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Evaluation of a spraying state using a nozzle oscillated by a torsional transducer

ねじり振動子により励振されたノズルによるスプレー状態の評価

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1. Introduction

There is a demand for low flow rate spraying. This is because the coating quality depends on a thickness of paint on the product surface. Additionally, a reduction of the amount of volatile organic compound which is used as a thinner is expected [1, 2]. Usually, spraying flow rate is controlled by the air pressure against the spraied liquid. However, when the spraying pressure is low, the spraying angle is also small. As a result, it is difficult to realize the high quality coating.

In our previous studies, torsional vibrators were used for a generation of micro size droplets [3-5]. Torsional vibration was also effective for the spraying [6, 7]. In this study, we have fabricated torisnal transducers and observed the spraying state when the spraying condition was changed.

2. Principle and Structure of the device

Figure 1 shows the photograph of the torsional transducer. **Figure 2** illustrates the structure of the transducer. Two PZT rings which are polarized circumferentially are used for the oscillation of torsional vibration. The transducer in Fig. 1 has a diameter of 24 mm and a length of 60 mm. When the driving frequency is 18.3 kHz, the 1st torsional mode is oscillated.

The principle for the enlargement of spraying angle is in controlling the surface tension at the nozzle tip. The spraying state depends on the Weber number [8]. The Weber number is represented by the ratio of the inrtia of the surface tension force and expressed as

$$We = \frac{\rho L V^2}{\sigma} . \qquad (1)$$

In Eq. 1, We, ρ, L, V and σ indicate the Weber number, the density of a liquid, the flow path of diameter, the flow rate and the surface tension, respectively.

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When the Weber number is much larger than 1, the liquid will not be atomized and the liquid threads are generated. When the Weber number is much smaller than 1, smaller droplets are generated and successfully atomized.

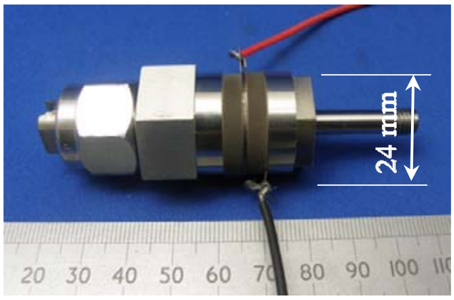

Fig. 1 Photograph of a torsional transducer with a spraying nozzle.

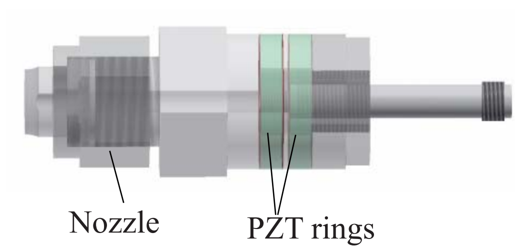

Fig. 2 Structure of a spraying nozzle oscillated by a torsional transducer.

3. Experimental results

Figures 3 and 4 show the spraying state. The driving voltage was 60 V as peak to peak value and the water flow rates were 15 and 25 ml/min, respectively. In Fig. 3, when the flow rate was 15 ml/min, the water was not atomized without the vibration. Although the water was atomized at 25 ml/min without vibration, the spraying angle was enlarged by the torsional vibration as shown in Fig. 4.

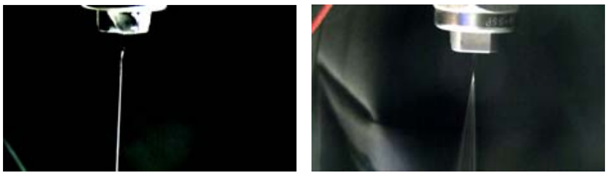

Fig. 3 Spraying state without vibration (left) and with vibration (right) when the flow rate of water was 15 ml/min.

Fig. 4 Spraying state without vibration (left) and with vibration (right) when the flow rate of water was 25 ml/min.

To observe the effect of torsional vibration, we have fabricated two types of torsional transducers. The driving frequency for the torsional mode are 64.5 kHz and 18.3 kHz. Figure 5 shows the relationship between the vibration velocity at the tip of the nozzle and the driving voltage of each torsional transducer.

Figure 6 shows the relationship between the splay angle and the water flow rate when those transducers were used for the oscillation. By using the higher vibration velocity, we have successfully atomized the water flow and obtain larger spray angle in low flow rate.

4. Conclusion

In this study, we have fabricated torisnal transducers and observed the spraying state when the spraying condition was changed. We have successfully atomized the water flow using the torsional vibration in low flow rate.

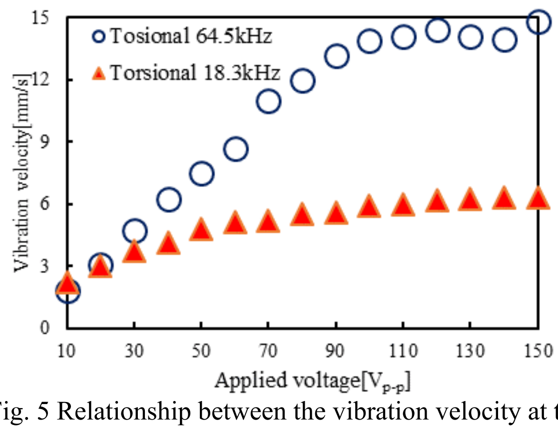

Fig. 5 Relationship between the vibration velocity at the tip of the nozzle and the driving voltage of the torsional transducer.

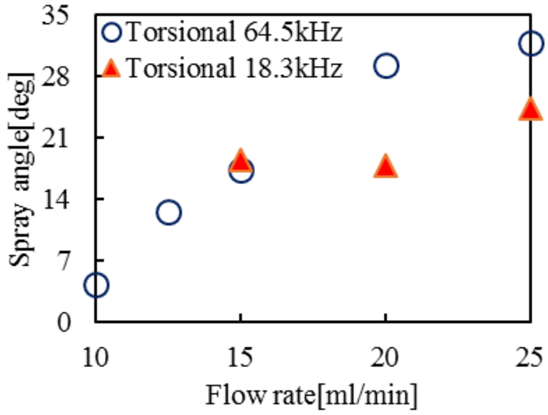

Fig. 6 Relationship between the splay angle and the water flow rate when the different type transducers were used for the oscillation.

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