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CNC Milling Portable PM 1035

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Abstract

The obstacles faced by the education world today are the lack of availability of CNC milling machines with economical prices and portable dimensions. The manufacture of CNC milling portable machine PM1035 is the right solution to meet the needs of education. This portable CNC milling machine is specially designed to meet the needs of the education world by adjusting the design to be properly used, efficient, and economical. This CNC milling portable PM1035 machine designed with a stepper motor with TB6560 3 axis control. The machine structure use aluminum 5052-H32 with a thickness plate 8mm to 12mm. Maximum step of each axis 100x100x35 mm with total portable CNC dimensions: 210x195x280 mm. The precision of the machine is 0.02mm.

Keywords: Portable CNC, motor stepper TB6560

INTRODUCTION

Growth of manufacturing industry in Indonesia is very rapid, it causes the need for availability of quality workforce is increasing [1].

To meet the needs of qualified workforce required cooperation of quality educational institutions. To support these needs the necessary balance between theory and practice that always follow the development of technology. It can be adjusted subjects in accordance with the needs of the latest technology and (physical) industry supported by a qualified laboratory facilities.

To meet these needs required a props namely CNC machine. The most commonly used CNC machines are CNC turning machines (CNC lathe machines) and CNC milling machines. The problem facing the world of education is the amount of investment they have to spend to buy a CNC machine. One solution to overcome the problem is a CNC milling machine tool with size and dimension designed specifically for education by using simple control system.

Therefore a CNC milling machine is needed at an economical price and a dimension not too large to make it portable and easier for students to learn the CNC machine control system. With the fulfillment of the need for a CNC milling machine adapted to these needs is expected to be useful to improve the quality of students / students [2].

BASIC THEORY

CNC Programming Language

CNC machine was first made by making command language to move motor with G Code language. The first G-Code was created in 1950 designed by the Massachusetts Institute of Technology at MIT Servomechanisms Laboratory. CNC coding standards in Europe use the ISO 6983 standard, although in other countries use other standards, such as DIN 66025 or PN-73M-55256, PN-93 / M55251 in Poland [3].

Shifting Trend of Conventional Machines Usage with CNC Machines

As time goes by, the growth of the manufacturing industry is very rapid. This causes the need for conventional machinery is reduced, because it is considered unable to meet the needs of high productivity and high precision. As well as the more varied models and types of workpieces with difficulty levels of high workmanship that is not possible to be done with conventional machines.

The presence of CNC machines cannot be denied is one of the best solutions to meet those needs. Because CNC machines can do complex work with high precision and constant results [4].

Mechanical System.

The mechanical system of the CNC milling machine is the same as the conventional milling consisting of the x, y, z axis. Each axis moves in sliding translation by using a linear rail in motion using a screw. In the milling machine may consist of several variations of movement on the y-axis, either by using a moving work table or with a fixed (silent) work table but a moving x-axis supporting pole.

In this study using linear ball bearing guide because by using this type of mechanism each axis can move more precise and lightweight. For driving it using leadscrew because of its small size so cannot use ballscrew.

Motor Driver

There are types of motor driver:

- Servo Motor

Servo motors have a better character than the steeper motor. Because the servo motor is a motor with a close loop system.

With such a system the motion of the motor rotation is more precise and the energy released is directly proportional to the rate of rotation. However the drawback is the price for an expensive servo motor. So it is less economical [5].

- Steeper Motor

Steeper motor has a large torque character at low rotation but the higher the rotation then the torque decreases. System that works on steeper motor is open loop system. So it needs the additional encoder or sensors in each axis.

However steeper motor lately more in demand because of the more affordable price of servo motors. For now there are many options motor driver with a higher level of accuracy with microsteep, so for the level of precision is not too different from servo motors [3].

Each motor has advantages and disadvantages respectively, in this study we use steeper motor to drive the three axis with the reason that the price is cheaper than servo motors.

Control System [4]

The system consists of:

- Steeper Motor
- Driver Motor
- Break out board (interface between PC and driver motor)
- PC
- Power cable USB.
- Port DB25 parallel cable.

Software Application

Solidwork for CAD drawing, SheetCam for CAM programming, and Mach3 (open source) for CNC machining operation milling [4].

Mini CNC Machine

The need for CNC machines is currently very high. This makes the development of CNC machine variation increas. Currently CNC machines are manufactured with different models usage and do not refer to conventional CNC milling (large sturdy structure dimensions, large power, high production costs, etc.). New model CNC machine is made specifically to do a certain job with a certain size and dimensions as well. Because the design and size tailored to its usefulness then the machine can be adjusted so that the cost required more efficient. Efficiency can be achieved because there are some unnecessary functions then not used and the structure is adjusted to the workpiece to be done. One example is a CNC engraving machine with a CNC machining center machine. Both machines are controlled by computer, the CNC machining center machineries a lot of sensors and sturdy structure so that the cost required to make the machine expensive. In the CNC engraving machine the structure is made as simple as possible and there are not many sensors and its dimensions are relatively smaller so the cost required to make the machine is relatively cheaper [6].

MATERIAL DAN METHODE

Material

The material used to make the CNC milling machine is as follows:

- Aluminum plate 5052 - H32 with a thickness of 8mm to 12mm used to make the framework of CNC portable milling machine. The properties of Aluminum can be seen in figure 1.
- Linier motion guide IKO LWL 7.
- Motor steeper Nema 17 EM 110.
- Spindle Yota 210E.
- Lead screw Stainless M6x1.
- Bolt 2mm,3mm,4mm,5mm,6mm,8mm.
- Aluminum Coupling.
- Voltage regulator 5v dan 12v.
- Break out board build in driver TB6560.
- PC.
- DB25 Wire.

Properties

Alloy Temper	Ultimate Tensile Strength		Tensile Yield Strength		Elongation[1]	Thermal Conductivity[2]
	MPa	KSI	MPa	KSI	%4D"	BTU in/hr-ft²F
5052-O	193	28	89.6	13	25%	960
5052-H32	228	33	193	28	12%	960
6061-T4	255	37	152	22	23%	1070
6061-T6	345	50	290	42	13%	1160

Availability

Alloy	Tempers	Gauges	Widths	Finishes	Typical Uses	Anodizeable
5052	O, H32	0.014"-0.190" 0.34-5mm	Up to 60" 1500mm	M, P, SB, LB, C	Laptops, Mobile devices	YES
6061	T4, T6	0.026"-0.125" 0.635-3.2mm	Up to 60" Up to 1524mm	M	Mobile devices	YES

Figure 1. Data Sheet Aluminum [7]

Methode

The method used is contained in the diagram of research activities to design and make portable CNC milling machine that is done is as in figure 2:

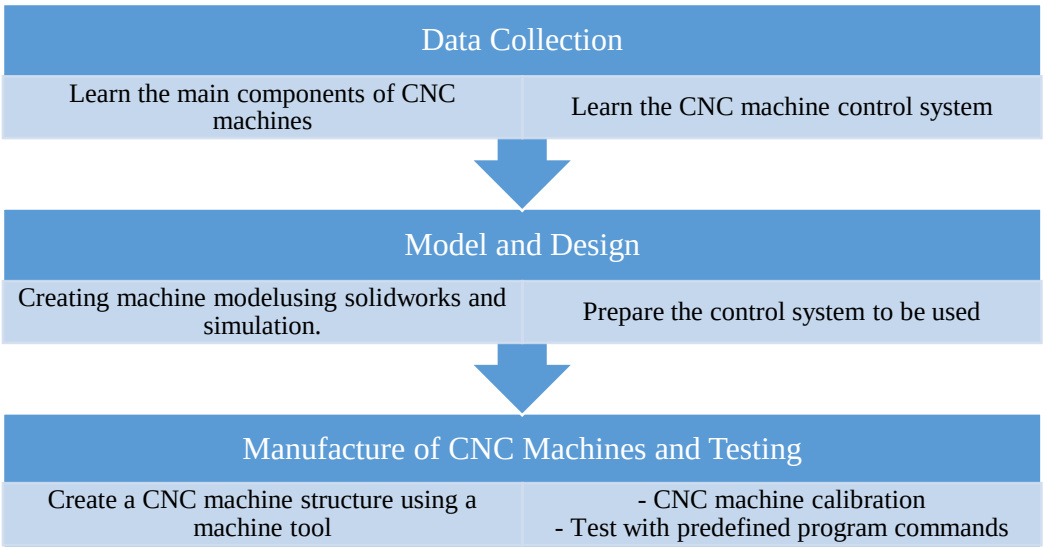

Figure 2. Diagram of Research Activities

1. Data Collection

Data collection is done by studying an existing CNC machine to determine the main components used and the main workings of the machine. Which is useful in designing and manufacturing prototype portable CNC milling machine that will be made.

2. Model and Design

At this stage is an activity to design and design a portable CNC milling machine. In this case determine the shape, dimensions, raw materials components that will be used in order to meet the needs of authors. That produces a portable CNC milling machine design. These activities include mechanical components (structures) and control system components.

In designing CNC machine structures researchers use solid works software to analyze and simulate the maximum load on the main components of a CNC machine. By simulating a certain loading on a particular point, a structured design that can meet the stiffness requirements of a CNC machine requirement.

The components tested are shown in figure 3 – figure 8.

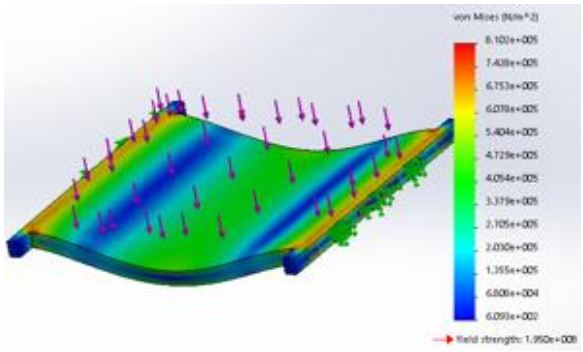

Figure 3. Von Mises stress of Main Base

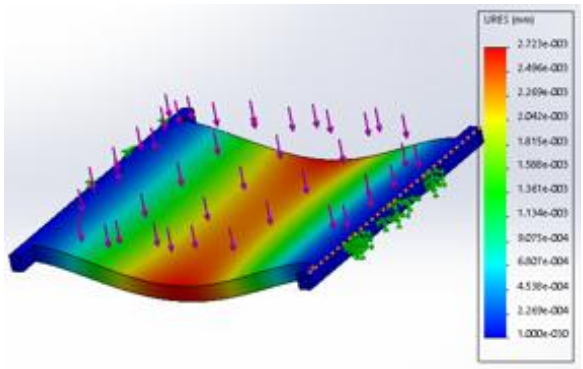

Figure 4. Displacement of Main Base

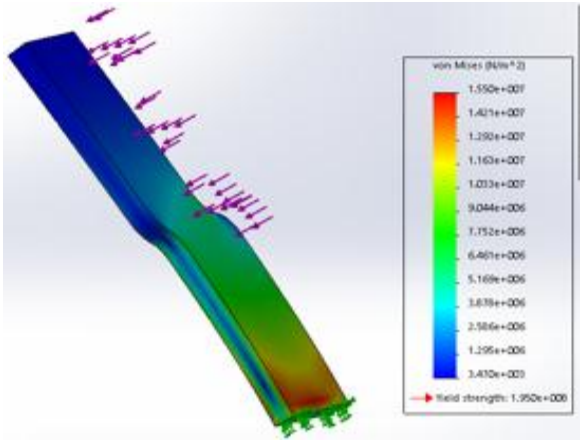

Figure 5. Von Mises Stress of Stand/ Column Y Load Direction

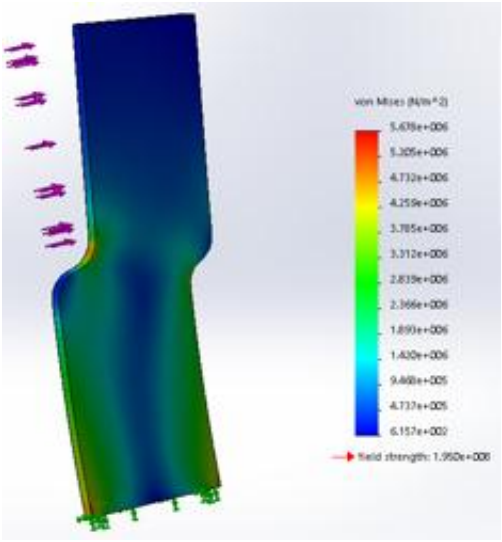

Figure 6. Von Mises Stress of Stand/ Column X Load Direction

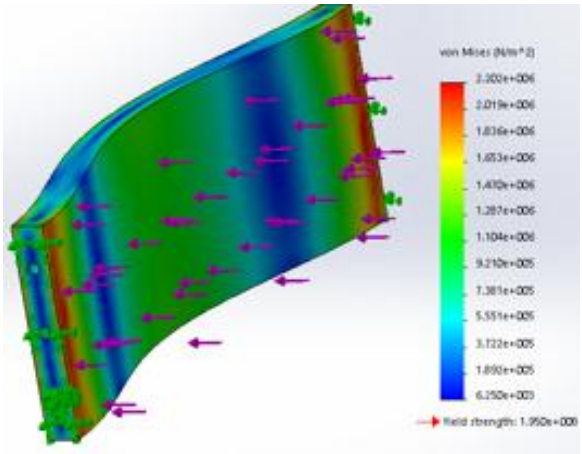

Figure 7. Von Mises Stress of X Axis Base

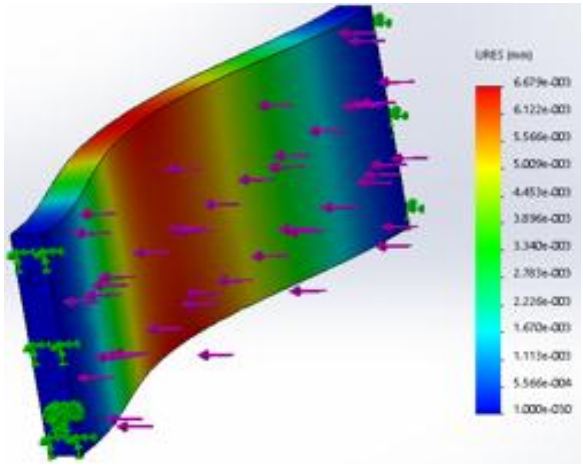

Figure 8. Displacement of X Axis Base

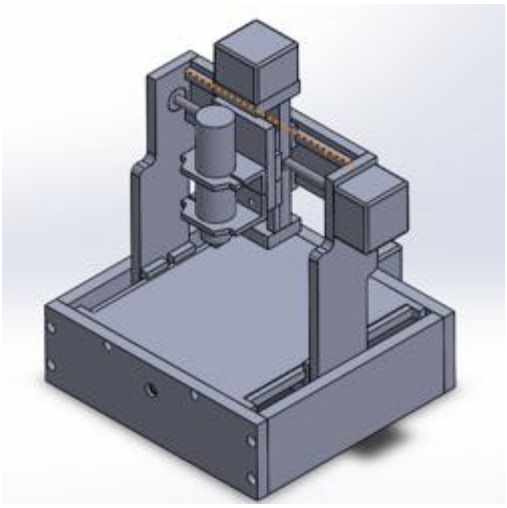

Figure 9. Assembling View Portable CNC Milling Machine PM1035

After performing the simulation, the result of the structure design has fulfilled the stiffness requirement so that it can be continued to stage of CNC machining manufacture frais.

Table 1. Deformation and Safety Factor

Part	Static Nodal Stress N/m²	Yield Strength N/m²	FOS (factor of safety)
Main Base	11,230	$1.95x10^8$	2540.68
Stand	45.26	$1.95x10^8$	34.34
X Axis Base	2335.64	$1.95x10^8$	88.57

Manufacture and Assembling Of Machine Components

In this activity the researchers create components accordance to the design calculated. The process of making components can be seen in figure 10.

Figure 10. Process Structure Making Portable CNC Machine PM1035

As for the control system component of the researcher using components sold publicly - Control BOB TB6560. The components are as shown in figure 11.

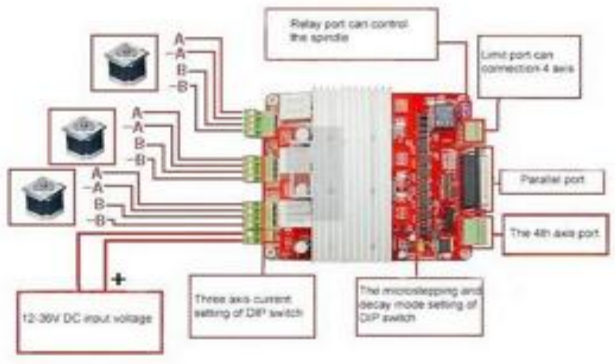

Figure 11. Control BOB TB6560 [8]

For the control system, the researchers only assemble a control system. Once the entire component is ready and complete then proceed to the assembly stage until it becomes a portable CNC milling machine PM1035 as shown in figure 12.

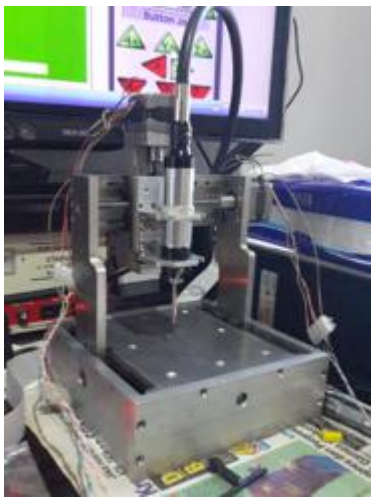

Figure 12. Portable CNC Milling Machine PM1035

TESTING AND ANALYSIS

In this activity the researcher did some testing and analysis to get complete data about the performance of portable CNC milling machine. This test uses SolidWork, MACH3 and SheetCam software for G code commands.

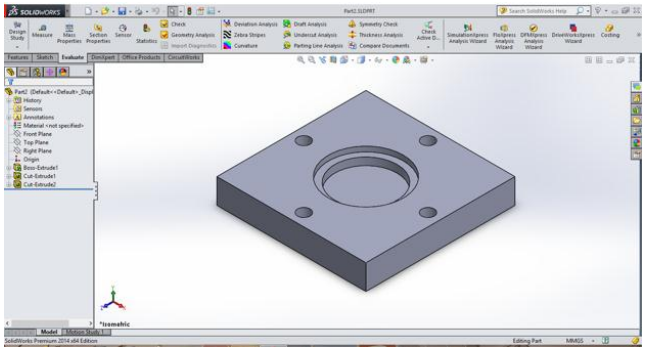

Figure 13. SolidWork Software Display

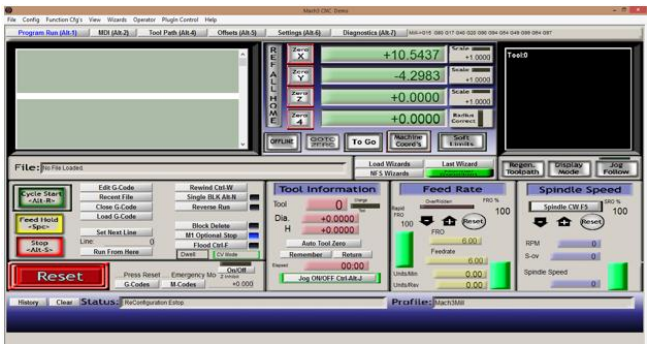

Figure 14. Mach3 Software Display

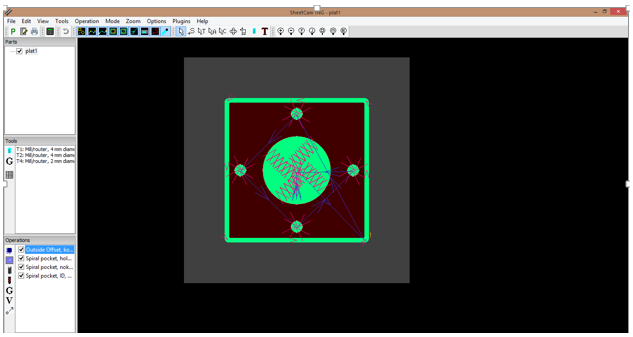

Figure 15. SheetCam Software Display

The tests performed are as follows:
1. CNC Calibration,
2. Testing Dimension and Working Range.

CNC Calibration

Calibration is performed on the three axis (X, Y, Z). In doing the calibration Mach3 software performs auto calibration by

using tuning motor parameters to adjust the movement of each axis.

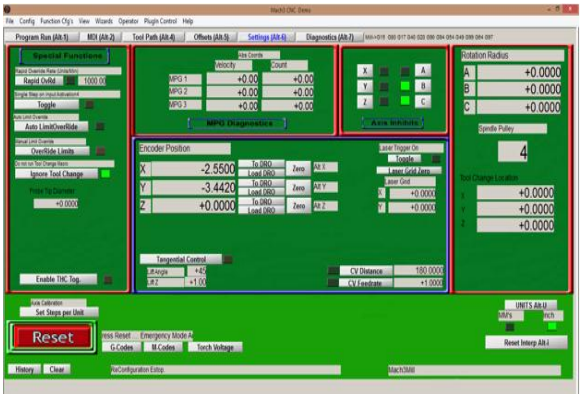

Figure 16. Calibration Menu Display

Figure 17. Axis Calibration Selection Display

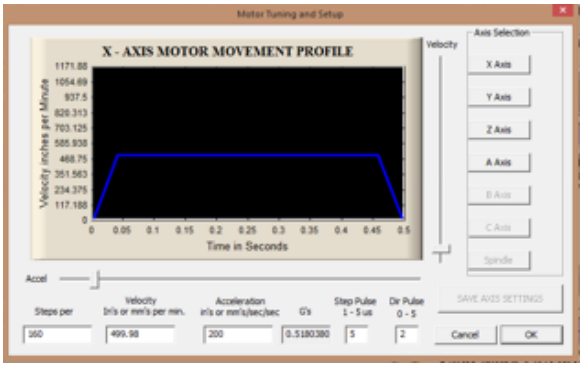

Figure 18. Motor Tuning Display

Testing Dimension and Working Range

Once the engine movement has been calibrated, the CNC machine runs its axis to get the maximum movement data of the step. From the test, data obtained as follows:

* X axis = 100mm

* Y axis = 100mm

* Z axis = 35mm

The movement of the engine can perform in accordance with command with level of accuracy 0.02mm.

The dimensions of the overall PM1035 CNC milling machine are as follows:

Length = 210mm

Width = 195mm

Height = 280mm.

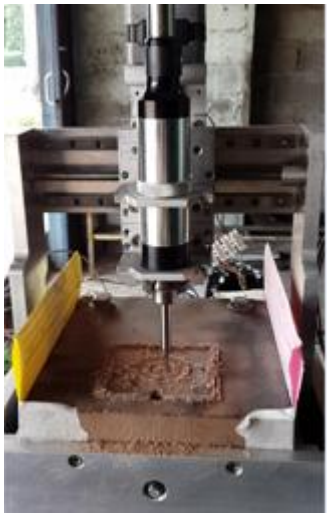

Figure 19. Process running command with G-code.

CONCLUSION

Conclusion

From the whole stages of the process that the researcher had been through, obtained accurate scientific data needed to verify whether the results of the study in accordance with the wishes (hypothesis) author or not (antithesis). And according to the data obtained feeding the author's hypothesis has been proven.

The researcher goal are: First to make the CNC size smaller and compact compare with general CNC and the second cheaper CNC price compare with existing market. The existing machine in the market price 8 to 12 million IDR while the machine can be made production costs up to 5 million IDR.

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