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Mechanical Evaluation to the Performance of Ultra-Sonic Vibration Horn (2nd Report)
超音波振動ホーン性能の機械的評価（第２報）

Hirofumi Miyamoto[†], Satoshi Nakamura and Toshiaki Furusawa(Faculty of Scie.＆Eng., Teikyo Univ.)
宮本裕文[‡]，中村聡史，古澤利明（帝京大 理工）

1. Introduction

The ultrasonic vibration cutting method[1)] enables a reduction in the apparent cutting resistance, leading to improvements in the machining accuracy and lifetime of tools[2)]. In micromachining, small tools must be used, and the use of the ultrasonic vibration cutting method, which is expected to reduce cutting resistance, has been promoted with the aim of preventing tool failure and the deterioration of accuracy caused by excessive cutting resistance. By the way, the productions of ultrasonic vibration cutting device are considerably difficult, because of some problems, for example, the frequency of piezoelectric transducer which recently adopted is limited to 20kHz, 30kHz, 60kHz etc, the controlled range of frequency is narrow, the energy loss occurs at connecting region, etc.

In this report, the power of elastic resonating horn is found by the measurements of deformation and load of vibration at the tip of horn simultaneously. Since the horn with high-power is able to effectively propagate the vibration against the load at the machining, the performance of horn is evaluated mechanically.

2. Experimental Methods

As shown in Fig. 1, a step horn without fillet (non-R horn), and a step horn with fillet of corner radius of 5mm between the thin edge and the flange (R horn) are used. The main conditions are as follows: the material of the aluminum alloy A7075, the frequency of 38kHz, and the amplitude magnification factor of 2.0. The flange of the horn is placed back and forth with two steel boards, and the steel board for fixation is equipped on the stock vice fixed to the base plate.

For the purpose of measurement at the lower level load to previous study[3)], an experimental device is manufactured, as shown in Fig. 2. The main improved points are as follows:

- The load which applied the horn is reduced by using the springs.
- The bolt which fixed the load-cell is rounded at the tip for improving the contact state.

The vibration energy is determined the area of the loop of displacement and the load is applied to the horn, the power is calculated from dividing the vibration energy by the period of the ultrasonic vibration[3)].

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e-mail address :u-53440@snow.ucatv.ne.jp

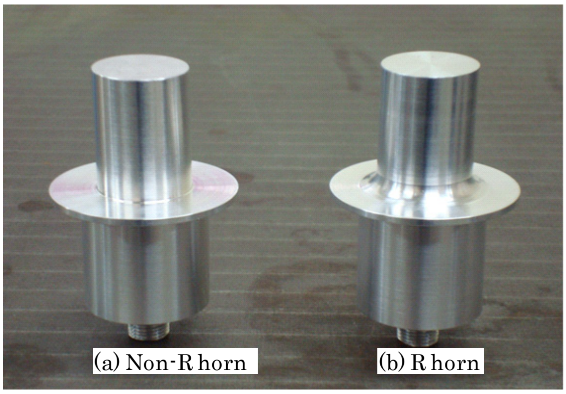

Fig.1 Used horn with and without fillet

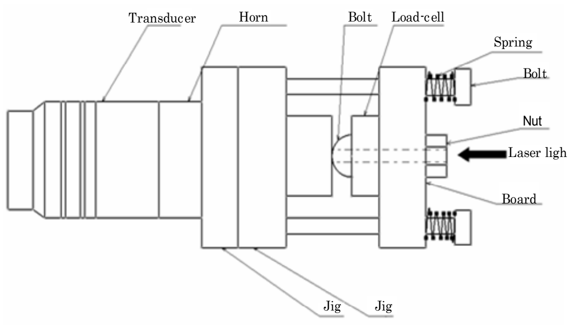

Fig.2 Sketch of power evaluation device

3. Experimental results and discussion

Figure 3 shows the relationships[3)] between the amplitude increase rate and power to the R and non-R horn, with respect to the applied load from 650N to 850N. In the case of the R horn, the power increases rapidly with increasing the amplitude amplification rate, and is not varied with each load from 650N to 850N. The horn is not suppress to the load of 850N, and generates the power efficiently. On the other hand, the power of the non-R horn is extremely small result from the amplitude is less generated.

However, the applied loads from 650N to 850N are too large for the usual load to the ultrasonic vibration cutting device. Shown in Fig. 4 are the results of the power with varying the applied load from 46N to 215N by using the device shown in Fig.2. The contrary results are obtained against Fig. 3, the powers when measured by using the non-R horn are larger than that of the R horn. In turn, we measure the power with varying the applied load on the condition of constant amplitude of 5μm at the tip of horn.

Shown in Fig. 5 are the results of the power with varying the applied load from 47N to 542N when using the R and non-R horn. In the case of the non-R horn, the powers increase with increasing the applied load from 50N to approximately 300N, but decrease with increasing with load. On the other hand, the powers of the R horn are almost constant with increasing applied load. As a result, the powers when using the R horn are larger than that of non-R horn above 400N. The results in Fig.5 are confirmed from Fig. 3 and Fig. 4.

This proposed mechanical evaluation method is verified by measurements of the admittance and the load at the tip of horn simultaneously. Fig. 6 is shown these results. The admittance when using the non-R horn is larger than that of the R horn in the range from 50N to 300N, these results are confirmed from Fig. 5. Therefore, the mechanical evaluation method is matched the electrical method.

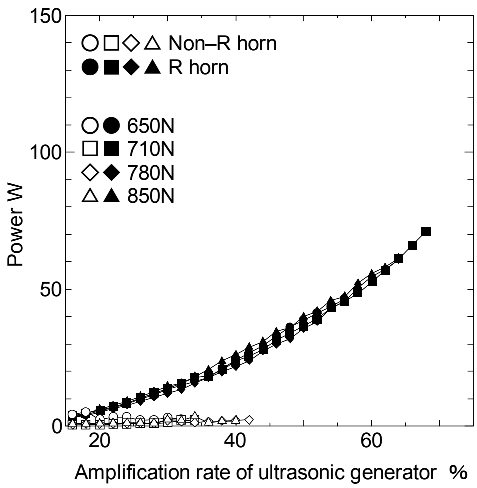

Fig.3 Relationship between power and amplification rate of ultrasonic generator at applied load of 650N-850N

4. Conclusion

For the evaluation of performance of horn, the simultaneous measurements of deformation and load of vibration are conducted. The mechanical evaluation method is matched the electrical method.

References

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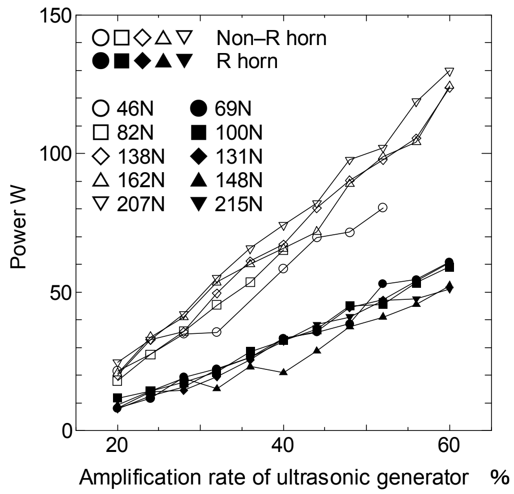

Fig. 4 Relationship between power and amplification rate of ultrasonic generator at applied load of 46N-215N

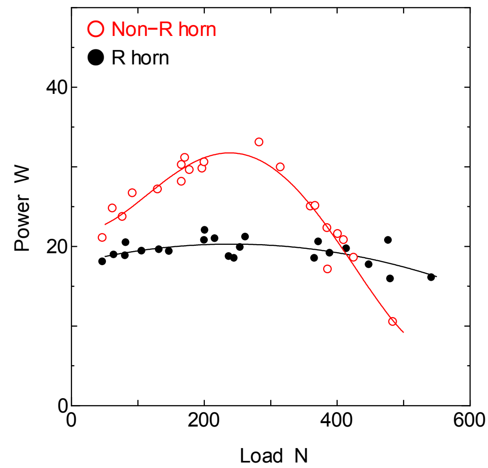

Fig.5 Relationship between power and load

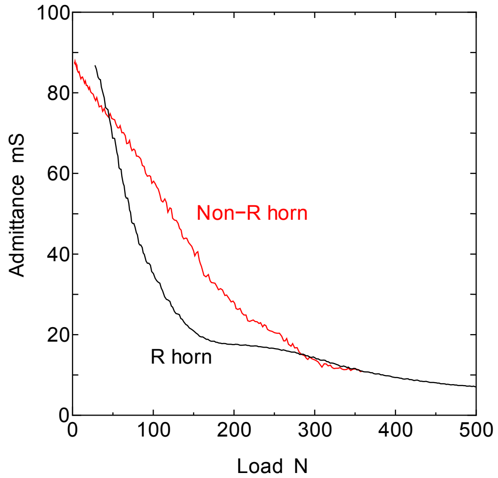

Fig.6 Relationship between admittance and load