2P-37

Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 363-364
6-8 December, 2010

Effect of Frequency on Ultrasonic Atomization
超音波霧化に及ぼす周波数の影響

Keiji Yasuda[1†], Hiroyuki Honma[1], Yoshiyuki Asakura[2] and Shinobu Koda[1] ([1]Grad. School of Eng., Nagoya Univ.; [2]Honda Electronics Co., Ltd.)
安田 啓司[1‡], 本間 裕幸[1], 朝倉 義幸[2], 香田 忍[1] ([1]名大 工; [2] 本多電子㈱)

1. Introduction

When liquid surface is subjected to the ultrasonic field with high intensity, a fountain jet is locally formed on the liquid surface and the atomization occurs from the surface of the fountain jet. The major advantages of ultrasonic atomization are that the droplet size and the fog density can be controlled by the ultrasonic frequency and the flow rate of carrier gas, respectively. The ultrasonic atomization is used in the various processes such as humidification, fuel spray and powder production, and it is also applied to the condensation of Japanese sake[1)].

However, it is difficult to measure the rate of droplet generation, that is, atomization rate because the evaporation from surface of fountain due to flow of carrier gas occurs at the same time. The estimation of atomization rate is important for the mechanism clarification and the industrial application of ultrasonic atomization. In this study, the ultrasonic atomization rate was estimated and the effect of frequency on the atomization characteristics was investigated.

2. Experimental

Fig. 1(a) shows the outline of experimental apparatus for ultrasonic atomization. The rectangular vessel consisted of aluminum wall and glass window. A disk-shaped PZT ultrasonic transducer was installed at the central position of the vessel bottom. The ultrasonic frequencies were 0.5 MHz, 1.0 MHz and 2.4 MHz, while the diameters of ultrasonic transducer were 60 mm, 30 mm and 14 mm, respectively, in order to become same directivity of ultrasonic field from transducer. The vessel was put on an electronic balance. In order to eject the atomized droplet and vapor from vessel, the inlet and outlet of carrier gas were set at middle and upper part of both sidewalls of vessel, respectively. The carrier gas was air. The distillated water was used as sample and bubbled by air for 30 min before ultrasonic irradiation. The flow rate of carrier gas was changed in the range from 0 to 70 l/min by using air pump. The mass change of vessel during ultrasonic irradiation was measured. The shape and size of fountain were observed by using video camera, and the surface area of fountain was estimated.

Fig. 1(b) shows the outline of experimental apparatus for measurement of vaporization amount. In order to produce the fountain by ultrasonic irradiation, the nozzle and the liquid pump were used. The shape of nozzle and the flow rate of liquid pump were changed. To eject the vapor from vessel, the inlet and outlet of carrier gas were set at middle and upper part of both sidewalls of vessel, respectively. The flow rate of carrier gas was changed and the mass change of vessel was measured.

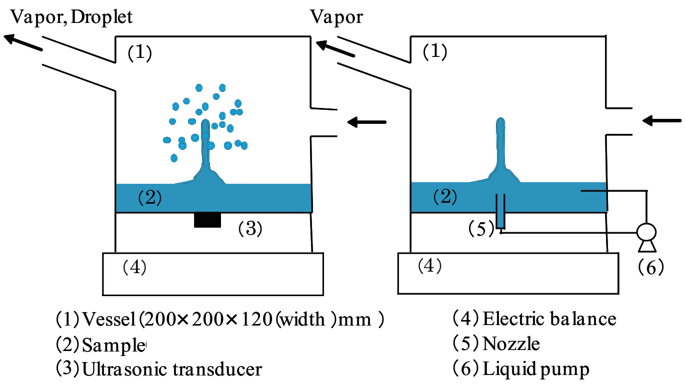

Fig.1 Outline of experimental apparatus

3. Results and Discussion

Fig. 2 shows the effect of flow rate of carrier gas on the mass change for ultrasound or pump and nozzle. In both cases, the mass changes increase with increasing flow rate of carrier gas. The mass change for ultrasound is higher than that for pump at same flow rate of carrier gas since the mass change for ultrasound includes atomized droplet and vapor from fountain. It is assumed that the mass change difference between ultrasound and pump is the amount of atomized droplet ejected from vessel. At low flow rate of carrier gas, the mass change difference increases with increasing flow rate of carrier gas. This is because the amount of atomized droplets which are fallen down on

yasuda@nuce.nagoya-u.ac.jp

water due to the aggregation of atomized droplet decreases with increasing gas flow rate. At high flow rate of carrier gas, the mass change difference becomes constant. It is considered that the mass change difference at high flow rate of carrier gas is the overall atomization rate in ultrasonic atomization.

Fig. 3 shows the effect of electric power to transducer on the atomization rate. For each frequency, the atomization occurs over a certain threshold of electric power and the atomization rate increases with electric power. The threshold vales for atomization were 17 W, 10 W and 3 W at 0.5 MHz, 1.0 MHz and 2.4 MHz, respectively. The threshold of electric power decreases with the ultrasonic frequency.

The diameter of atomized droplet was calculated by using Lang equation[2)] so that the number of droplet generation was evaluated. The diameters of atomized droplet at 0.5 MHz, 1.0 MHz and 2.4 MHz were 6.6 μm, 4.2 μm and 2.3 μm, respectively.

The number of atomized droplet increased with increasing electric power over threshold of electric power. For the same electric power, the number of atomized droplet became larger as the ultrasonic frequency increased.

The fountain appeared over a certain threshold of electric power. The threshold values for fountain were 8 W, 6 W and 1 W, respectively. The threshold for fountain also decreased with increasing ultrasonic frequency. Compared with threshold values for atomization, the threshold values for fountain are low for each frequency.

Fig. 4 shows the plot of number of atomized droplet against surface area of fountain. For each frequency, the number of atomized droplet increases when the surface area of fountain are about 100 mm^2. This result indicates that the atomization occurs after the fountain appears. The number of atomized droplet increases with increasing surface area of fountain for each frequency. For the same surface area of fountain, the number of atomized droplet becomes larger as the ultrasonic frequency increases. This is because the number of capillary wave per unit surface area of fountain increases with increasing frequency.

Acknowledgment

A part of this work was supported by a Grant-in-Aid from the Japan Society for the Promotion of Science (for Scientific Research (No. 20560713)).

References

1. K. Yasuda et al.: Ultrason. Sonochem. **12** (2005) 37.
2. R. J. Lang: J. Acoust. Soc. America, **34** (1962) 6.

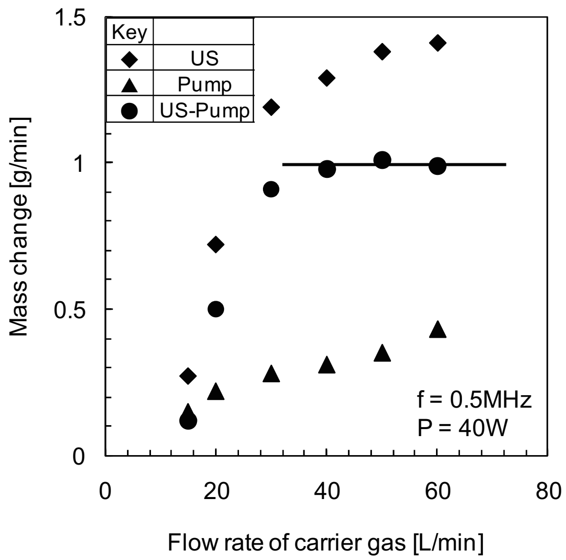

Fig. 2 Effect of flow rate of carrier gas on mass change

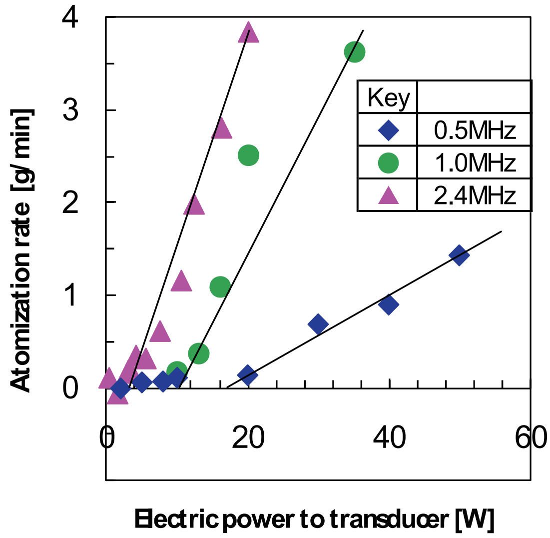

Fig. 3 Effect of electric power to transducer on atomization rate

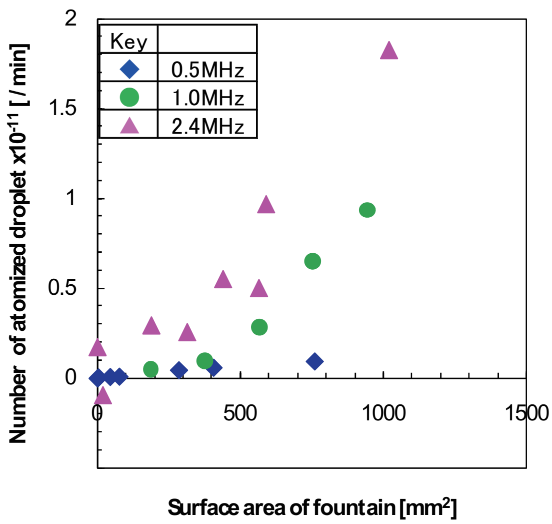

Fig. 4 Plot of number of atomized droplet against surface area of fountain