1P4-10

Fundamental Research on Acoustic Characteristics of Wet Cotton Fabric by Using Ultrasound of 28 kHz

28 kHz の超音波を用いた水を含んだ綿布の音響特性の基礎検討

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1. Introduction

Techniques have been studied for using ultrasonic vibration to dry wet clothes.[1] The method involves bringing an ultrasound source into contact with the wet clothes, thereby atomizing the moisture and drying the clothes.

Based on the above, we are investigating the use of aerial high-power ultrasonic waves to dry clothes. Drying clothes using aerial high-power ultrasonic waves involves ultrasonic atomization when the moisture content is relatively high and ultrasonic drying when the moisture content is lower.[2, 3] In other words, as the moisture content of the clothes changes during drying, so do the acoustic characteristics. From this, we reason that drying clothes involves optimizing the irradiation conditions of the aerial high-power ultrasonic waves for each phenomenon.

In this paper, as fundamental research into the acoustic characteristics of water-containing cotton cloth, we investigate the formation of a standing wave field using ultrasonic waves with a frequency of 28 kHz and an acoustic tube when using as the reflector cotton fabric that contains water.

2. Measuring device

Figure 1 shows a schematic of the measurement device used in this study. The device had an acrylic pipe as its acoustic tube, the inner diameter of which was 6.0 mm; this is less than or equal to 0.58 times of 12.4 mm which is one wavelength of 28 kHz ultrasonic waves propagating in air (24°C) for to use acrylic pipe as acoustic tube. To measure the sound pressure distribution, the acrylic pipe contained a notch (of width ~1 mm) in the longitudinal direction. The reflector was sandwiched between two duralumin boards that have holes are used as fixing jigs. In that state, the reflector was connected to the acrylic pipe.

As the ultrasound source, the vibration source shown in **Fig. 2** surface of which had a diameter of 5.5 mm and vibrated uniformly. The ultrasound source comprised a bolt-clamped Langevin-type longitudinal vibration transducer (NGK Spark Plug D2428PC), an exponential horn, and a stepped horn. These parts were joined by stud bolts. From measuring its admittance loop, the ultrasound source resonated at 27.7 kHz, and this frequency was also used for measurement. Measurements were made of the impedance of the ultrasound source when the distance *y* between the reflector and the ultrasound source was changed, and the sound pressure distribution formed between the reflector and the sound source.

3. Relationship between distance *y* and source impedance

To determine the distance at which a standing wave occurred, the impedance of the ultrasound source was measured as the distance *y* between the reflector and the source was changed. The impedance of the source was calculated from the terminal voltage of the sound source and the supply

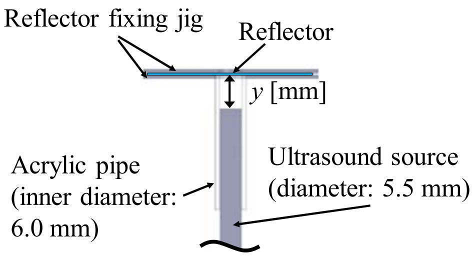

Fig. 1. Schematic of measurement device.

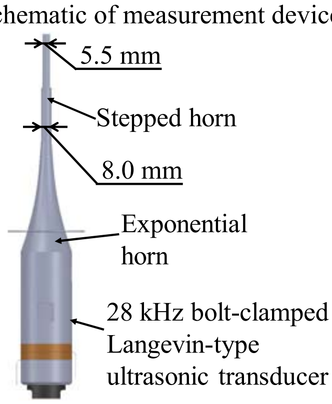

Fig. 2. Outline of 28 kHz ultrasound source.

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current. The sound source was driven at a constant terminal voltage of 5 V_{rms} and a driving frequency of 27.7 kHz. The conditions of the reflector were as follows: an aluminum plate (thickness 0.5 mm) and cotton fabric (100% cotton, 0.19 g) with a dry basis moisture content of either 0% or 100%.

Figure 3 shows the results. The impedance reaches a local maximum value periodically as the distance *y* is changed; the period is around 6.4 mm. For the aluminum plate and the cotton fabric with 100% moisture content, the magnitudes of the change in impedance are almost the same. From this, we reason that almost the same standing wave is formed when either an aluminum plate or cotton fabric with 100% moisture content is used as the reflector. On the other hand, for the cotton fabric with 0% moisture content, the impedance is smaller than that in the other two cases. From this, we reason that the standing wave in the case of cotton fabric with 0% moisture content has a small standing wave ratio.

4. Sound pressure distribution

To clarify the standing waves formed by each reflector, the sound pressure distribution between the reflector and the sound source was measured. The driving conditions of the sound source and the condition of the reflector are the same as in §3. The distance between the reflector and the ultrasound source was 12.8 mm. The sound pressure distribution was measured by inserting a microphone (ACO TYPE-7017) on a probe via the notch in the acrylic pipe and scanning it in the *y* direction.

Figure 4 shows the results. The dotted lines in the figure are sine waves drawn to show the imagined sound pressure where the microphone cannot measure. From Fig. 4, the different sound pressure distributions are such that the positions of the nodes/antinodes of the sound pressure accord and have a distribution of one wavelength. The standing waves for the aluminum plate and the cotton fabric with 100% moisture content have almost the same magnitudes of sound pressure. From this, the cotton fabric with 100% moisture content reflects most acoustic waves in the same was as the aluminum plate and forms a standing wave with a high standing wave ratio. On the other hand, for the standing wave of the cotton fabric with 0% moisture content, the standing wave ratio is much lower. From this, the cotton fabric with 0% moisture content has a small acoustic reflection coefficient.

5. Conclusion

In this paper, to investigate the fundamental acoustic characteristics of wet cotton fabric, we studied the formation of 28 kHz standing waves using cotton fabric with differing moisture content as the reflector. When using cotton fabric with 100% moisture content, a standing wave formed that was the same as that when using an aluminum plate. On the other hand, when using cotton fabric with 0% moisture content, a standing wave formed with a low standing wave ratio. From this, we clarified that the reflection of sound waves differs according to moisture content, and the resulting standing wave that forms also differs according to moisture content.

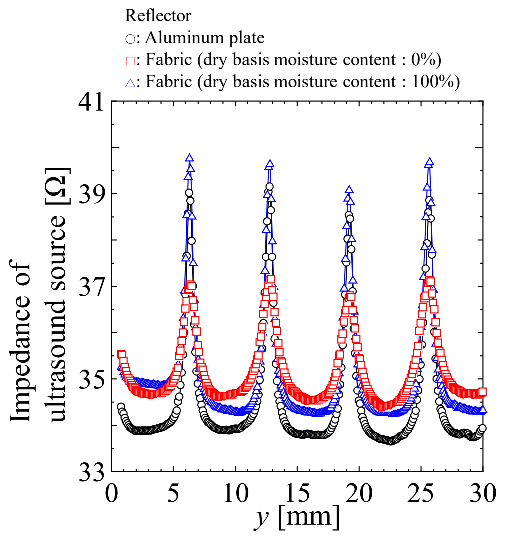

Fig. 3. Relationship between distance *y* and impedance of ultrasound source.

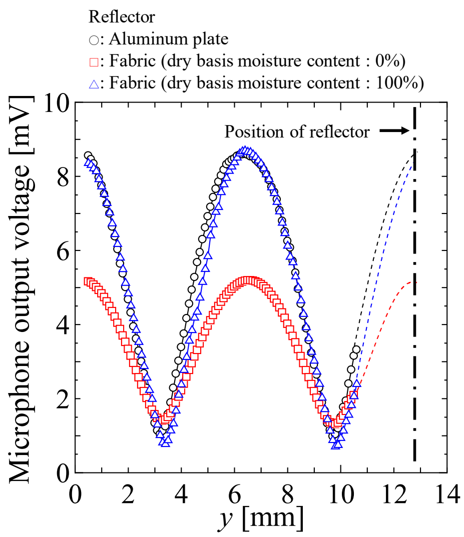

Fig. 4. Sound pressure distributions at y = 12.8 mm.

References

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