Failure Analysis of Drive Motor Bracket on Mini CNC Machine Using Finite Element Analysis Software

M. Luthfi, Muchlisinalahuddin, Desmarita Leni, M. Rehal, and Rudi Kurniawan Arief(✉)

Muhammadiyah University of West Sumatera, Padang, Indonesia
rudikarief@umsb.ac.id

Abstract. The local made CNC machine is already available by utilization of CNC router technology, but this machine is not suitable to be used for educational purposes because the construction and movements are not similar to the real CNC machine, therefore the Mechanical Engineering Department UM Sumbar. This machine has been finished and all of the functions are working but some problems occur so that it cannot be used for practicum properly. Therefore, this research was conducted to analyze and examine the problems that occur. The problems occurred related to the failure of the motor drive bracket. It is found that the material is not suitable and also lack of assembly activities indicated.

Keywords: mini CNC · FEA · simulation · bracket · PLA

1 Introduction

Mini CNC or router CNC is similar to usual CNC but designed for a limited area and lower precision result with a spindle head to cuts and moves in directions along the X, Y, and Z axis [1]. The CNC router itself is a machine that is usually built to use to cut, engrave and mark the workpiece with a rotating chisel to form flat, angular or curved shapes [2] and is often used in the woodworking industry [3]. The flow CNC process started with Computer Aided Design (CAD) software and then continued with Computer Aided Manufacturing (CAM) software to facilitate and automate manufacturing processes [4].

Most CNC machine available in Indonesia are imported directly from other countries, therefore the price is relatively expensive [5]. The high price of CNC machines evokes difficulties for educational institutions to purchase manufacturing lab facilities [6].

Even though the CNC router is already manufactured by local small industries at a relatively affordable price, these machines are not suitable for the practicum of the CNC machining process. The router CNC method moves all the X, Y and Z during the process while the anvil does not move which cannot represent the actual CNC machine movement method. For this reason, the UMSB Mechanical Engineering Department created a mini CNC machine with a movement method that corresponds to the actual movement of a CNC machine. This machine has been completed and is functioning

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properly but some problems occur so that it cannot be used for practicum. Therefore this research was conducted to analyze and examine the problems that occur. Problems examination using Finite Element Analysis (FEA) in the CAD/CAID/CAE software has proven superior advantages compared to previous methods to examine stress, strain and displacement [7, 8].

The problem stems from the drive mount bracket which is made of PLA plastic with a 3D printing process. Some of the problems that occur include the position of the holes that change from the design due to shrinkage, the motor gets very hot while working so it is feared that the plastic bracket will melt and the bracket will crack during assembly. Therefore this research was conducted to analyze the problems that occur and find solutions which include redesigning and selecting new materials.

2 Materials and Methods

This study uses a mini CNC machine developed by the Mechanical Engineering Department of UM Sumbar(Fig. 1). This research uses the observation method to find out the problems that occur in the mini CNC machine that make this machine cannot run properly. The detected problems will be evaluated using a 3D simulation with the help of FEA software. The simulation was also conducted with other alternative materials such as; ABS and Aluminum 1060. The Solidwork simulation does not provide the properties for PLA (Polylactic Acid) materials, therefore PS (polystyrene) is used as it has closer properties to PLA [9].

3 Results

From the results of observations, it was observed that there was movement on the X-axis which tended to stagnate. This stuttering movement is indicated caused by a problem with the X-axis motor bracket. This bracket is not parallel to the threaded shaft and cracks also occur (Fig. 1, Fig. 2) Besides that, it is also known that the temperature of the driving motor is hot enough so that it is checked with a thermal gun resulting 80.2 °C (Fig. 3).

The problem is validated by measuring using a calliper where there is a centricity difference of 1,45 mm. The occurrence of cracks will be validated by force simulation in the cutting process using FEA.

The static simulation results for the strength of the bracket against the maximum cutting force with PLA (Polylactic Acid) material yield the maximum Von Misses Stress value of 6.11e + 06 while material yield strength is 1.66e + 07 (Fig. 4). The 36.8N of force applied as a maximum permissible cutting force.

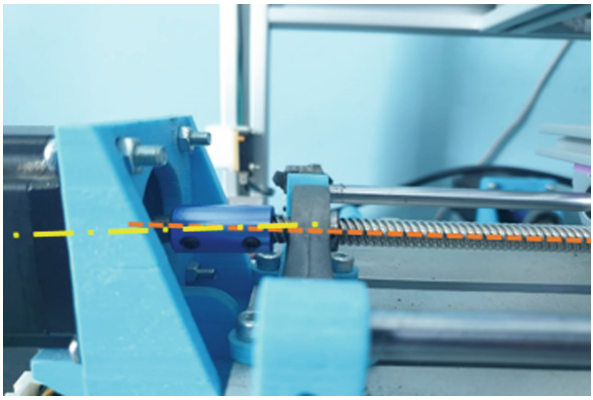

Fig. 1. Bracket is not parallel to the threaded shaft

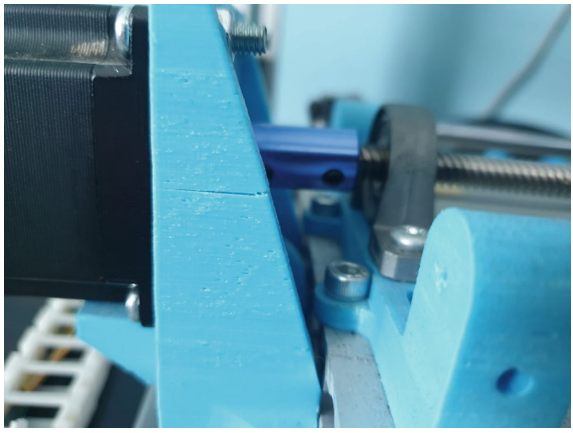

Fig. 2. Bracket drive motor crack

The simulation results for the strength of the bracket against the maximum cutting force with ABS (Acrylonitrile Butadiene Styrene) material yield the maximum Von Misses Stress value of 6.072e + 06while material yield strength is 1.66e + 08 (Fig. 5).

The simulation results for the strength of the bracket against the maximum cutting force with ABS (Acrylonitrile Butadiene Styrene) material yield the maximum Von Misses Stress value of 6.626e + 06 while material yield strength is 2.757e + 07 (Fig. 6).

Fig. 3. Drive motor temperature check

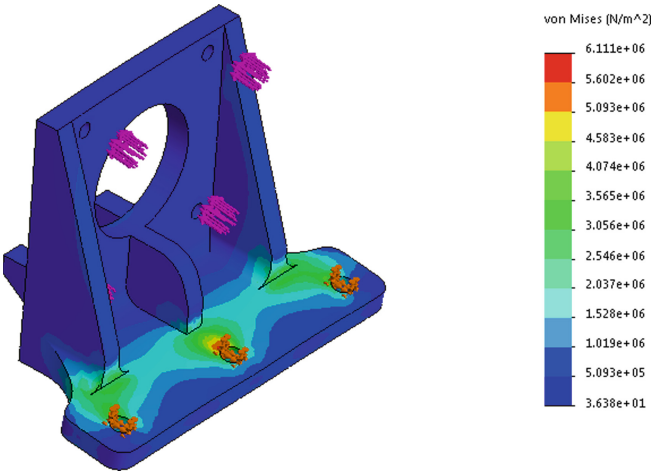

Fig. 4. Von Mises Stress Simulation Results for PLA materials

4 Discussion

The problem stems from the drive mount bracket which is made of PLA plastic with a 3D printing process to reduce cost. Some of the problems that occur include the position of the holes that change from the design due to shrinkage, the motor getting very hot while working so it is feared that the plastic bracket will melt in long-term use and the crack of the bracket during assembly. PLA has a melting temperature between 170 °C and 180 °C [10] and ABS is melting at 200 °C [11] where motor drive temperature reaches up to 80 °C. Even though the motor drive temperature is below the material melting

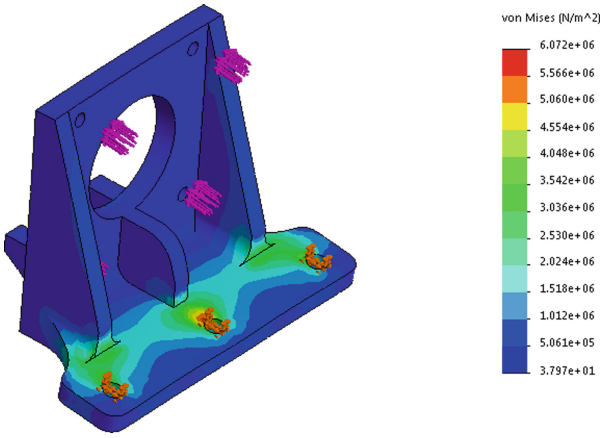

Fig. 5. Von Mises Stress Simulation Results for ABS material

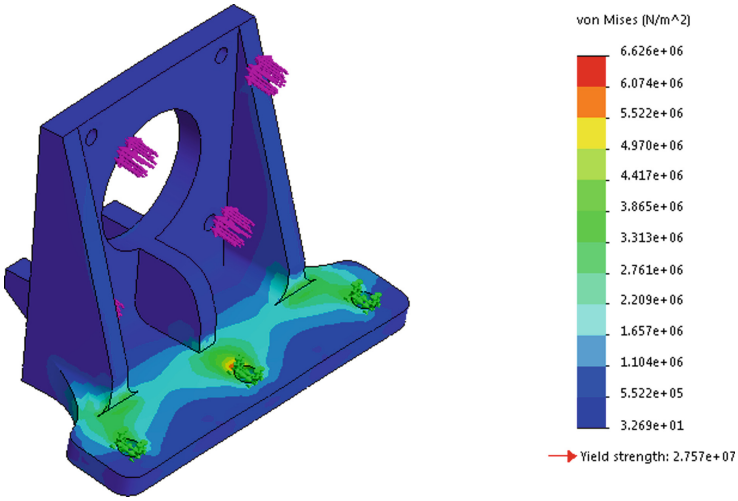

Fig. 6. Von Mises Stress Simulation Results for PLA materials

temperature, it reaches almost half of the material's melting temperature and prolonging runs of the machine will reduce material strength, therefore non-polymer material such as aluminium is suggested.

The static simulation of all materials shows that the von misses strength is still below the material's yield strength, which means that the bracket design and materials assigned are already compatible. The crack that appears on the bracket is possibly caused by improper assembly operation where the operator is force to assemble the defect printed bracket, the bracket that is not parallel with the threaded shaft then breaks down when firstly operated.

5 Conclusion

The crack found in the bracket is indicated caused by improper assembly activities. The simulation result shows that the design and material of the motor driver bracket are strong enough to retain the cutting force during the machining operation. However, due to the high temperature produced by the motor driver, it is suggested to replace polymer materials with aluminum to prevent further failures.

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