A Study on the Modal Analysis of Hybrid Machine Tool for Laser-Plasma assisted Machining

K. W. Kim[1], W. S. Woo[1], H. I. Jeong[1] and C. M. Lee[2*]

[1] Mechanical Design and Manufacturing, School of Mechatronics Engineering, Changwon National University, Changwon-si, Republic of Korea
[2] Dept. of Mechanical Engineering, College of Mechatronics, Changwon National University, Changwon-si, Republic of Korea

*Corresponding author: cmlee@changwon.ac.kr

1. Introduction

Recently, researches on the processing of difficult-to-cut materials such as titanium alloys, nickel alloys and ceramics used in various fields have been actively carried out.[1] Due to its excellent mechanical properties, difficult-to-cut materials are difficult to process with conventional machining methods and high processing costs are required. Therefore, a thermally assisted machining (TAM) can be applied to improve the machinability of the material by preheating an external heat source prior to machining.[2~4] Generally, a single heat source such as laser, plasma and induction is used for the TAM, but it has a disadvantage that it is difficult to maintain the high preheating temperature. Therefore, to supplement the disadvantage, TAM using the multi heat sources has been studied. The high preheating temperature can be maintained by multi heat sources. But it is necessary to study on structural stability because the device is complicated by multi heat sources. The modal analysis of hybrid machine tool for laser induction assisted machining was performed by present author [5]. In this study, the modal analysis of the hybrid machine tool for laser-plasma assisted machining was performed to analyze the structural stability by predicting the mode shape by vibration and the resonance frequency of the developed device.

2. Modal analysis

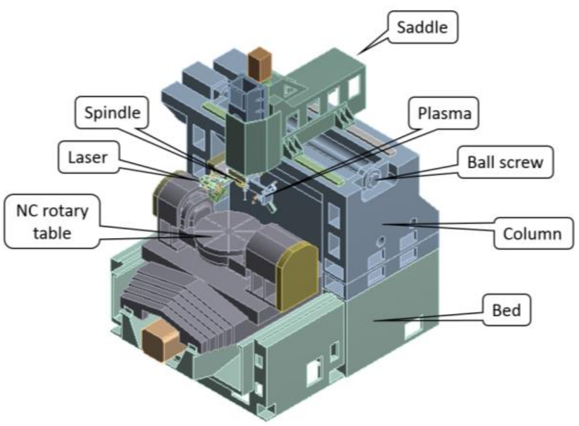


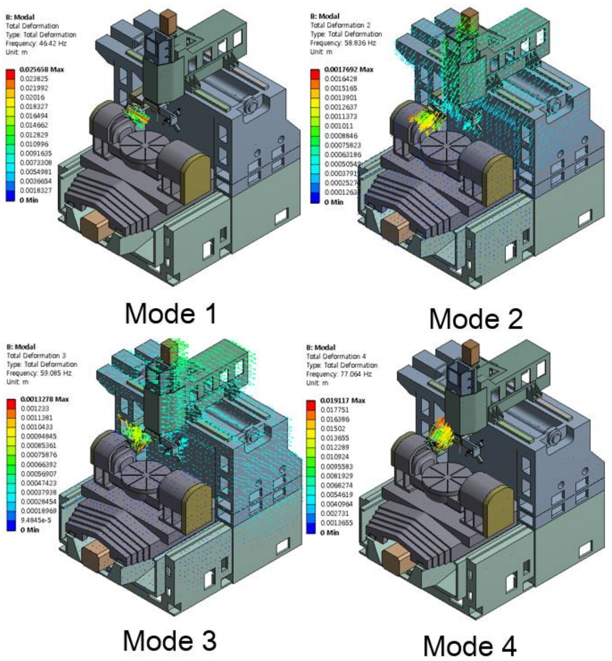
Fig. 1 Geometry of hybrid machine tool

Table 1 Material properties

	SM45C	GC300
Density	7,870 kg/m^3	7,250 kg/m^3
Elasticity	260 GPa	130 GPa
Poisson's ratio	0.29	0.25

Fig. 1 shows the 3D model of the hybrid machine tool for laser-plasma assisted machining. Table 1 shows the material properties of SM45C and GC300 used for modal analysis. Hex dominant mesh was used. The mesh of the laser-plasma module part was densely formed with a mesh size of 3 mm. Nodes and elements were 935,703 and 232,958. For the boundary condition, the bottom surface of the hybrid machine tool was fixed and modal analysis was performed by applying the self-weight.

3. Result and conclusion



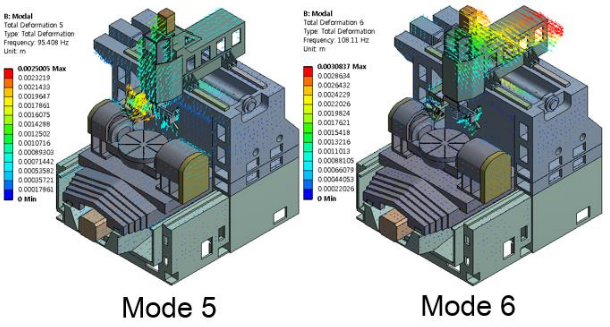


Fig. 2 Mode shape

Table 2 Frequency and deformation

Mode No.	Frequency [Hz]	Deformation [mm]
1	46.42	25.66
2	58.85	1.77
3	59.09	1.33
4	77.06	19.12
5	95.41	2.50
6	108.11	3.08

The mode shape of modal analysis is shown in Fig. 2. This shows the vibration modes from 1 to 6 of the hybrid machine tool.

Through the modal analysis, the resonance frequency was also analyzed. Table 2 shows the frequency and deformation result according to the mode. The resonance frequency of Table 2 should be avoided for structural stability when operating the hybrid machine tool.

This result will be used as a basic data for the hybrid machine tool platform development and operation.

Acknowledgment

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. 2019R1A2B5B03070206).

References

[1] M. G. Gang, G. H. Kim, K. W. Shin, A. M. Jeong, H. T. Kim, C. H. Kim, S. W. Lee, and T. G. Kim, Mechanical Cutting Process Trends for Difficult-to-Cut Materials : A Review, Journal of the Korean Society for Precision Engineering, 35 (3) (2018) 253-267.

[2] W. S. Woo, Y. H. Lee and C. M. Lee, A Study on the Thermally Assisted Machining of Titanium Alloy, Proc. of SASE, (2017) 158-159.

[3] O. A. Shams, A. Pramanik and T. T. Chandratilleke, Thermal-Assisted Machining of Titanium Alloys, Advanced Manufacturing Technologies, (2017) 49-76.

[4] S. H. Moon and C. M. Lee, A study on the machining characteristics using plasma assisted machining of AISI 1045 steel and Inconel 718, International Journal of Mechanical Sciences, (142-143) (2018) 595-602.

[5] S. G. Kim and C. M. Lee, A Basic Study on Structural Analysis of Hybrid Machine Tool with Multi-Heat Source, Proc. of KSPE Spring Conference, (2014) 610.