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Consideration of output signal from cylindrical hollow type cavitation sensor –Investigation by dissolved oxygen level and sonochemical luminescence–

キャビテーションセンサの出力信号の検討ー溶存酸素濃度、ルミノール発光による評価ー

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1. Introduction

Recently, cancer therapy and medication by acoustic cavitation have been studied[1]. Meanwhile, the cavitation can damage normal cells of human body. Therefore, it is necessary to control the cavitation for human body safety assurance in medical field. However, there is currently no quantitative measurement method of the amount of generated cavitation necessary for proper control of the cavitation. Consequently, it is important to establish the technique for measurement of the amount of the generated cavitation.

Mechanical index (MI) calculated by sound pressure has been currently used for the investigation of the generation of the cavitation in medical filed[2]. However, it is necessary to develop the technoloy of precision measurement of the amount of the genetated cavitation for highly accurate investigations of human body safety.

We have been studied the development of quantitative measurement of the cavitation. The measurement method by cylinder hollow type cavitation sensor is suggested by Zeqiri et al in National Physical Laboratory in United Kingdom[3,4]. It is important to investigation the relationships between output siganls from the cavitation sensor, generation condition of the cavitation, and the secondary effects by the cavitation for practical applications. Consequently, we investigated the output signal from the sensor by using dissolved oxygen (DO) level and sonochemical luminescence in this paper.

2. Cylindrical hollow type cavitation sensor

Basic structure of the cylindrical hollow type cavitation sensor in this study was shown in Fig.1. Construction of the cylindrical hollow type cavitation sensor was referred to Zeqiri's papers[3,4]. Acrylic resin cylinder with outside diameter of 40 mm was used. Closed cell sponge was attached at inner surface of the acrylic resin cylinder. The closed cell sponge was used for acoustic isolator. A 110 mm thick polyvinylidene fluoride (PVDF) film (Tokyo Sensor) was attached at inner surface of the sponge.

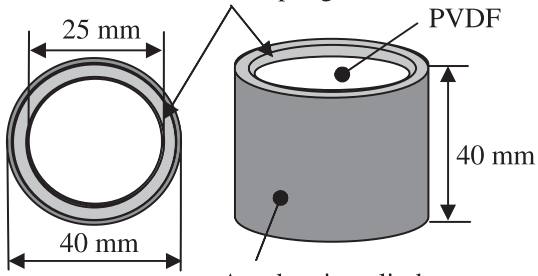

Fig.1 Construction of cylindrical hollow type cavitation sensor

3. Experimental method

A bolt-clamped Langevin-type transducer (Honda Electronics HEC-45402) was equipped on the center of a stainless-steel vibrating disk with a thickness of 2 mm, and diameter of 180 mm. The vibrating disk was attached on the bottom of the water vessel (190 mm long, 190 mm wide, 120 mm high). The output signal of a function generator (Tektronix AFG310) was amplified using a power amplifier (AR 75A250). The amplified signal was applied to the transducer. Operating frequency was 150 kHz. The height of the distilled water in water vessel was about 100 mm. The cavitation sensor was placed at the center in water tank. The sensor was about 40 mm above the vibrating disk. The output signal from the cavitation sensor was acquired with digital oscilloscope (Tektronix TDS2012B).

High frequency components of the MHz range in the output signal from the sensor were analyzed. The origin of high frequency components of MHz range come from shockwaves caused by

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the collapse and vibration of bubbles produced by the cavitation[5]. The high frequency components in output signal were processed as Broad Integrated Voltage (BIV). BIV was calculated by integrating the high frequency components of MHz range. BIV defined by the equation:

$$\mathrm{BIV} = \int_{f_1}^{f_2} V(f)df, \tag{1}$$

where *V(f)* represents the frequency spectrum. In this paper, the frequency limits of integration are taken to be f_1 = 1 MHz and f_2 = 5 MHz.

4. Experimental results

The relationships between BIV and DO level in distilled water was shown in Fig.2. DO level was measured by dissolved oxygen meter (Iijima Electronics ID-100). When applied voltage to the transducer was increased, BIV was increased at DO level of about 8.3 mg/L as shown in Fig.2. In case of DO level of about 2.3 mg/L, Change of BIV was small. The amount of bubbles generated by acoustic cavitation is known to be affected by DO level. A higher DO level results in more bubbles being generated. Therefore, it was thought that BIV was increased as the amount of the generated cavitation increase at about 8.3 mg/L. There was small change in BIV at about 2.3 mg/L because the amount of the generated cavitation was small.

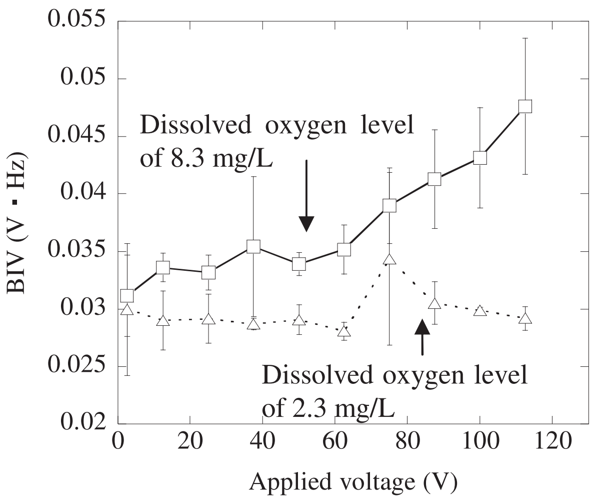

Fig.2 Change of BIV by dissolved oxygen level in distilled water.

Next, Relationships between BIV and sonochemical luminescence was investigated. The results are shown in Fig.3. DO level was about 8 mg/L in this measurement. The sonochemical luminescence is chemical reaction between luminal anion and active oxygen species generated by the cavitation. The intensity of sonochemical luminescence is proportional to the amount of the generated cavitation. As the result, when sonochemical luminescence was increased from about 60 V, BIV was increased from approximately the same value. BIV was positively correlated with sonochemical luminescence as shown in Fig.3

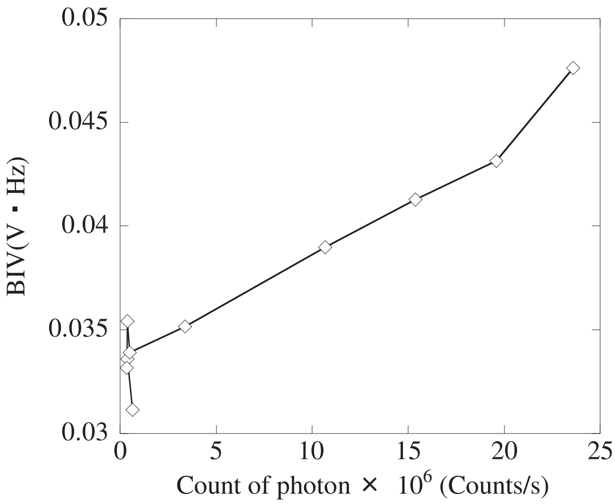

Fig.3 Investigation of BIV by sonochemical luminescence.

As these results as shown in Figs 2 and 3, it was thought that BIV was amount proportional to the generation of the cavitation.

5. Summary

The characteristics of BIV calculated from output signal of the cavitation sensor were investigated. As the results, BIV was changed by DO level. Also, a correlation was found between BIV and sonochemical luminescence. This indicates that BIV has the potential to be used as an index of the amount of the generated cavaitation.

In the future, we will investigate relationships between BIV and active oxygen species in detail. Also, we will consider the ultrasound equipments such as ultrasonic washing machine by using BIV.

References

1. A. Watanabe, K. Kawai, T. Sato, H. Nishimura, N. Kawashima and S. Takeuchi : Jpn. J. Appl. Phys. **43** (2004) 3245.
2. IEC62359 First edition (2005).
3. B. Zeqiri, P. N. Gelat, M. Hodnett and N. D. Lee : IEEE Trans. Ultrason., Ferroelct., Freq. Contr. **50** (2003) 1342.
4. M.Hodnett and B.Zeqiri : IEEE Trans. Ultrason., Ferroelct., Freq. Contr. **55** (2008) 1809.
5. J. Frohly, S. Labouret, C. Bruneel, I. Looten-Baquet and R. Torguet : J. Acoust. Soc. Am. **108** (2000) 2012.