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Study on measurement technique of ultrasonic power by calorimetric method in frequency range from 1 MHz to 3 MHz

1 MHz～3 MHz の周波数帯域におけるカロリメトリ法による超音波パワー測定技術

Takeyoshi Uchida[1†], Tsuneo Kikuchi[1] ([1]NMIJ・AIST)
内田武吉 [1†]，菊池恒男 [1] ([1] 産業技術総合研究所 計測標準研究部門)

1. Introduction

Ultrasonic power is one of the key quantities related closely to human safety of medical ultrasound equipments. The National Metrology Institute of Japan (NMIJ) has established ultrasonic power standard between 1 mW and 15 W by the radiation force balance (RFB) method in 2006.[1,2)]

Recently, the euipqment having ultrasonic power of several tens W and over has been used in medical field. For example, high intensity therapeutic ultrasound (HITU) device has been used to the treatment of prostate cancer. In order to use the ultrasound devices such as HITU safely to human body, output of the devices should be accurately controlled. Therefore, the ultrasonic power standard in high ultrasonic power range should be required.

RFB method is widely used for ultrasonic power measurement. However, RFB method is not well suited to the measurement of ultrasonic power of several tens W and over due to problems including thermal damages to the absorbing targets, acoustic streaming, and so on. Hence, a new ultrasonic power measurement method should be developed as an alternative to RFB method. At NMIJ, we have been developing the measurement technique of ultrasonic power by a calorimetric method using water as heating material for the establishment of high ultrasonic power standard.

Previously, we reported about the effects of heat loss from water vessel and heat generation from the ultrasound transducer.[3,4)] In this paper, we investigated the ultrasound transducers at operating frequency of 1 MHz, 2 MHz, and 3 MHz which be planned to use a reference trasndcuer.

2. Experimental method

Figure 1 shows a block diagram of the calorimetric water vessel. The water vessel is cylindrical with a diameter of 150 mm and a depth of 90 mm. An ultrasound transducer is attached horizontally to the wall of the vessel. The wall of the vessel is hollow of 10 mm and the inner wall thickness is 0.6 mm. The irradiated ultrasound reflected almost perfectly on the inner wall of the vessel. Consequently, ultrasound is circulating in a single direction in the vessel, and so the almost total ultrasound energy is absorbed in the water. Additionally, ultrasound does not re-enter the transducer surface again. Free filed measurement which is an important condition for ultrasonic power measurement can be achieved.[2)] The whole body of the water vessel is covered by a heat insulator of polyethylene foam to prevent the inflow and outflow of heat.

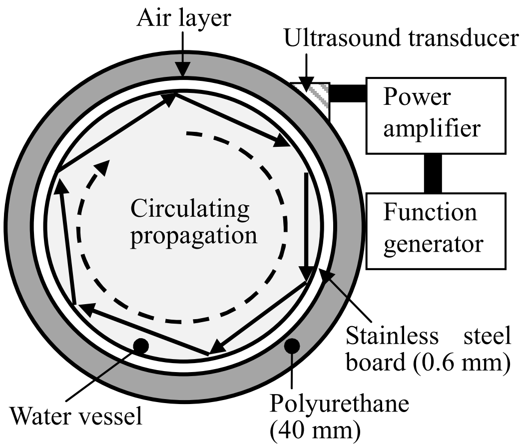

Fig. 1 Calorimetric water vessel in this experiment (top view).

The air-backing type ultrasound transducers are used for the experiments. The center frequencies of the transducer are 1 MHz, 2 MHz, and 3 MHz. In the future, these transducers are planned to be used as reference ultrasound transducer for supply of ultrasonic power standard by calorimetric method. The water temperature is measured by the thermistors which are placed at the center and near the wall of the vessel. The resolution of the temperature measurement is 0.01 °C. Degassed water at dissolved oxygen level of 2 mg/L is used. Ultrasonic power by calorimetric method calculates from water temperature measurement before and after irradiating ultrasound.[4)]

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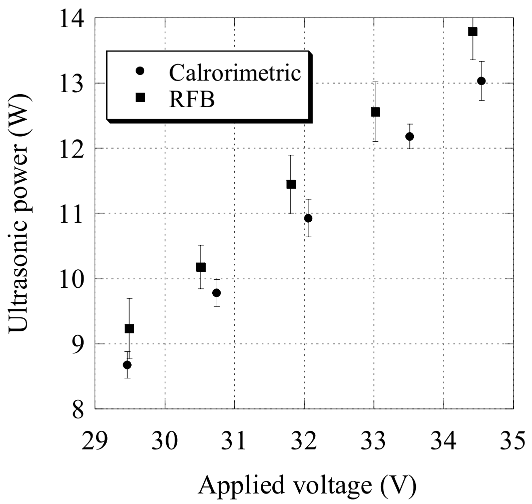
takeyoshi.uchida@aist.go.jp

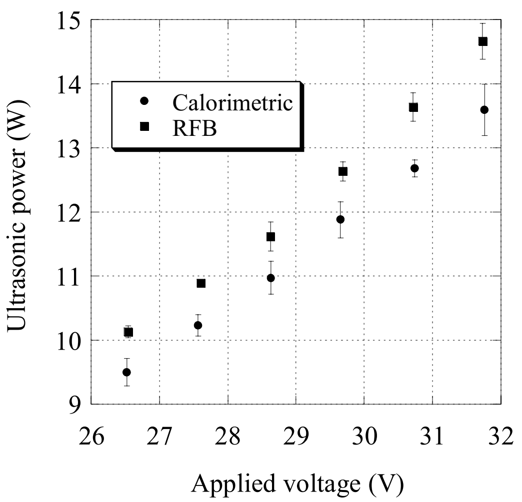
3. Experimental results

Between 10 W and 15 W, the values obtained by calorimetric method were compared with those measured by RFB method. The results was shown in Fig. 2. Error bar is standard deviation of measured values.

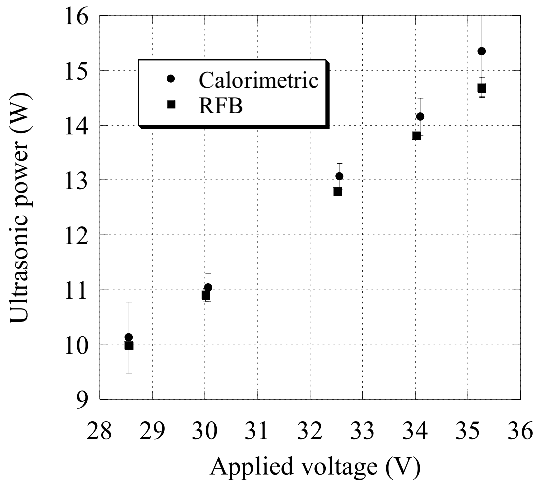
In case of the transducers with operating frequency of 1 MHz and 2 MHz, the ultrasonic powers measured by calorimetric method were about 5 % lower than those measured by RFB. In case of the transducer at operating frequency with 3 MHz, the ultrasonic powers obtained using calorimetric method were about 3 % higher than RFB. One of the possible causes of the effect is relationship between heat loss in the vessel and heat generation of the transducer. The vessel has a constant heat loss. Heat generation of the transducers differ among the piezoelectric materials with each operating frequencies. It is considered that the heat generation of the 1 MHz and 2 MHz transducers are lower than heat loss of the vessel, and the 3 MHz transducer are higher.



a) Operating frequency of 1 MHz



b) Operating frequency of 2 MHz



c) Operating frequency of 3 MHz

Fig. 2 Relationships between applied voltage to the transducers and ultrasonic power obtained by calorimetric and RFB method. Operating frequencies are 1 MHz, 2 MHz, and 3 MHz, respectively.

4. Summary

We have been developing the measurement technique of ultrasonic power using calorimetric method as national standard. In this paper, we investigated the ultrasound transducers at operating frequency of 1 MHz, 2 MHz, and 3 MHz which are planned to use as a reference transducers. As the results, it is found that there were differences between the results by the calorimetric method and RFB.

In the future work, the differences in values measured by RFB method and calorimetric method will be investigated. Also, we will investigate the measurement of uncertainly of ultrasonic power by calorimetric method.

Acknowledgment

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References

1. T. Kikuchi and S. Sato: IEICE Technical Report, US2006-21(2006-06) 33.
2. IEC 61161 (2013) 3rd ed.
3. T. Uchida, and T. Kikuchi: Proceeding of Symposium on Ultrasonic Electronics, **33** (2012) 55
4. T. Uchida, and T. Kikuchi: Jpn. J. Appl. Phys. **52** (2013) 07HC01.