1P4-9

Atomization amount of water by direct dropping using a transverse vibrating plate type ultrasonic source

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1. Introduction

The authors are currently investigating an atomization method in which is dropped directly onto a transverse vibrating plate ultrasonic source[1)].

In this work, the electric power to the ultrasonic source and the water drop rate onto the vibrating plate were changed, and the difference in the atomization amount under each set of conditions were investigated.

2. Ultrasonic source and experimental equipment

2.1 Transverse vibrating plate ultrasonic source

Figure 1 shows a schematic of the transverse vibrating plate ultrasonic source with a jetting driving point, used in this study. The ultrasonic source consisted of a 20 kHz bolt-clamped Langevin transducer, an exponential horn for amplifying amplitude, a resonance rod connected by screws, and a transverse stripe-mode vibrating plate, with a resonance frequency of 19.9 kHz connected to the rod tip by screws. The vibrating plate was 3 mm thick, 174 mm long in the x-axis direction, and 123 mm long in the y-axis direction, The dimensions of the convex end part were 12 mm in the x-axis direction and 65 mm in the y-axis direction.

2.2 Atomization experimental apparatus and experimental method

Figure 2 is a schematic of the experimental equipment used for atomization. The ultrasonic source was placed inside the container to exclude external factors, such as air currents. The red arrow in the figure indicates the flow of water, and a fixed amount of water was dropped onto the vibrating plate from a point 3 cm above the vibrating plate surface by using a metering pump. The water was dropped onto the transverse vibrating plate antinode that was 7 mm from the center of the plate in the direction of the driving point.

LabVIEW software was used to maintain the resonance state of the ultrasonic source and to keep the electric power constant. The method is shown in Fig. 2. Data acquisition was used in the experimental equipment to measure parameters such as the current and voltage, and the phase and electric power were controlled in LabVIEW. The ON/OFF control of the pump was performed at the same time. During the experiment, a circulator was used to send air to the upper part of the vibrating plate so that the atomized water would not adhere to the vibrating plate again. The amount of water that fell on the vibrating plate without being atomized was measured by an electronic balance with a container (200 × 130 × 70 mm) placed under the vibrating plate.

3. Water atomization experiment

3.1 Experiment overview

The time when the pump started dropping water was set to 0 s, and after 30 s, the ultrasonic source was turned on to control the resonance state and keep the electric power constant. After 210 s (ultrasonic irradiation time is 180 s), the ultrasonic source was turned off and water was dropped until 240 s. During this period, the driving frequency, the phase difference between the current and the voltage, the electric power to the ultrasonic source, and the mass of non-atomized water were measured. The mass of non-atomized water was measured with an electronic balance.

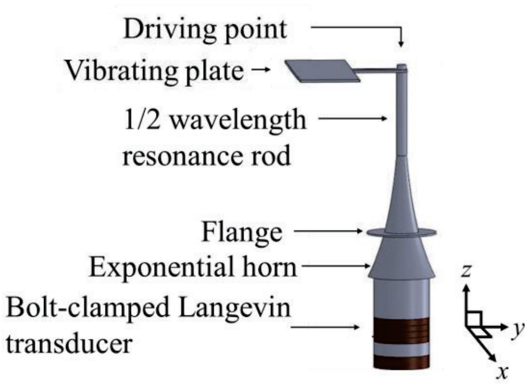

Fig. 1. Aerial ultrasonic sound source.

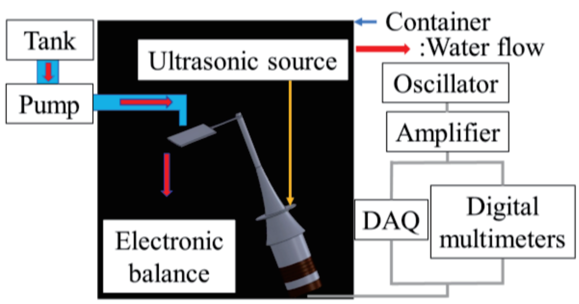

Fig. 2. Atomization experimental equipment. DAQ: data acquisition.

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The experiment was conducted with the water drop rate set to 10, 30, and 50 mL/min, and the electric power varied from 0 to 25 W in 5 W steps. Five experiments were conducted under each set of conditions. The atomization amount was calculated as the difference between the mass of atomized water at an arbitrary time when the electric power was 0 W and the mass of water at the same time at each electric power for each water drop rate.

3.2 Experimental results

Figure 3 shows the mass of atomized water versus elapsed time when the water drop rate was constant at 50 mL/min and the input electric power was changed. The vertical axis is the mass of atomized water, the horizontal axis is the elapsed time, and the legend shows the electric power. The mass of atomized water increased linearly at electric powers of 20 and 25 W from 30 to 210 s, when ultrasonic irradiation was performed, and almost all of the water was atomized. However, when the electric power was 10 W, the mass of atomized water amount increased linearly, but not all the water was atomized.

Figure 4 shows the relationship between the electric power and the atomization amount. The vertical axis is the atomization amount per unit time, the horizontal axis is the electric power, and the legend is the water drop rate per unit time. Almost no atomization occurred at an electric power of 5 W, but at 10 W or more, atomization occurred with all water drop rate, and the atomization amount increases as the water drop rate increased. Up to 50 mL/min, all the water was atomized at an electric power of 20 W.

Figure 5 shows the relationship between the atomization amount and water drop rate at different electric powers, and the legend is the electric power shown in Fig. 4. Almost all the water was atomized up to 50 mL/min at powers of 20 and 25 W. At electric powers of 10 and 15 W, the atomization amount increased as the water drop rate increased, although not all water was atomized at 30 mL/min or more. From the result in Fig. 3, at an electric power of 15 W, the atomization amount increased, similar to electric powers of 20 and 25 W, but it took time to reach the resonance state. Therefore, the difference in the amount of atomization per unit time increased as the water drop rate increased.

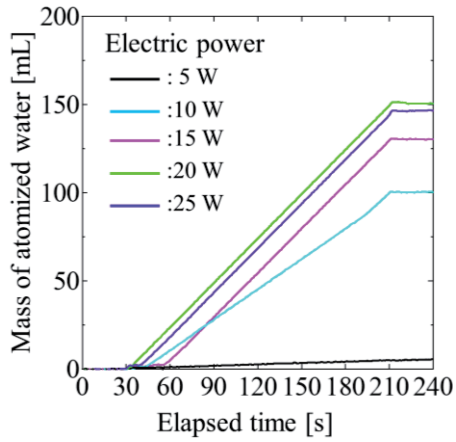

Fig. 3. Relationship between mass of atomized water and elapsed time.

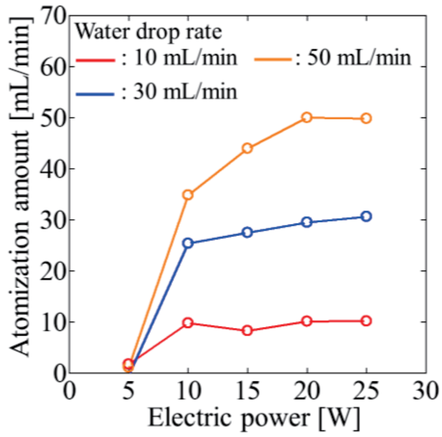

Fig. 4. Relationship between electric power and atomization amount.

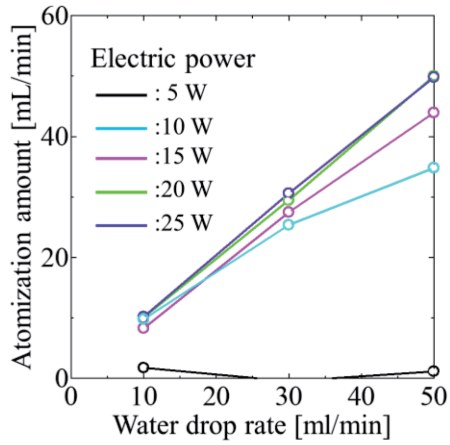

Fig. 5. Relationship between water drop rate and atomization amount.

4. Conclusion

Water was atomized using a transverse vibrating plate ultrasonic source with different amounts of dropping water and electric power. The higher the electric power, the greater the atomization amount. In addition, when the water drop rate was 50 mL/min, almost all the dropping water was atomized at electric powers of 20 and 25 W.

Reference

1) R. Igarashi, T. Asami, H. Miura, Proc. 2023 Spring Meet. Acoustical Society of Japan, 2023, p. 45 [in Japanese].