1P4-2

Proceedings of Symposium on Ultrasonic Electronics, Vol. 37 (2016)

16-18 November, 2016

Measurement of Sound Pressure in the Presence of Cavitation Bubbles
キャビテーション気泡下における音圧測定

Tam Thanh Nguyen[1, 3‡], Yoshiyuki Asakura[2], Nagaya Okada[2], Keiji Yasuda[1]
([1]Grad. School Eng., Nagoya Univ.; [2]Honda Electronics.; [3]Faculty of Environment, Univ. of Science, VNU-HCM)
グエン　タム [1,3‡], 朝倉　義幸 [2], 岡田　長也 [2], 安田　啓司 [1] ([1] 名大院工, [2] 本多電子, [3] ベトナム国家大学ホーチミン市校)

1. Introduction

Among evaluation methods of ultrasonic fields in an ultrasonic device, sound pressure measurement by a hydrophone is proven to be effective to obtain a distribution of sound pressure. In theory, the sound pressure is proportional to a square root of the electric power driven to a transducer. However, in strong ultrasonic fields such as sonochemical reactors, non-linearity between the sound pressure and the square root of the electric power is observed[1)]. A problem of the sound pressure measurement is that a hydrophone is often broken by ultrasonic cavitation.

Recently, novel anti-cavitation hydrophones were fabricated by hydrothermal synthesis method[2)]. In this research, the sound pressure of fundamental and broad integrated voltage (BIV) were measured until high electric power driven to the transducer using the anti-cavitation hydrohone. Behaviors of the sound pressure and BIV at strong ultrasonic fields were discussed. The sound pressure of harmonic and subharmonic were also measured.

2. Experiment

Figure 1 shows the schematic diagram of the experimental setting. All samples were air-saturated water and volume was 100 mL. The sonochemical reactor with inner diameter of 56 mm was used and its side came with two tiers to circulate temperature-controlled water at 298 ± 0.1 K. A Langevin type transducer with 45 mm in diameter was used at frequencies of 22, 43, 98 and 142 kHz. Disc type PZT transducers with 50 mm in diameter were used at 304, 488, 1000, 2000 and 4880 kHz. The sound pressure of fundamental, harmonic and subharmonic and white noise were measured by a hydrophone (Honda Electronics HUS-200S) and a spectrum analyzer by gradually increasing the electric power applied to the transducer. A preamplifier (Honda Electronics HUS-200A) was used to transform output impedance of the hydrophone. The transducer was driven by a power amplifier which amplified a continuous sinusoidal wave produced by a signal generator. An effective electric power driven to the transducer was calculated from a voltage at the both ends of the transducer and a current measured by an oscilloscope and a current probe.

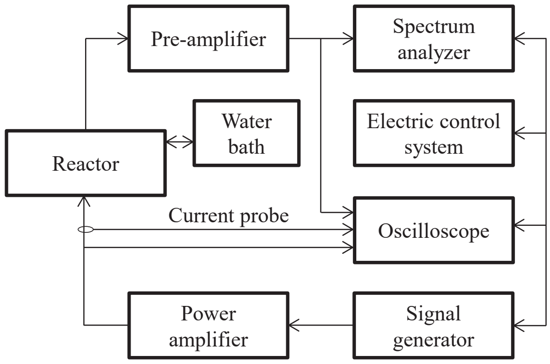

Fig. 1 Experimental setup.

3. Results and discussion

In this study, the hydrophone was put at the position giving highest acoustic pressure in the solution for all experiments. Experimental results at 488 kHz are shown in **Figs. 2 - 4**. The sound pressure of fundamental, BIV, harmonic and subharmonic are plotted against the square root of the electric power. Cavitation threshold is considered the sound pressure when white noise appears[3)]. As can be seen in **Fig. 2**, below cavitation threshold, the sound pressure increases linearly with increasing the square root of the electric power. Right below the cavitation threshold, the sound pressure does not increase linearly with the square root of the electric power because bubbles are trapped in the solution and on the hydrophone surface. In **Fig. 3**, the harmonic component appears near cavitation threshold.

---

‡nguyen.thanh.tam@e.mbox.nagoya-u.ac.jp

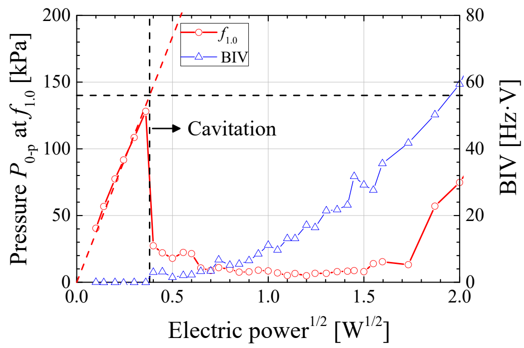

Fig. 2 Relations of pressure of fundamental and BIV to the square root of the electric power at 488 kHz (maximum power = 4 W).

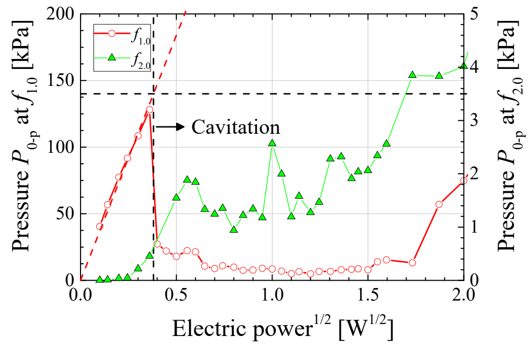

Fig. 3 Relations of pressure of fundamental and harmonic to the square root of the electric power at 488 kHz (maximum power = 4 W).

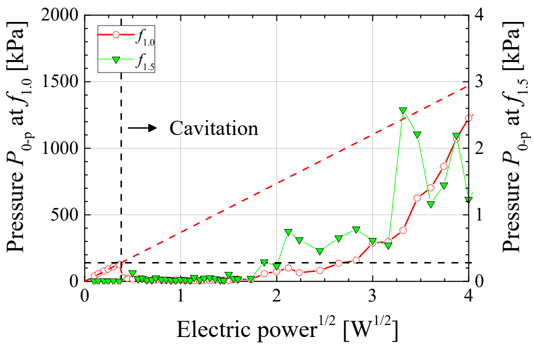

Fig. 4 Relations of pressure of fundamental and subharmonic to the square root of the electric power at 488 kHz (maximum power = 16 W).

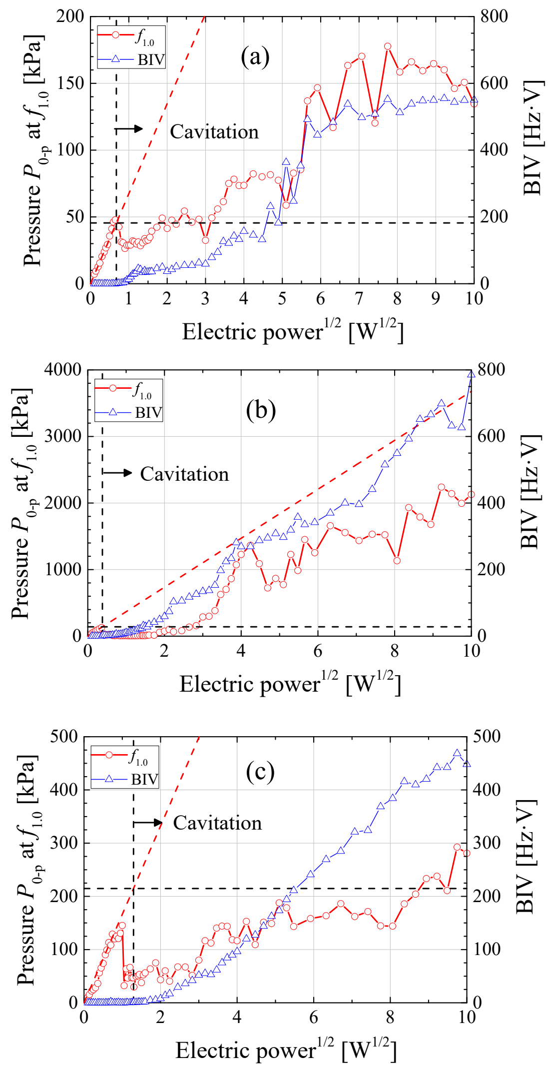

Fig. 5 Relations of pressure of fundamental and BIV to the square root of the electric power (maximum power = 100 W) at (a) 98 kHz, (b) 488 kHz, (c) 1000 kHz.

The harmonic derives from non-linear oscillations of stable bubbles in the solution.

In **Fig. 4,** the applied electric power to generate subharmonic component is much higher than that for white noise. It is known that subharmonic is generated at the collapse phase of transient cavities. It might be the case that a sufficient amount of collapsing bubbles is required to generate subharmonic in the irradiated liquid.

Figures 5 (a) – (c) show the sound pressure of fundamental and BIV to 100 W at 98, 488 and 1000 kHz. Far beyond the cavitation threshold, the sound pressure increases again. This might be due to the high irradiation force from the transducer at high power, trapped bubbles in the standing waves and on the hydrophone surface are removed. However, at high power, the increasing rate of sound pressure at fundamental frequency is lower than the increasing rate below cavitation threshold. This can be explained by the attenuation and scattering caused by bubbles in the solution.

References

1. E. A. Neppiras: IEEE Trans. Son. Ultrason. **15** (1968) 81.
2. M. Shiiba, N. Okada, T. Uchida, T. Kikuchi, M. Kurosawa, and S. Takeuchi: Jpn. J. Appl. Phys. **53** (2014) 07KE06.
3. J. Frohly, S. Labouret, C. Bruneel, I. Looten-Baquet and R. Torguet: J. Acoust. Soc. Am. **108** (2000) 2012.