calculated from the minor axis. To obtain reliable results, the measurement was repeated 10 times under the same conditions and the average value was taken. **Figure 5** shows the results. The horizontal axis is the particle size and the vertical axis is the average number of particles in the figure. The distribution is a symmetrical curve, the median particle diameter is 81 μm, and the average number of particles is 3778.

6. Conclusions

In this study, we observed the state of atomization, and were measured the size of atomized particles. Water has been atomized in a number of gap places. It is clear that the median particle diameter is 81 μm at the input power of 3 W.

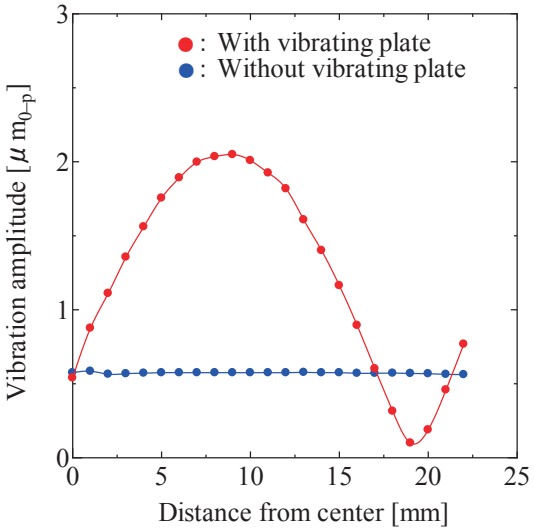

Fig.3 Relationship between the vibration amplitude and distance from center.

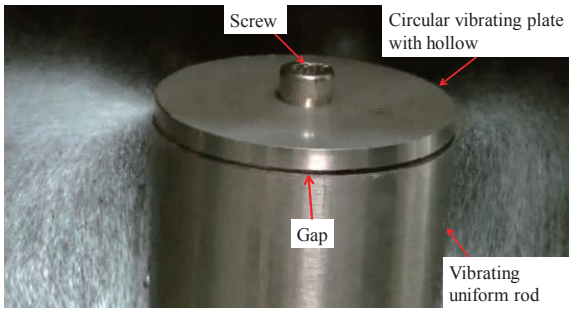

Fig.4 Photograph of water atomization.

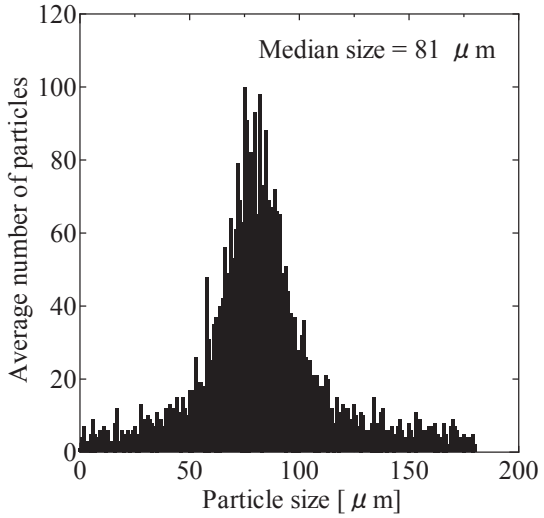

Fig.5 Relationship between the average number of particles and particle size.

References

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