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Measurement of the sound pressure and the cavitation intensity in the ultrasonic cleaning machine using fiber prove optic hydrophone

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1. Introduction

The resolved gas concentration gives large influence on the cavitation intensity of the ultrasonic cleaning machine[1]. However, it is difficult to measure absolute values of the high intensity sound pressure of the ultrasonic cleaning machine. Because the cavitation gives the severe damage to the conventional piezoelectric prove hydrophone. One of the applicable sound pressure method is a fiber prove optic hydrophone (FPOH)[2],[3]. Authors already have reported the sound pressure measurement in the new waveguide type ultrasonic cleaning machine (WGUCM)[4],[5]. In the WGUCM, the sound field inside the waveguide is too high to measure the sound pressure distribution using the conventional hydrophone. The authors successfully measure the sound distribution inside the waveguide using FOPH.

In this report, the FOPH is applied the sound pressure measurement of the bath type ultrasonic cleaning machine of which driving frequency is 100kHz. For the bath type ultrasonic cleaning machine, it is required to produce the same sound pressure all over the inside bath. In order to create such a sound field, size and concentration of the resolved gas in the cleaning water has to be controlled. The cavitation intensity and the resolved gas concentration are estimated using FOPH.

2. The employed ultrasonic cleaning machine

Figure 1 shows the experimental setup. The ultrasonic cleaning machine consists of a high power waterproof submersible transducer (Advantec Multi, Otrai, inc.). The transducer can be oscillated at several frequencies, 35kHz, 70kHz and 100kHz and the maximum supplied power of transducer is 600W. In this report, the employed frequency is 100kHz. The size of the transducer is 210mm × 250mm × 80mm. The size of the cleaning bath is 300m × 400mm × 408mm. The water depth is 320mm. In order to investigate the sound pressure distribution roughly, the relative sound pressure level in the cleaning bath is measured by the PZT ceramic type probe (SONOSAVER, Otrai, inc.). The measured points are also indicated in Fig.1. The measurement points are thirteen at the same depth and the depth of measurement varies at three levels as shown in Fig.1. The location of measured point is expressed using the numbers and the alphabets in Fig.1 for example, 1, a1 or b3

Figure 2 shows the configuration of FOPH. A C-band amplified spontaneous emission (ASE) light source (ASE-C-10S, Fiber Labs Inc.) is employed where the wavelength is from 1530nm to 1570nm. The light is propagated through the single mode glass fiber(SMF) and is emitted from the fiber end. Reflection intensity depends on the index of the

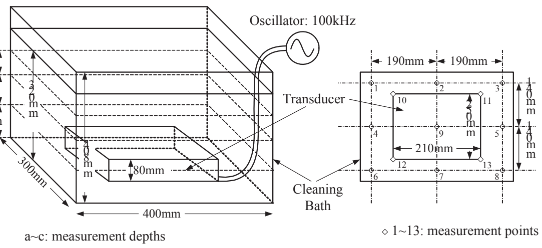

Fig.1 Size of the ultrasonic cleaning machine.

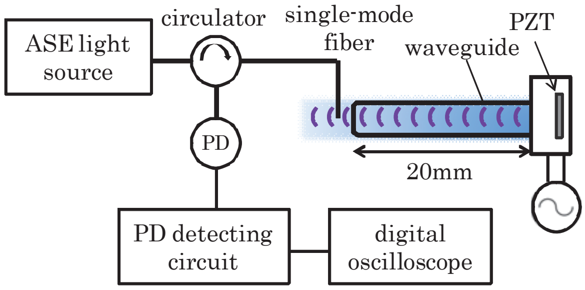

Fig.2 Configuration of the FOPH.

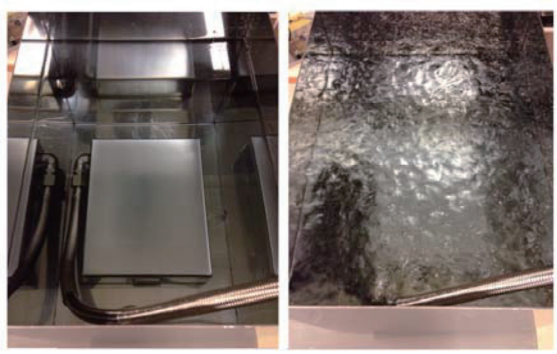

Fig.3 Water surface of the cleaning bath water.

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water in the front of the fiber end. Index of the water is proportional to the density of the water. The density is also proportional to the sound pressure at the fiber end. The propagation path of the reflected light is changed by the circulator and is incident on the photo diode(PD). The PD output is amplified and the output waveform is observed by the oscilloscope. The sensitivity of the hydrophone is 2.25×10^{-5} mV/Pa.

3. Results and Discussion

The picture of the water surface during operation is shown in Fig.3. In the case that the resolved gas concentration is less than 5ppm, water surface is ruffled in both of the right above of the emission area and the outside of the emission area of the transducer. If the resolved gas concentration is more than 5ppm, the ruffled water surface does not appear stably in the cleaning bath. It is also confirmed that the raffled water surface also appears at lower input power, for example 100W in the case that the resolve gas concentration is enough thin. When the ruffled water surface occurs, it is expected that the sound pressure level inside the whole cleaning bath reaches enough magnitude. The measurement result of the relative sound pressure distribution using PZT probe is shown in Fig.4. The standing wave distribution is appeared and the magnitude of sound pressure decreases approaching to the water surface. Figure 5 shows the sound pressure distribution in the same depth as shown in Fig.1. The sound pressure is also measured by the PZT probe. As shown in Fig.5, the almost same sound pressure level as inside emission area in each depth level is available outside of the emission area. The deviation of the sound is due to standing wave formed along the depth direction.

Next, FOPH as shown in Fig.2 is applied to the sound pressure measurement. Figure 7 shows the spectrum of the FOPH output. In this report, the noise radiated from the oscillator cannot be reduced. Therefore, the spectrum at 100kHz of frequency includes the noise signal although the spectrum appears at 100kHz.

Our future plan is investigation on the relation between the sound pressure level and the emission area of the transducer and is examined the occurred condition of the raffled water surface of the cleaning machine.

References

1. B. Niemczewski, Ultrasonics-Sonochem., **6** (4) (1999) pp. 211–216.
2. J. Staudenraus and W. Eisenmenger: Ultrasonics **31**(1993)267.

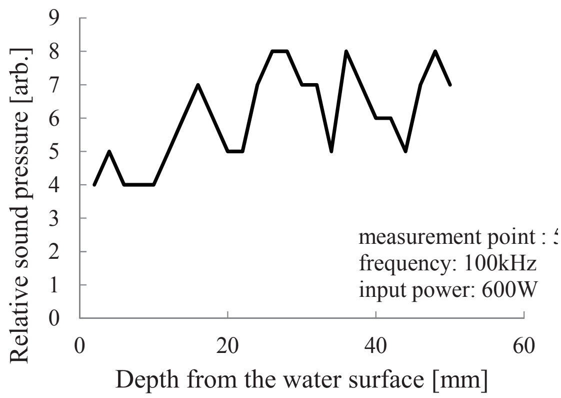

Fig.4 Relative sound pressure distribution along the vertical direction of the center of emission area in the cleaning bath.

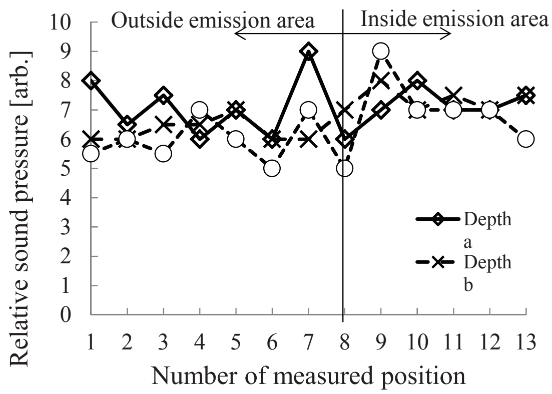

Fig.5 Relative sound pressure distribution along the vertical direction of the center of emission area in the cleaning bath.

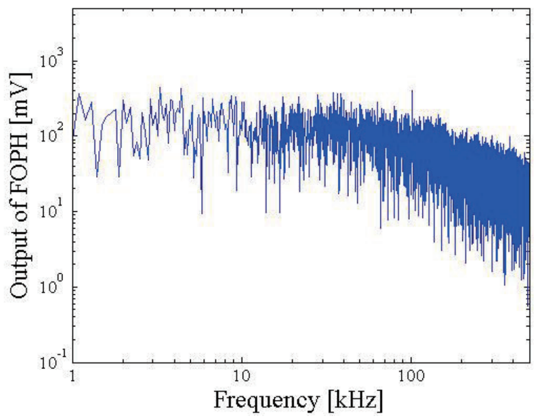

Fig.7 Spectrum of the FOPH output.

3 K.Nakamura: Jpn. J. Appl. Phys. **46** (2007) 4555.
4. K.Suzuki et al., Jpn.J.Appl.Phys., **48** (2009) 07GM04.
5. K.Suzuki et al., Jpn.J.Appl.Phys., **48** (2009) 07GM05.