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Study on Measurement for Amount of Generated Acoustic Cavitatiion –Effect of Dissolved Oxygen Level and Acoustic Streaming-

キャビテーション発生量計測技術の開発－溶存酸素濃度と音響流の影響の検討－

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1. Introduction

Recently, acoustic cavitation generated by high-pressure ultrasound has been used in medical applications such as cancer therapy and industrial applications such as semiconductor cleaning. However, cavitation can damage normal cells in the human and cleaning target. Therefore, it is important to develop a technique that can quantitatively measure the amount of generated cavitation for simultaneous pursuit of safety and effectiveness of acoustic cavitation applications.

Medical index calculated from the sound pressure in medical field[1] and sonochemical luminescence[2] in sonochemistry have been used as the investigation of the cavitation. However, neither method measures the cavitation signal both. Therefore, it is necessary to measure the amount of generated cavitation both for high accurate investigation of safety and effect of the cavitation.

We have been studying a technique for measuring the amount of generated cavitation used broadband integrated voltage (BIV). BIV is calculated by integrating the high-frequency components of frequency spectra of output voltage from cavitation sensor. The high-frequency components originate from signals caused by the collapse and vibration of cavitation bubbles. Previously, we found a correlation between the BIV and the sonochemical luminescence[2]. In this paper, we investigate the effect of the dissolved oxygen (DO) level and acoustic streaming on the BIV.

2. Experimental method

Figure 1 shows the configuration of the experimental system. The cavitation sensor proposed by Zeqiri[3] was used. The sensor has a three layer structure consisting of acrylic resin, closed-cell sponge and a 110 mm-thick poly(vinylidene fluoride) film. The sensor had an external diameter of 40 mm.

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The ultrasound exposure system consisted of a stainless-steel vibrating disk with a Langevin-type transducer. The vibrating disk was installed on the bottom of a water vessel (190 mm long, 190 mm wide and 120 mm high) and was operated at a frequency of 150 kHz. The depth of distilled water in the vessel was 100 mm. A standing wave acoustic field was formed in the vessel. The sensor was positioned at the height of 40 mm above the vibrating disk. The sensor was scanned across the center of the vibrating disk to investigate the change in the BIV with position across the vessel. Also, the sound pressure was measured using a hydrophone for the same scanning conditions. In this time, the integrated frequency range for calculation of BIV was between 1 and 5 MHz.

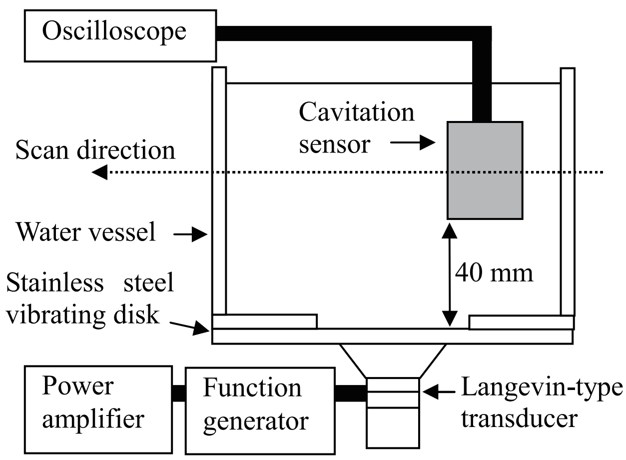

Fig.1 Experimental system for measuring the BIV.

3. Experimental results

Figure 2 shows the variation in the BIV as a function of the DO level of distilled water. Distilled water with DO levels of about 2 and 8 mg/L was used in the experiment. The results show that the BIV varied considerably across the vessel for water with a DO level of about 8 mg/L. The maximum BIVs occurred at about 70 and 100 mm. However, the BIV changed little across the vessel for water with a DO level of about 2 mg/L. The number of bubbles generated by cavitation depends on DO level. A higher DO level results in more bubbles being generated. Therefore, it was thought that change of BIV was different by DO level.

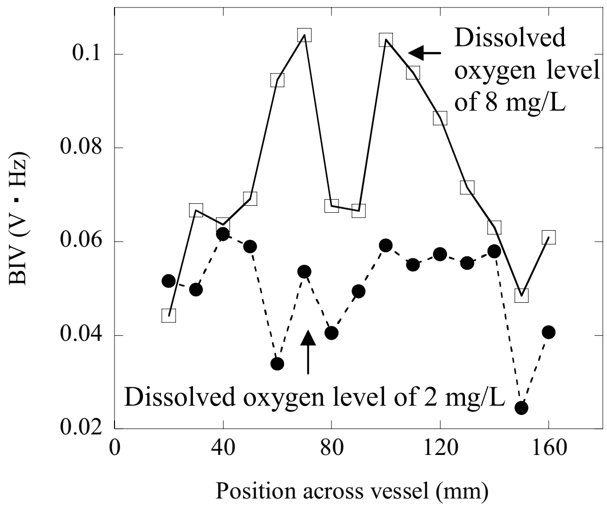

Fig.2 Variation in the BIV with position across the water vessel at DO level of about 2 and 8 mg/L.

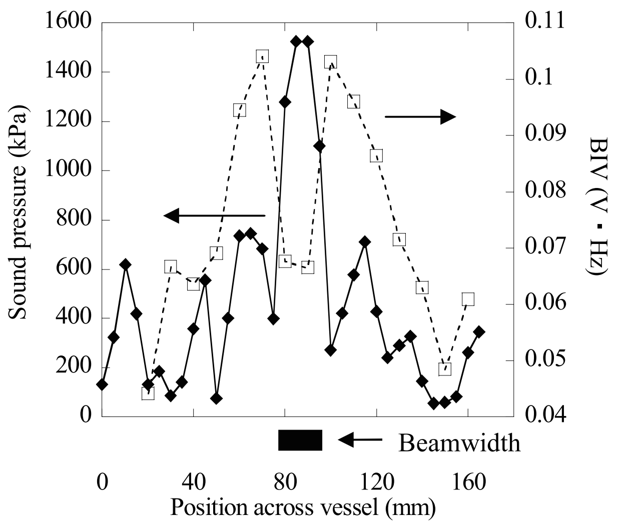

Fig.3 Variation in the BIV and sound pressure with position across the water vessel.

Figure 3 shows the variation in the BIV and the sound pressure with position across the vessel. Distilled water with a DO level of 8 mg/L was used in the experiment. The maximum BIV and the maximum sound pressure occurred at different positions in the vessel. The maximum sound pressure was at the center of the vibrating disk, whereas the maximum values of BIV occurred at positions of about 70 and 100 mm in the vessel.

Figure 4 shows a photograph of acoustic streaming in the vessel. Aluminum powder and dodecyl sodium sulfate were used in this observation. Figure 4 shows that acoustic streaming was generated in the central region of the vessel.

The results of Figs.3 and 4 show that the maximum values of the BIV and of the sound pressure were different due to acoustic streaming that was generated at the center of the vibrating disk. Cavitation bubbles were not trapped at the center of the disk at a position of 80 mm because of streaming. Rather, bubbles were trapped at positions of about 70 and 100 mm. Consequently, the BIV indicated the maximum values at the position of about 70 and 100 mm. BIV has a potential that the cavitation generation distribution can be measured accurately than sound pressure.

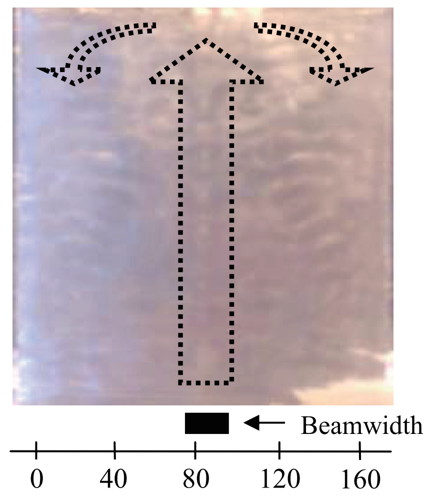

Fig.4 Photograph of acoustic streaming in water in the water tank of our ultrasound exposure system.

4. Summary

We have been investigating a technique for measuring the amount of generated acoustic cavitation. In this paper, the effect of DO level and acoustic streaming on the BIV was investigated. The results revealed that the BIV varied depending on the DO level. Also, the BIV was considered to be more suitable for precisely measuring the cavitation generation distribution than sound pressure.

In the future, we will use the BIV to investigate ultrasound devices.

Acknowledgment
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References

1. IEC62359 First edition(2005)
2. T. Uchida, H. Sato, S. Takeuchi and T. Kikuchi: Jpn. J. Appl. Phys. **49** (2010) 07HE03.
3. B. Zeqiri, P. N. Gelat, M. Hodnett and N. D. Lee : IEEE Trans. Ultrason. Ferroelectr. Freq. Control **50** (2003) 1342.