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Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 277-278
6-8 December, 2010

The Investigation on the Temperature Measurement based on the Infrared Imaging with the Split TMM

分割 TMM を用いた熱画像による温度測定の妥当性検討

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1. Introduction

The acoustic output of medical ultrasound diagnostic equipments are regulated by nondimensional indices from the viewing point of the potential risk of bioeffects. They are MI (mechanical index) and TI (thermal index), which consider mechanical effect of cavitations and thermal effect of temperature rise generated by ultrasound absorption, respectively. Those definitions were originated in [1] by AIUM / NEMA in 1992 and reviewed by Dr. J. G. Abbott in [2]. In case of TI, however, the definition is based on the heating due to the absorption of ultrasound although the causes of thermal effect durting ultrasonic diagnostics are not only absorption of ultrasound but also thermal conduction transducer developed. To discriminate these two effects, infrared imaging with split TMM (Tissue Mimicking Material) was proposed to measure the temperature rise and to find the position of maximum temperature while ultrasound irradiation by the ultrasound diagnostic systems and the usefulness has been shown in [3] and [4].
In this study, to cralify the measurement ability of this method, the simple relations among radiated ultrasonic energy, the energy used for generating temperature rise and the diffused energy were quantitatively estimated using the intrared images and split TMM.

2. Method

Fig. 1 shows measurement procedure. The circular disk transducer of the standard ultrasound source (CW, 3.5 MHz, Precision Acoustic Limited, UK) was located 1 cm above the split line of the combined TMM which was located in water. as shown in (a) The uncertainty of the radiated power from the check source was estimated about 4 %. After a specified radiation time, the split TMM was moved out from the water and separated to two pieces for capturing infrared image in air as shown

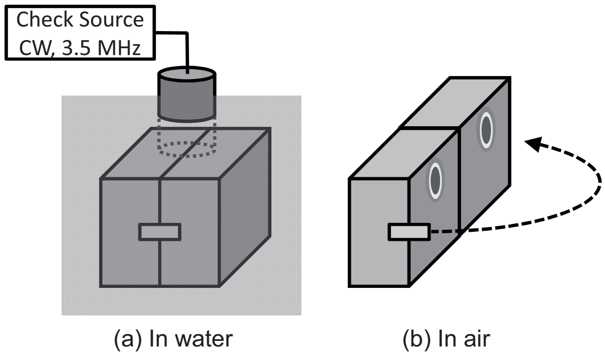

Fig. 1 Procedure. (a) Ultrasound was radiated from the ultrasonic source to the combined split TMM in water. (b) After a specified radiation time, the TMM was moved in air and split into two pieces for capturing infrared image.

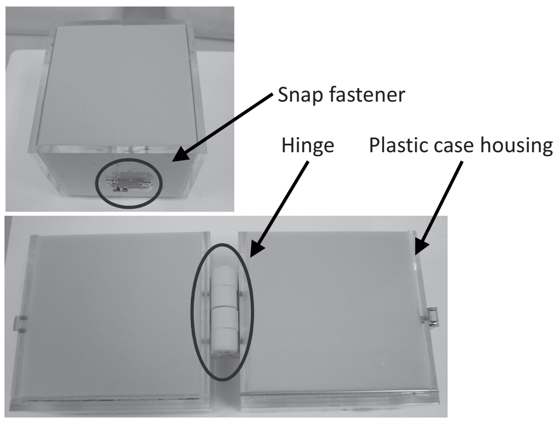

Fig. 2 Improvement of Split TMM.

in (b). In this case, the first order approximated relation, $E_P = E_A + E_B$, was considered among the radiated acoustic energy by the ultrasound check source, E_P, the energy for heating the TMM along the transmit pattern of radiated ultrasound, E_A and the diffused energy to the water surrounding the TMM, E_B. E_A is a product of heat capacitance, the volume of cylindlical shape, density and temperature rise. E_B is also a product of thermal conductivity, surface area of cylindlical shape,

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difference of temperature and time. In this study the relationship among E_P, E_A and E_B was evaluated in the actual infrared image (CPA-SC660, CHINO). Additionally, the split TMM was improved as shown in **Fig. 2**. For easy handling and keeping the property, it was in the plastic case housing except for acoustic window. The hinge combined each piece of split TMM. And the snap fastener made the easy and tight combination of them.

3. Results

The result for three conditions of E_P was obtained as shown in **Fig. 3**. In this case the output power of the ultrasound check source was set in 1(W) and radiation time was selected as 5 (min), 10 (min) and 20 (min) for making E_P 300 (J), 600 (J) and 1200 (J), respectively. **Fig. 4** shows the infrared image with E_P of 600 (J) as an example.

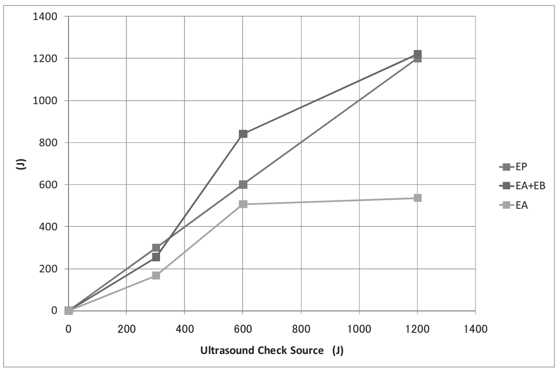

Fig. 3 Comparison between E_P and (E_A + E_B).

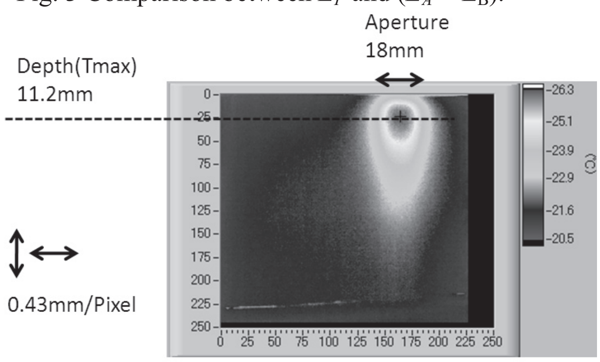

Fig. 4 Infrared image for E_P of 600 (J).

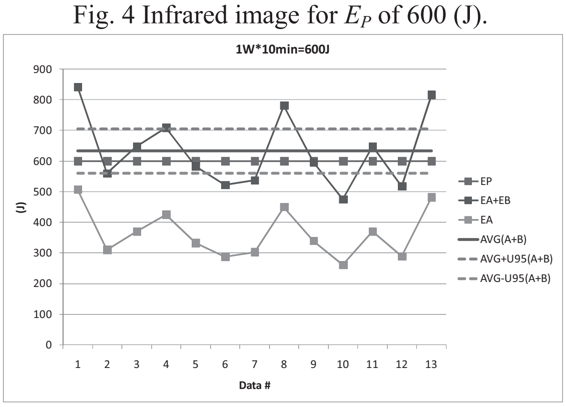

Fig. 5 Repeatability for E_P of 600 (J).

The ratio of (E_A + E_B)/ E_P were 0.85, 1.40 and 1.02 for E_P of 300 (J), 600 (J) and 1200 (J), respectivelly. Although the value of ratio were around 1, they were under the just coarse fitting based on the simple approximation.

13 times measurements for E_P of 600 (J) was performed in order to evaluate the repeatability as shown in **Fig. 5**. The averaged value of (E_A + E_B) was 633.3 (J) although the radiated energy was 600 (J). The difference between these values was+6 (%) and it was within the range of variation of +/-72.8 (J).

4. Summary

In this study, the measurement ability of temperature rise in the split TMM by using infrared images are estimated by using the standard ultrasonic source. The simple relation among the radiated acoustic energy, the energy for generating temperature rise in TMM and the diffused energy in TMM and ambient was investigated on the actual infrared image with improved split TMM. Consequently, radiated acoustic energy, E_P and the summation of the energy for generating temperature rise and the diffused energy, E_A + E_B agreed within the variation of repeatability .

From these experimental resuls, it is found that the proposed measurement system and method are appropriate for the measurement of temperature rise by ultrasonic irradiation.

Acknowledgment

I am grateful to Mr. Hisao Iino and Mr. Tomohide Nanakubo for their contribution to the measurements.

The applied split TMM was lent for this study in the Ultrasound Committee, JEITA.

References

1. AIUM/NEMA, UD 3 – Standard for Real-Time Display of Thermal and Mechanical Indices on Diagnostic Ultrasound Equipment, American Instutute for Ultrasound in Medicine / National Electrical Manufacturers Association, (1992)
2. J. G. Abbott, Ultrasound in Med. & Biol., vol. 25, no. 3 (1999) 431.
3. S. Yamazaki, Proc. IUS, UFFC, IEEE (2008) 377.
4. S. Yamazaki, UMB, vol. 35, no. 8S, Aug. (2009) S120.