DEVELOPMENT OF A TRIGGER SYSTEM TO MEASURE TOOL POSITION IN PLANETARY MILLING

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INTRODUCTION

In a normal ball end milling, the relative velocity between tool and material becomes zero at the rotation axis of the tool. The relative velocity is necessary to machine materials suitably. A planetary milling method[1)] is proposed to generate relative velocity at the rotation axis of the tool, so that a high quality dimple texture can be manufactured to append surface technologies to the materials.[2)]

In the planetary milling method, the dimple shape is distorted. The ball center of the tool is not set to the intersection point of the rotation axis and the revolution axis of the tool. Therefore an optical edge detection method and an image processing technique is proposed to adjust the position of the tool for the dimple. [3,4)] The tool position should be adjusted dynamically, because the tool turns at more than 40,000 revolutions per minute. And it is necessary that the image acquisition synchronize with the revolution of the tool, because the position analysis needs images observed from the same angle. However, as a rotary encoder is not installed in the tool spindle of a general milling machine, a trigger system is needed to synchronize acquisition with the revolution.

In this paper, a simple trigger system is proposed for position measurement in planetary milling working tools. In the proposed method, marking, add-on devices etc. are unnecessary because the proposed method uses light reflected at the tool. Experimental results shows that, trigger signals obtained by the proposed method are better than the one by using marker on the tool. In the image acquisition, there were no errors with the proposed trigger system.

PLANETARY MILLING

The principle of planetary milling is shown in Fig. 1. The planetary milling method is proposed to manufacture a high quality dimple. In the planetary milling, the ball end mill turns around the rotation axis and the revolution axis. The rotation axis and the revolution axis cross each other on the center of the curvature of the cutting edge in the ball end mill. In the proposed method, the dimple shape becomes distorted if the center of the curvature of the cutting edge of the ball end mill is not set to the intersection point of the rotation axis and the revolution axis of the ball end mill. As the ball end mill turns at more than 40,000 revolutions per minute, the position of the ball end mill should be adjusted dynamically.

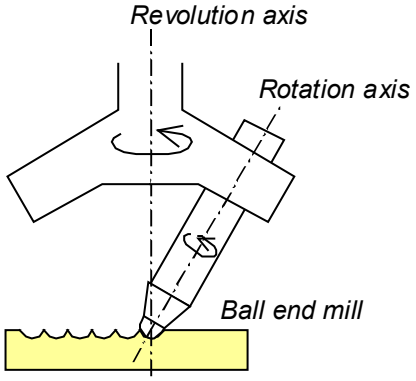


Figure 1: Principle of planetary milling

PRINCIPLE OF TOOL EDGE MEASUREMENT SYSTEM

An optical edge detection method and an image processing technique is proposed to adjust the position of the tool for machining the dimple texture. Figure 2 shows a schematic drawing of tool edge measurement system. The lens 1 and the lens 2 are Fourier transform lens and Inverse Fourier transform lens respectively.[5] The anti pinhole is put on the Fourier plane at the lens 2 for the high pass filter to generate an edge image of the tool. The lens 3 and the lens 4 magnifies the image of the tool. An edge image of the tool is captured by the CCD during spindle turning. The edge image is analyzed and the tool position is calculated by a computer.

TRIGGER SYSTEM

As rotary encoders are not installed in the spindle of the planetary milling machine, a trigger system is needed to synchronize acquisition with the revolution. Figure 3 shows a trigger system that uses the intensity of a reflecting light from a mark on the tool. It was not suitable because the signal changes depending on the size of mark and the revolution speed of the tool. A relationship between the rotary position and the signal obtained by conventional type trigger system is shown Fig. 4. The trigger signal in the old system is not responsive.

Therefore a method is proposed that uses light reflected at the tool edge. Figure 5 shows the shape of the tool edge. In this paper, the light reflected at the colored area in the flank face is used for the trigger signal. Figure 6 shows a proposed trigger system. Figure 7 shows a photograph of experimental setup. Figure 8 shows a trigger signal obtained by the proposed method. The trigger signal obtained by the proposed method is more responsive than the trigger signal obtained by the conventional system. Sensitivity has increased by seven times.

To evaluate the performance of the proposed trigger signal, tool images were captured. Figure 9 shows an edge image. As the result, there is no wrong image in 300 images captured by the proposed trigger signal.

CONCLUSIONS

In this paper, a simple trigger system is proposed for the position measurement in planetary milling while a tool is turning. As the results of experiments, the trigger signals by the proposed method are better than one using a marker on the tool. Sensitivity of the trigger signal has increased by seven times. In the image acquisition, there were no errors with the proposed trigger system.

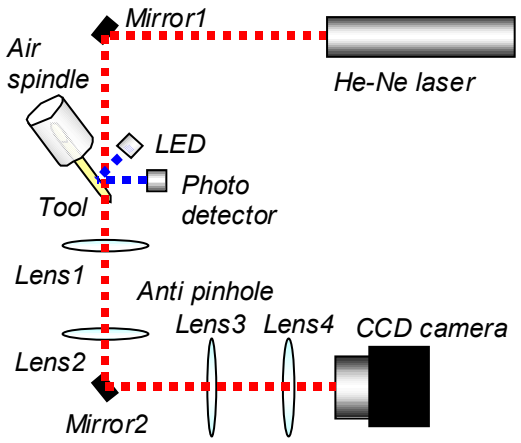


Figure 2: schematic drawing of experimental setup

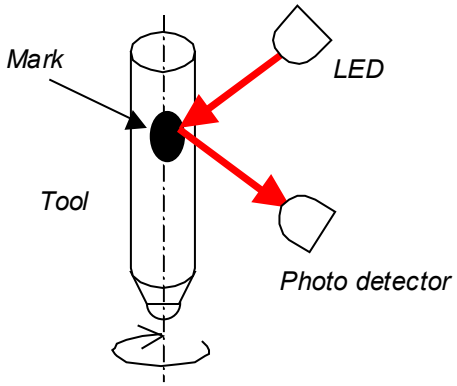


Figure 3: Conventional trigger system

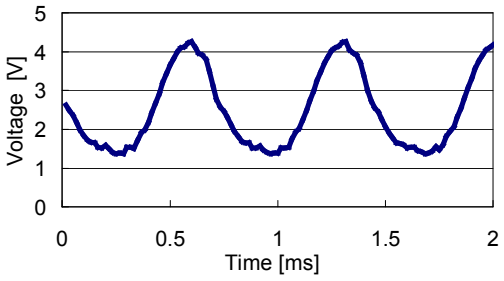
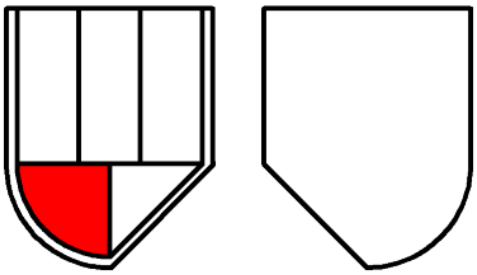


Figure 4: Trigger signal obtained by old type trigger system



(a) Flank face (b) Rake face

Figure 5: Diamond ball end mill

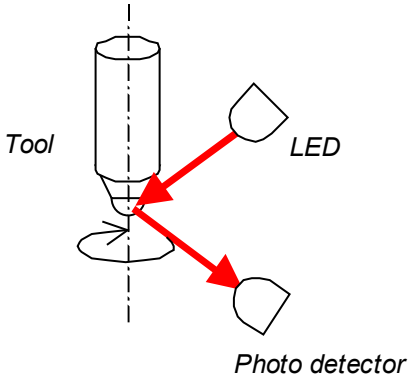


Figure 6: Proposed trigger system

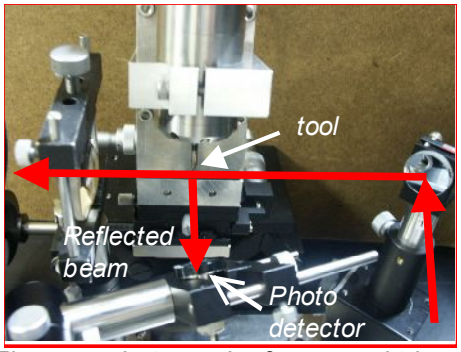


Figure 7: photograph of proposed trigger system

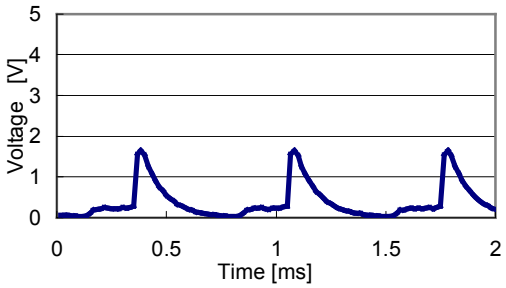


Figure 8: Trigger signal obtained by proposed trigger system

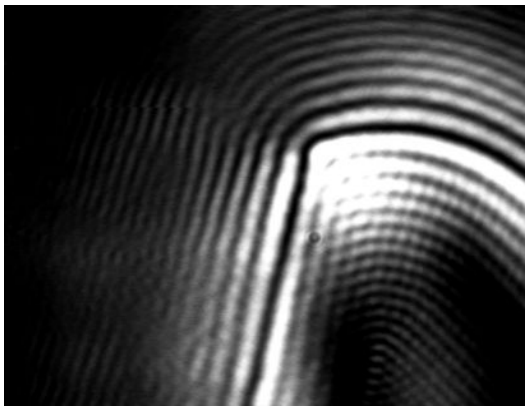


Figure 9: An edge image

ACKNOWLEGEMENTS

This work was financially supported in part by a special grant in aid from Toyama Prefectural University.

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