표면조직을 위한 피에조구동 공구홀더의 동특성

Dynamic Performance of Tool Holder by Using Piezo Actuator for Surface Texturing

*쿠르니아완 렌디 [1], #고태조 [2]

*Kurniawan Rendi[1], #Ko Tae Jo(tjko@yu.ac.kr)[2]

[1] 영남대학교 기계공학과, [2] 영남대학교 기계공학과

Key words : natural frequency, mode shape, piezo actuator, textured surface

1. Introduction

Recently, surface texturing method that establishes on surface of various mechanical components becomes a promising method to enhance lubricant performance. By modifying the surface with dimples pattern and controlling dimple size, shape, orientation, and density, we are able to achieve lower friction and wear at sliding and rotating contact interfaces[1]. To establish the dimples pattern, a tool holder that attaches in conventional CNC turning machine has been developed by using piezo stack in open-loop condition that has maximum displacement 15 μm is as main heart of actuator and a basic parallelogram flexure guiding system to magnify displacement becomes 26 μm. This paper totally presents about dynamic performance of the developed tool holder which is important parameter of building dynamic system. According to simulation and experiment data, the natural frequency of the tool holder is approximately 480 Hz.

2. Design

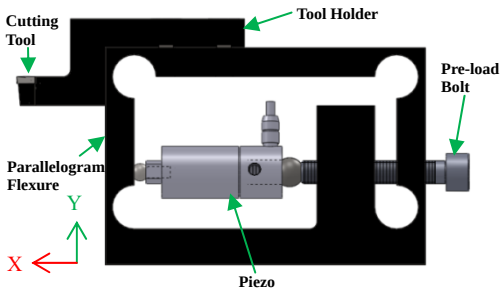


Fig1. Illustration developed tool holder design.

Figure 1 shows detail the illustration of the developed tool holder design whereby the tool holder consists of two main parts. The first part, it is called as tool holder where a cutting tool either Polycrystalline Diamond (PCD) or Cubic Boron Nitride (CBN) is attached. The second is the parallelogram flexure that could be called as parallel spring box has stiffness value 48 N/um with radius 7.5 mm each flexures.

The effective stroke value of tool was designed; so that it does not achieve 50% of nominal displacement value of piezo. The effective stroke of piezo assembled within a parallel spring is given by:

$$\Delta L = \Delta L_o \left(\frac{K_T}{K_T + K_S} \right) \quad (1)$$

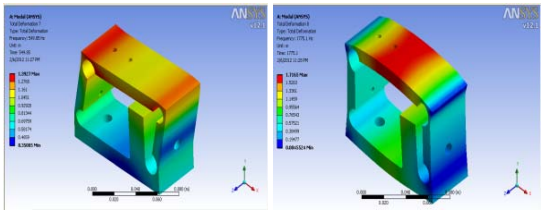
Where ΔL is effective stroke of piezo with external spring load, ΔL_o is the nominal displacement (in this case, 15 μm), K_T is piezo stack actuator stiffness (90 N/μm), and K_S is the parallel spring stiffness in (N/μm) unit.

3. Dynamic performance

Table1. Modal test analysis in Ansys

Material: SCM 440
Young's Modulus: 205 GPa
Poisson's Ratio: 0.29
Density: 7850 kg/m^3

Mode Shape	Frequency(Hz)
1	549.85
2	1775.1
3	2312.8
4	2805.1
5	3004.1



(a) (b)

Fig2. Modal test was performed in Ansys. **a.** first mode, **b.** second mode.

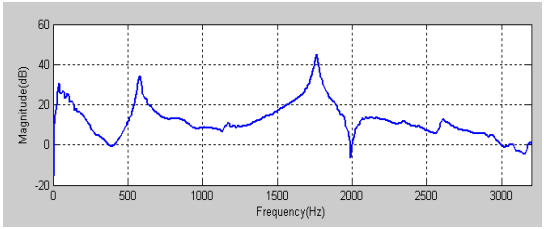


Fig3. Impact test result

Table1 reports about the modal frequencies of tool holder by analyzing in Ansys. According to the results, the movement of tool that moves linear through x-axis is as similar as shown in figure 2a has a natural frequency about 549.85 Hz. On the order hand, based on the experimental data of impact test, the first mode occurs approximately at 584 Hz as shown in figure 3.

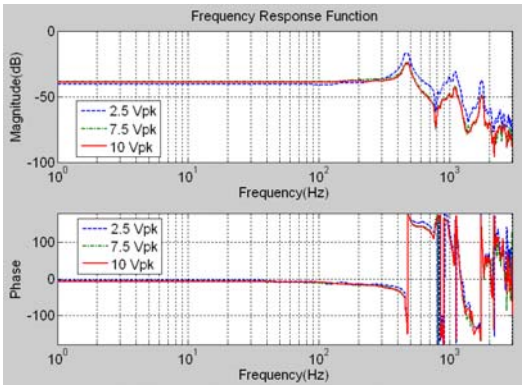


Fig4. Bode plot measurement

The bode plot that was performed in digital analyzer as shown in logarithmic scale in figure 4 shows the natural frequency occurs about 480 Hz. In addition, the displacement of tool movement was measured by optical fiber sensor, as shown in figure 5.

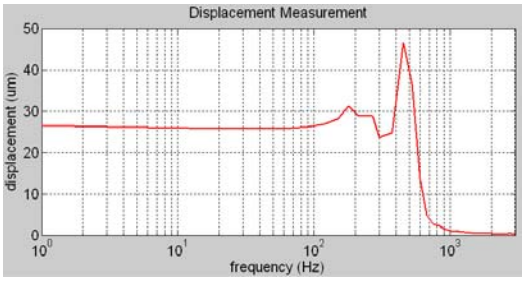


Fig5. Displacement Measurement

4. Experimental result

Machining was performed on aluminum surface at frequency modulation 120 Hz with spindle rotation 60 rpm, as shown in figure 6.

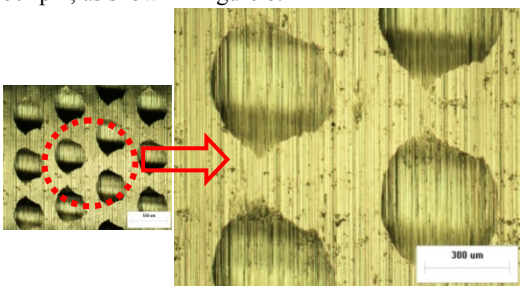


Fig6. Textured surface at f_m 120 Hz

5. Conclusion

In conclusion, based on simulation and experiment data, the tool holder has natural frequency approximately at 480 Hz, furthermore the tool holder enables to establish textured surface.

Acknowledgments

The Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (MEST) (Grant No. 2011–0013496) supported this work.

Reference

1. Erdemir, a. (2005). Review of engineered tribological interfaces for improved boundary lubrication. *Tribology International*, *38*(3), 249-256.