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Experimental Study on Vibration Characteristics in Vibration Cutting Process

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Abstract—Vibration cutting is one of the effective machining to cut hard materials, however, the surface roughness is decreased as the cutting speed increases. The purpose of this study is to observe the change of vibration state when the cutting speed is varied and to show that the sign of chatter vibration occurrence can be detected by the power spectrum analysis.

1. Introduction

The vibration cutting is a method of machining while giving a forced vibration with amplitude a and frequency f to a tool [1]. In recent years, researches on an elliptical vibration cutting are progressing to achive lower cost and higher precision machining [2].

The vibration cutting has an upper limit of cutting speed which is called the critical cutting speed v_c $(= 2\pi af)$ [3]. It is known empirically that the surface roughness is decreased at the cutting speed exceeding $v_c/3$. In order to increase the productivity of vibration cutting, it is necessary to make active use of the high cutting speed region. In this paper, we observe the vibration characteristics at the cutting speed exceeding $v_c/3$ and show the sign of chatter vibration occurrence using the power spectrum.

2. Experimental equipment and conditions

Figure 1 shows our vibration cutting device on a CNC lathe. The vibration tool is clamped by a pair of tool clamping frames with two tightening screws. The longitudinal vibration horn is connected with edge of the vibration tool by the set screw, and the tool is vibrated with the amplitude of 16 μm and the frequency of 20kHz. The work displacement in the thrust force direction is measured by a gap sensor with high response frequency. The experimental conditions are shown in the following : the cutting depth is 0.1mm, the feed rate is 0.05mm/rev, the work material is S45C steel, the critical cutting speed v_c is 120m/min and the sampling frequency is 20kHz.

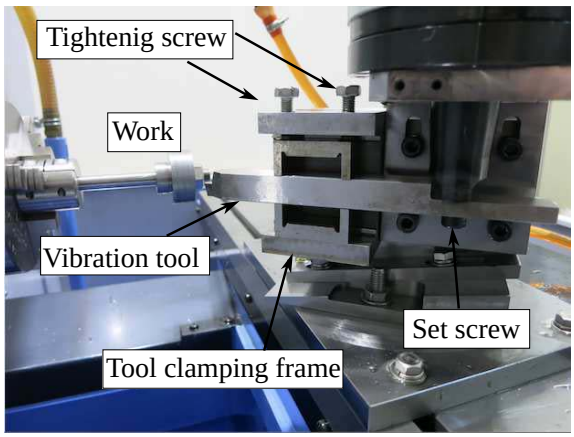

Figure 1: Vibration cutting device

3. Experimental results

We consider the relationship between the peak-to-peak value of work displacement x_{p-p} and the cutting speed v_i. When the cutting speed v_i is lower than about $3/4v_c$, the change in x_{p-p} and the arithmetic average roughness R_a are small, however, the peak of spectrum near the natural frequency of the work system gets higher as v_i increases. After the peak exceeds the reference value determined by us, the chatter vibration occurred. Therefore, we think that the power spectrum analysis is effective for predicting chatter vibration.

4. Conclusion

At the lower cutting speed than chatter vibration occurrence speed, the characteristic peak was observed by the power spectrum analysis. We expect that the fact is useful for avoiding the chatter vibration in the vibration cutting process.

Acknowledgments

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