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Mechanical Evaluation to the Performance of Ultra-Sonic Vibration Horn
超音波振動ホーン性能の機械的評価

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1. Introduction

The technologies applied a strong ultrasonic vibration to various processing and machining have an old history, in the 1960's the various methods such as abrasive machining, welding, cutting(1), and drawing using the ultrasonic vibration had been examined(2), and the part of processing methods had been put to practical use. These are placed as a processing method to special material and developed, and secretly operated in the factory as so-called production know-how.

This study has aimed to clarify the technique of the device design and manufacturing by making the ultrasonic vibration machining device with a lot of know-how of production for trial purposes. In this report, the conditions of shape and the size with better mechanical performance of parts called a horn which amplifies the vibration from the ultrasonic transducer are investigated. Designing the horn using three dimensional CAD of CATIA, and machining the horn for trial purposes, the performance is evaluated with varying the amplitude magnification factor and with changing the fixing method by measuring the frequency, the amplitude, and power as mechanical methods.

2. Experimental Methods

At the design of the horn by using CATIA, the modeling and the eigenvalue analysis are executed so that the material, shape, and the size are decided to the given frequency. The objective horn is a step horn which is easy to design, 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. Figure 1 shows drawings of designed shape and size of the horn as the fundamental type.

Moreover, in the condition of the amplitude magnification factor of 2.0, the horn with rounding the corner of a radius of 5mm between the thin edge and the flange, and the horn with and without rounding the corner of a radius of 5mm whose flange are drilled six screw holes are designed and machined. For the horn of fundamental type, the flange of the horn is placed back and forth with two steel boards(insert type), another the flange with screw is fix with the screw directly to the steel board(screw type). Finally the steel board for fixation is equipped on the stock vice fixed to the base plate.

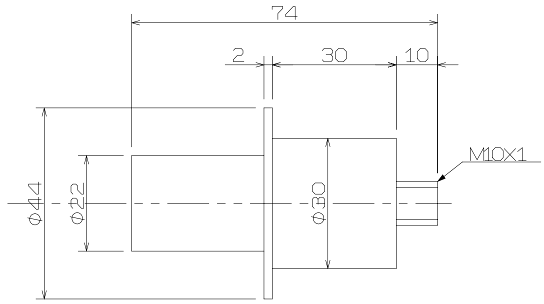

Fig.1 Fundamental horn (Amplitude magnification factor = 2.0)

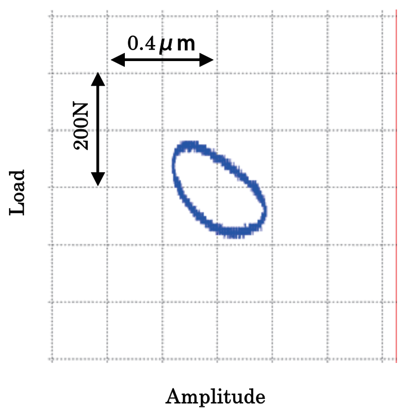

Fig.2 Energy loop formed by displacement and load

The ultrasonic vibration oscillator has the maximum supplied power of 200W and adopts the automatic frequency of PLL pursuit method with control rage of 38±1kHz. The examined horn are combined with a bolt-clamped Langevin-type transducer(3) connected with the oscillator.

The load will applied on the horn, and the vibration of the horn will be suppressed when cutting or plastic working. For the purpose of measuring the load and power, the piezo-electric type load cell with the response frequency of 200kHz is placed between the horn and the steel board, and the applied load to the horn is varied by tightening the screw attached with the steel board. As shown in Fig. 2, since the vibration energy that the area of the loop of displacement and the load is

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applied to the horn, the power is calculated from dividing the vibration energy by the period of the ultrasonic vibration.

3. Experimental results and discussion

Shown in Fig. 3 is the result of the amplitude and the frequency to the amplitude amplification rate of the oscillator with varying the applied load when using the horn without rounding the corner and the fixing method of insert type. Although the amplitude is observed from 1 to 2μm at the load of 650N, little vibration less than 1μm is observed to the load of 710N. The frequency increases with increasing the amplitude amplification rate, exceeds 39kHz which is controlled border value of the ultrasonic oscillator at the amplitude amplification rate of 20%, and arrives at 41kHz over that of 40%.

On the other hand, the horn with rounding the corner is stable from 38 to 39kHz with a few changes of the frequency as shown in Fig. 4. The amplitude amplification rate of 15% to 6μm at that of 60% in proportion to an increase of the amplitude amplification rate. It is obvious that setting the rounding the corner at flange is very effective.

Figure 5 shows the relationship between the amplitude increase rate and power with respect to the applied load to the horn with and without rounding the corner. In the case of the horn with rounding the corner, the power increases rapidly with increasing the amplitude amplification rate, and is not varied with each load. The horn is not suppress to the load of 850N, and generates the power efficiently. On the other hand, the power of the horn without rounding the corner is extremely small result from the amplitude is less generated as shown in Fig. 3.

4. Conclusion

For the purposes of trial manufacture of cutting devise or plastic working devise using the ultrasonic vibration, the conditions of shape and fixing method of the step horn are evaluated by mechanical methods.

Acknowledgment

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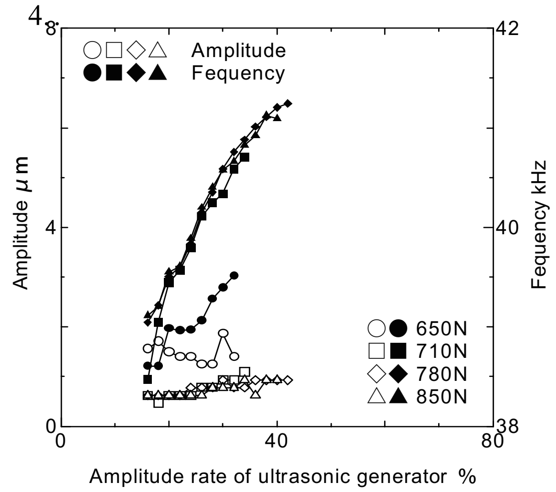

Fig.3 Relationship between amplitude, frequency and amplification rate when using horn without rounding the corner

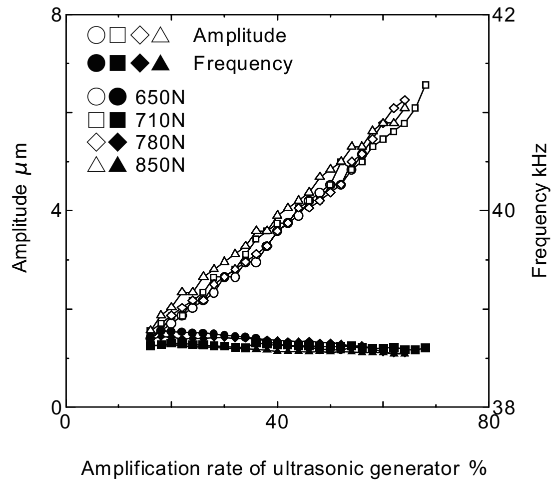

Fig.4 Relationship between amplitude, frequency and amplification rate when using horn with rounding the corner

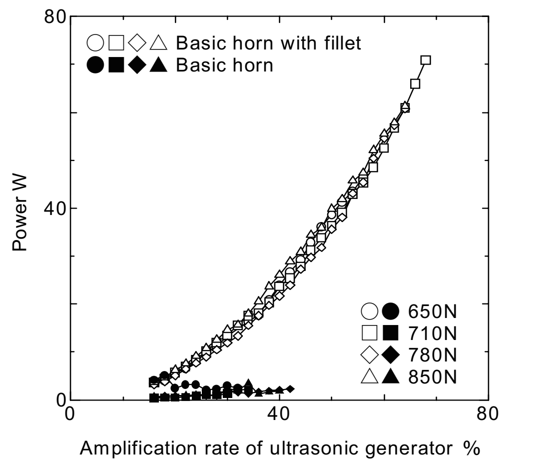

Fig.5 Relationship between power and amplification rate when using basic horn with and without rounding the corner