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Temperature rise of soft material surface by irradiation with high-intensity aerial ultrasonic waves
強力空中超音波照射時の ソフトマテリアル表面の温度上昇の検討

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1. Introduction

Recently developed aerial ultrasonic sound sources are capable of generating extremely high-intensity aerial ultrasonic waves, and it has seen applied across a variety of technologies [1]. The sound pressure radiated by such sources is over 20 kPa. Incidentally, many studies have reported a heat elevation effect in human tissue under ultrasonic irradiation (e.g. in high-intensity focused ultrasound treatment) [2,3], mainly due to absorption of the sound wave energy. Therefore, we would expect that soft materials as well will experience heating when irradiated with high-intensity aerial ultrasonic waves; however, very few studies have attempted to examine this.

In this investigation, we therefore examined temperature distribution on the surface of soft materials irradiated with high-intensity aerial ultrasonic waves.

2. Measurement

The experimental devices were arranged as shown in **Fig. 1**. A point-converging acoustic source with a stripe-mode vibration plate (frequency: 19.6 kHz) [4] was used to generate high-intensity aerial ultrasonic waves. The convergence point was on the z-axis running through the center of the vibration plate, approximately 130 mm from its edge. **Fig. 2** shows sound pressure distribution around the convergence point in the x–y plane, and shows that the ultrasonic waves converge to a 15 mm diameter focus. The intensity of the aerial ultrasonic waves is about 23.5 kPa (181 dB) at an input power of 150 W. The center of the sample was placed to coincide with this convergence point.

The sample material was prepared silicone rubber (KE-12; Shin-Etsu Chemical Co., Ltd.), shown in **Fig. 3**. The sample had thickness 15 mm and dimensions of 80×80 mm^2; the total sample dimensions were therefore larger than the sound waves convergence area. The sample was irradiated for 5 minutes at an electric input power of 150 W, 100 W, and 50 W. The temperature of the sample surface under ultrasonic irradiation was measured from a single angle with an infrared camera, located above the sample.

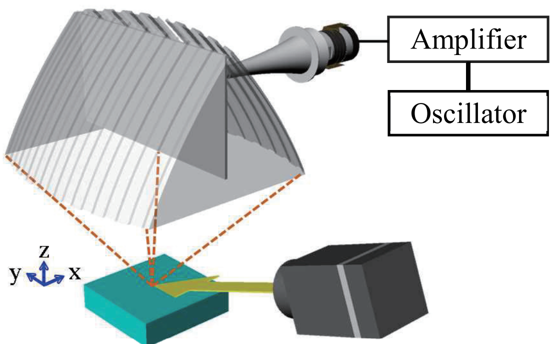

Fig. 1 Experimental sevices.

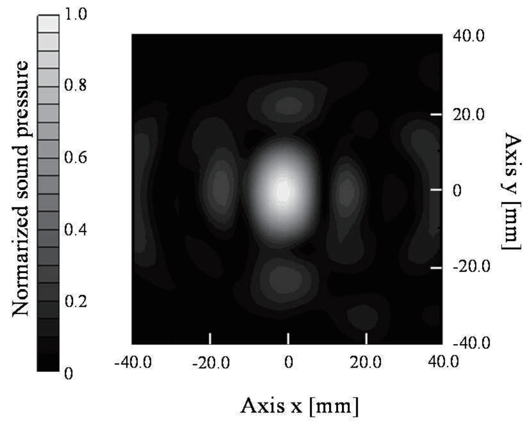

Fig. 2 Sound pressure distribution around the convergence point.

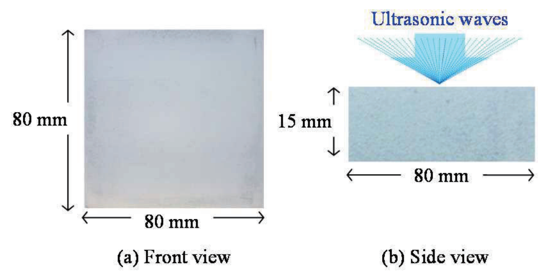

Fig. 3 Schematic view of silicone rubber.

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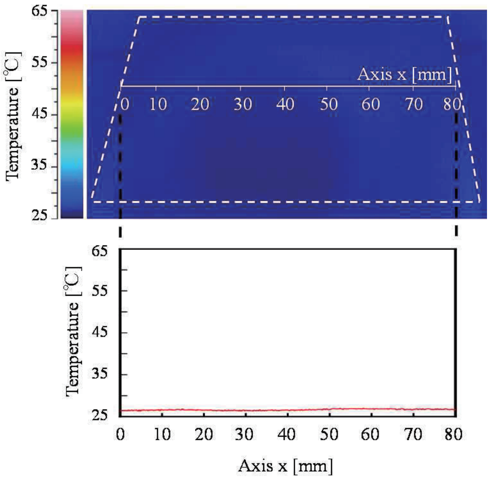
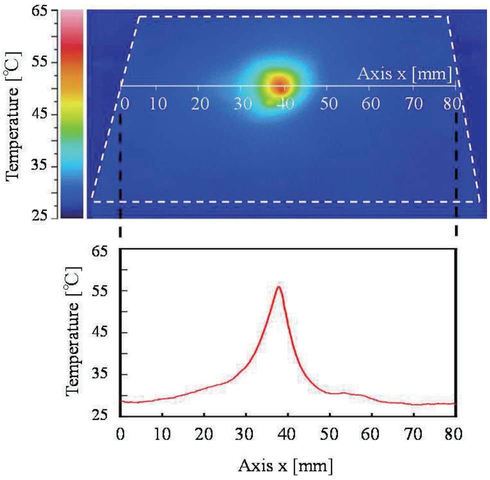
3. Results

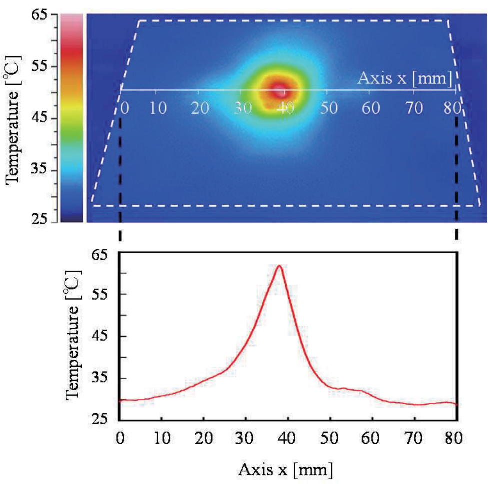
Fig. 4 shows the thermal image on the sample surface and the temperature distribution on the X-axis under ultrasonic irradiation at 150 W electric input power. Fig. 4(a) shows the initial state, 4(b) 10 s later, and 4(c) 60 s later. The results indicate an increase in surface temperature over time. In addition, the temperature elevation area spatially agrees with the convergence area of sound waves (as seen in Fig. 2) and also widens gradually as time passes.



(a) Initial state



(b) 10 seconds later



(c) 60 seconds later

Fig. 4 Temperature distribution on the surface of sample at electric input power 150 W.

Fig. 5 shows the temperature rise over time for each electric input power, measured at the hottest point of sample. In each case, a rapid temperature rise was observed immediately after beginning ultrasonic irradiation. After 60 s, the temperature on the surface of sample had become nearly saturated and thereafter did not change much. The maximum temperature rise reached 35 °C at electric input power 150 W.

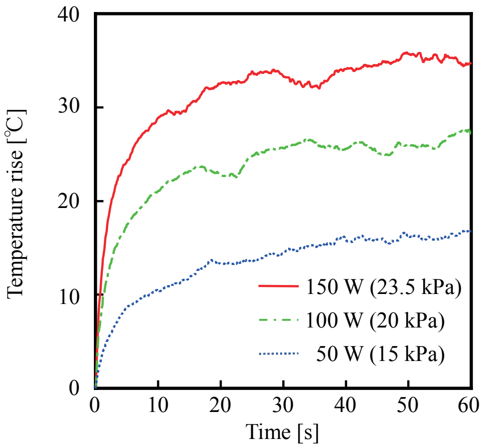


Fig. 5 Relationship between temperature rise and time.

4. Conclusion

We investigated temperature elevation on the surface of a soft material when exposed to high-intensity aerial ultrasonic waves. There was a clear temperature-elevation effect on the area corresponding to the area of the surface irradiated with ultrasonic waves. The temperature rise occurred immediately after ultrasonic irradiation began, and a maximum temperature elevation of 35 °C was observed with an electric input power of 150 W.

References

1. Y. Ito: Acoust. Sci. & Tech. **36** (2015) 216.
2. Y. Ito: J. Acoust. Soc. Jpn. **71** (2015) 247. [in japanese]
3. S. Tanaka, K. Shimizu, S. Sakuma, T. Tsuchiya, and N. Endoh: Jpn. J. Appl. Phys. **52** (2013) 07HF09.
4. A. Asai, H. Okano, S. Yoshizawa and S. Umemura: Jpn. J. Appl. Phys. **52** (2013) 07HF02.