Proceedings of Symposium on Ultrasonic Electronics, Vol. 30 (2009) pp. 291-292
18-20 November, 2009

Characteristics of Longitudinal Vibration to Cut a Circle Shape by Ultrasonic Vibration

超音波振動によって円形に切断するための振動体の縦振動特性

Takuya Asami[1‡], Hikaru Miura[1] ([1]College of Science and Technology, Nihon Univ.)
淺見拓哉 [1‡]，三浦　光 [1]（[1] 日大・理工)

1. Introduction

Currently, laser and water jet are used to cut brittle material in a circle shape. However, the disadvantage of these methods is that conventional equipment is large and its structure is complex.

To solve this issue, a method using ultrasonic vibration of a hollow type stepped horn for cutting is developed, and we foresee that equipment can be simplified and miniaturized.

The preceding study of longitudinal and tensional vibration characteristics of a hollow type stepped horn joined cutting tip has been performed.[1)] However, detailed examination of a hollow type stepped horn was not performed in the preceding study.

In this study, ultrasonic vibration sources of a hollow type stepped horn are used. Vibration characteristics of a hollow type stepped horn are clarified and the relationship between the measurement position and vibration amplitude is discussed.[2)] The relationship between cross-sectional ratio and amplification factor are also discussed.

2. Ultrasonic Vibration Source

Figure 1 shows the ultrasonic vibration source. The ultrasonic vibration source consists of a 20 kHz bolt-clamped langevin-type transducer, an exponential horn for amplitude amplification (large end diameter: 55 mm, small end diameter: 12 mm, amplification factor: approximately 4.7, material; duralumin), and a hollow type stepped horn, which is discussed later in this paper.

Figure 2 shows the hollow type stepped horn. The dimensions of the hollow type stepped horn are as follows: length 120 mm; large diameter 12 mm; depth of the hollow part a [mm]; inner diameter of the small end (hollow-pipe type) b [mm]. The resonance frequency of the ultrasonic vibration source is 19.1～20.9 kHz.

3. Ring-type magnetic ultrasonic vibration detector

The longitudinal vibration of a hollow type stepped horn at the measurement position L was measured using the ring-type magnetic ultrasonic vibration detector.[3)]

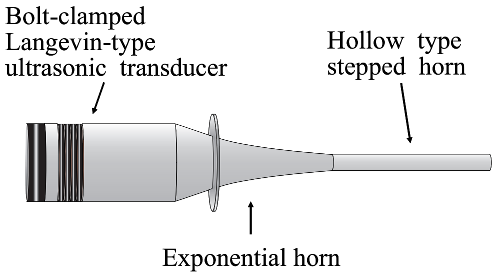

Fig. 1 Ultrasonic vibration source

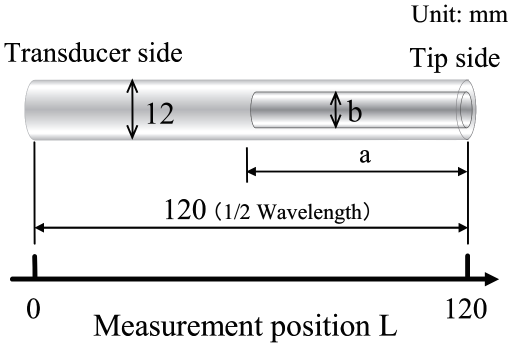

Fig. 2 Hollow type stepped horn

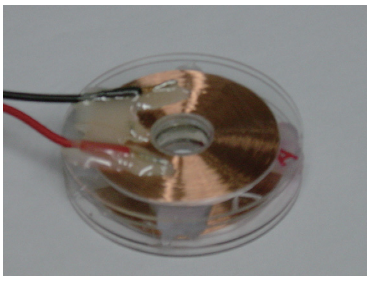

Fig. 3 Ring-type magnetic ultrasonic vibration detector

Figure 3 shows the ring-type magnetic ultrasonic vibration detector. The dimensions of the ring-type magnetic ultrasonic vibration detector are as follows: thickness 11 mm; outside diameter 40 mm; inside diameter 13 mm.

The detector output voltage is the result of eddy currents produced by magnetic flux and vibration velocity at the vibration surface, and is proportional to the vibration velocity amplitudes. Two coils are connected in a series with anti-phase polarity.

4. Longitudinal vibration distribution of hollow type stepped horn

To study the longitudinal vibration distribution of a hollow type stepped horn, the

----

E-mail address: miura@ele.cst.nihon-u.ac.jp

Table 1 Relationship between inner diameter and cross-sectional ratio

Inner diameter b [mm]	0.0	8.5	9.3	9.8	10.1	10.4	10.5	10.6	10.7	10.9	11.0
Cross-sectional ratio	1.0	2.0	2.5	2.9	3.4	4.0	4.3	4.6	4.9	5.7	6.3

longitudinal vibration of a hollow type stepped horn at the measurement position L (effective value) was measured by changing the depth of the hollow part a in the range of 50～70 mm at 5 mm intervals. In the experiment was conducted while the longitudinal vibration amplitude of the transducer side was held constant at 0.2 μm, and the inner diameter of the small end b was held constant at 10.4 mm.

Figure 4 shows the result. The vertical and horizontal axes in Fig. 4 represent the longitudinal vibration amplitude (effective value) and measurement position L. According Fig. 4, the loop position of the longitudinal vibration amplitude is at the transducer side (L= 0 mm), its node position is at the L= 49～56 mm and its loop position appears again at the tip (L= 120 mm). The longitudinal

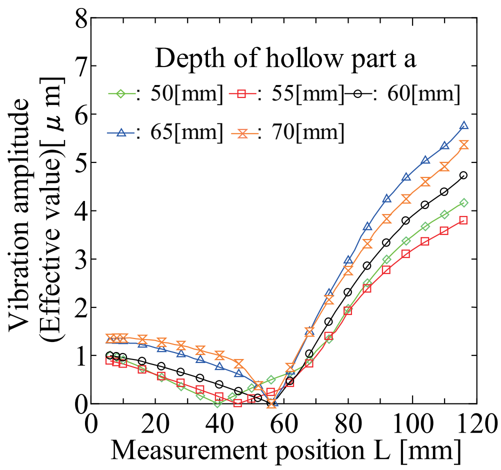

Fig. 4 Vibration distribution

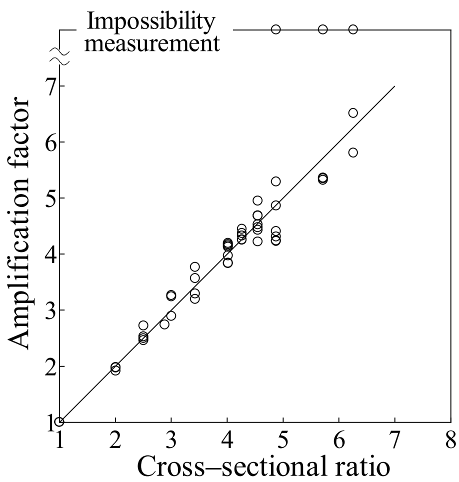

Fig. 5 Relationship between cross-sectional ratio and amplification factor

vibration has a resonance of 1/2 wavelength at this hollow type stepped horn length. This result indicates that the longitudinal vibration distribution is affected by the length of the hollow part a.

5. Relationship between cross-sectional ratio and amplification factor

To study the relationship between the cross-sectional ratio of a hollow type stepped horn and the amplification factor, the longitudinal vibration at the tip (effective value) of a hollow type stepped horn was measured by varying the inner diameter of the small end b as shown in Table 1. In the experiment was conducted while the longitudinal vibration amplitude of the transducer side was held constant at 1 μm, and the depth of the hollow part a was held constant at 60 mm.

Figure 5 shows the result. The vertical and horizontal axes in Fig. 5 represent the amplification factor (the longitudinal vibration at the tip of a hollow type stepped horn/ the longitudinal vibration at the tip of a uniformity rod) and the cross-sectional ratio (transducer side cross-sectional of a hollow type stepped horn/ tip side cross-sectional). According Fig. 5, amplification factors are proportional to the cross-sectional ratio, but if the amplification factor exceeds 4.6, it was not proportional to the cross-sectional ratio.

6. Conclusions

The shape of the hollow type stepped horn and characteristics of longitudinal vibration was examined to obtain excellent vibration. As a result, the longitudinal vibration has a resonance of 1/2 wavelength at this hollow type stepped horn length. The most appropriate the depth of the hollow part a is 60 mm for the hollow type stepped horn that vibrates longitudinally. Finally, amplification factors are proportional to the cross-sectional ratio, but if the amplification factor exceeds 4.6, it was not proportional to the cross-sectional ratio.

References

1) H. Miura : Jpn. J. Appl. Phys. **47** (2008) pp. 4282.
2) T. Asami and H. Miura : *Proc. National Spring Meet. Acoust. Soc. Jpn.* (2009) p.1215 [in Japanese].
3) J. Tsujino : Jpn. J. Appl. Phys. **23** (1982) Supplement 23-1, pp. 212.