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Development of Impact-reduction System Using Ultrasonic Melting
超音波溶融を利用した衝撃軽減装置の開発

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1. Introduction

Impact-reduction structures and materials are used for many applications such as crushable zones of vehicles and buffers for precision equipments. However, they do not necessarily absorb sufficient energy from the impact in all cases. Furthermore, the impact-reduction characteristics can not be changed instantaneously. In this light, in this study, we aim to develop an impact-reduction system by applying the ultrasonic vibrations that can change the rigidity of the material instantaneously in the event of a impact.

Various studies have focused on the use of ultrasonic vibrations for plastic deformation [1, 2]. We have previously reported on the deformation and impact-reduction characteristics when applying ultrasonic vibrations to a high-tensile steel plate [3, 4]. In this study, we developed an experimental device to confirm the impact-reduction effect by applying ultrasonic vibrations to a hot-melt adhesive (HMA). The vibration characteristics of the ultrasonic transducer and the impact-reduction characteristics were measured.

2. Configuration

Fig. 1 shows the configuration of the experimental equipment that consists mainly of an ultrasonic transducer (a bolt-clamped Langevin-type transducer (BLT) with a stepped horn), a drop weight (4.4 kg) for impact testing, a jig, and a dynamic force sensor. These components except for the sensor can be separately moved up and down by attaching them to a slide guide. The diameter and resonant frequency of the BLT are 56 mm and approximately 17 kHz, respectively. The stepped horn is installed to increase the vibration amplitude. The material of the horn is chromium molybdenum steel (JIS SCM440).

The crumple specimens (HMA used for an electric hot glue gun) are 11.5 mm and 10 mm in diameter and height, respectively. The ultrasonic transducer is pressed against the crumple specimen at the edge of the horn.

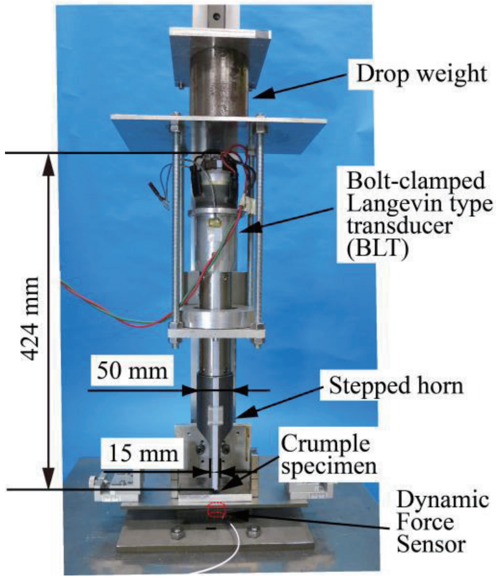

Fig. 1 Configuration of experimental equipment for impact-absorbing test by applying ultrasonic vibration.

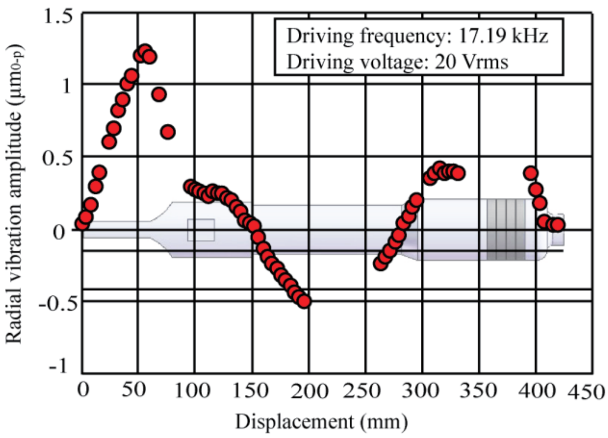

Fig. 2 Radial vibration amplitude distribution along ultrasonic transducer under no-load condition.

3. Vibration characteristics

Fig. 2 shows the vibration distributions along the transducer. The radial vibration distribution was measured using a laser Doppler vibrometer. The longitudinal vibrations at the free end of the horn had the maximum value at a frequency of 17.19 kHz. Hence, the vibration distributions were measured at a frequency of 17.19 kHz (driving

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voltage: 20 Vrms). It is confirmed that the vibration amplitude is expanded by the horn. The nodes of the radial vibration distributions exist at both ends of the horn; this indicates that a bending vibration does not occur along the ultrasonic transducer and that the ultrasonic transducer is driven as designed.

4. Impact-reduction characteristics

The impact-reduction characteristics were measured at a frequency of 17.19 kHz and a voltage of 100 Vrms. **Fig. 3** shows the relationship between the fall height of the impact weight and the impact force. The impact force was measured using the dynamic force sensor. The impact force increased with the fall height of the impact weight and decreased to 89% upon the application of the ultrasonic vibrations when the fall height of the impact weight was 100 mm. We confirm that the impact is reduced by the application of ultrasonic vibrations.

Fig. 4 shows the impact waveforms when the ultrasonic vibrations were applied and when they were not applied. The fall height of the impact weight was 100 mm. **Fig. 5** shows the crumpled conditions of the HMA specimens when the ultrasonic vibrations were applied and when they were not applied.

5. Conclusion

We developed an experimental device to confirm the impact-reduction effect by applying ultrasonic vibrations to a HMA. In this study, we measured the vibration characteristics of the ultrasonic transducer and the impact-reduction characteristics. The following main results were derived from this study:

(1) The ultrasonic transducer was driven as designed.
(2) The impact force was reduced by up to 11% by the application of ultrasonic vibrations.

The effect of ultrasonic vibrations can be further enhanced by selecting appropriate materials, shapes, and sizes of the crumple specimens. The future challenge is to improve the effect further and to reduce the size and cost of the equipment.

Acknowledgment
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References

1. J. Tsujino, H. Ito, and H. Sato, Proc. of Symposium on Ultrasonic electronics (1990) 162.
2. T. Wen, L.Wei, X. Chen, and C. Pei: International Journal of Minerals, Metallurgy and Materials **18** (2011) 70.
3. A. Suzuki, E. Ueki, and J. Tsujino., International Congress on Ultrasonics, AIP Conf. Proc. 1433 (2011) 369.
4. A. Suzuki, T. Onitake, K. Ikunaka, and J. Tsujino, Proceedings of IEEE 2013 Joint UFFC, EFTF and PFM symposium (2013) 1650.

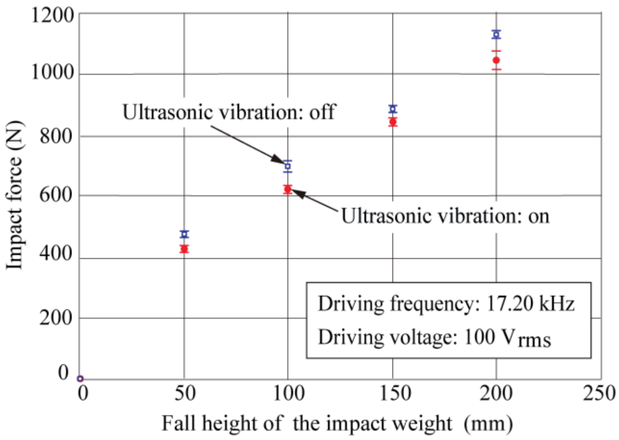

Fig. 3 Relationships between fall height of the impact weight and impact force when ultrasonic vibrations were applied and when they were not applied. (fall height: 100 mm).

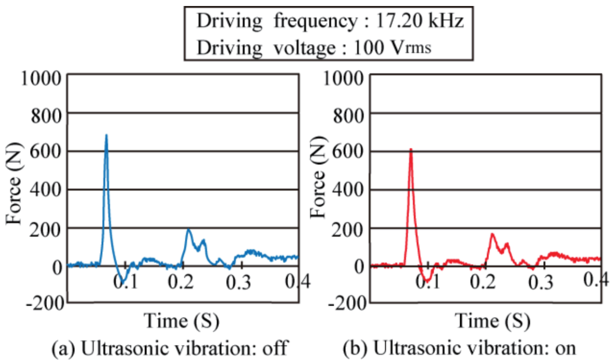

Fig. 4 Impact waveforms when ultrasonic vibrations were applied and when they were not applied (fall height:100 mm).

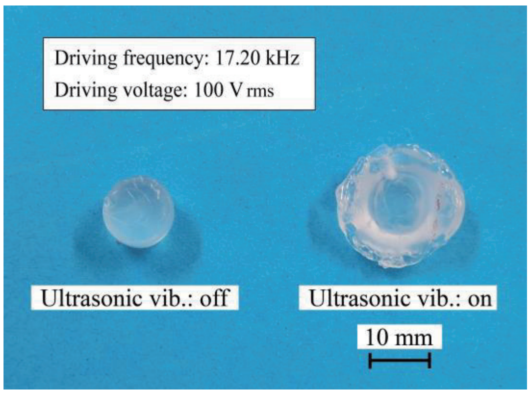

Fig. 5 Crumpled conditions of hot-melt adhesive specimens when ultrasonic vibrations were applied and when they were not applied.