ISSN 2229-5518

CNC MILLING PORTABLE PM 1035 ANALYSIS

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Abstract

CNC milling portable PM 1035 is the machine has been created to provide educational needs. The draft obtained is a table that holds the workpiece of wood equipped with a vertical and horizontal milling chisel equipped with a drive system with a stepper motor controlled by Break Out Board / interface TB6560 as a liaison between CNC machine and computer, with frame size with 210mm long engine dimension, width 195mm, 280mm height. The result is a miniature CNC milling machine with a maximum step size of x, y, z axis of 100mm, 100mm, 35mm. CNC machine can work on wood material. Hope then machine can usefull for education needs.

1.INTRODUCTION

The need for a qualified workforce and having basic knowledge of the operation of CNC machines is needed by today's manufacturing companies [1]. The need for a quality workforce is directly related to the world of education, especially high school. As one of the providers of quality labor, vocational schools must now be able to adapt to market needs. One of them is by providing training and debriefing to operate CNC machines for each student. However, a number of very basic problems arise to be able to meet the needs of the availability of these CNC machines. This is due to the price of expensive CNC machines and the quite difficult operating system. In conducting the introduction and training, it is not possible to use a CNC machine directly because it is too high risk. This is due to the possibility of errors in the operation of the machine during training which can cause damage to the CNC machine.

Many miniature CNC machines are available in the market, but these machines have quite expensive prices and large enough dimensions. From these problems a miniature CNC machine is needed at an affordable, appropriate and simple operating system that can represent the actual CNC machine. The CNC machine miniature must meet several criteria in order to solve the problem. Among others, the dimensions of the engine are not too large, a simple operating system and an affordable price. With the fulfillment of the need for CNC milling machines that are tailored to these needs, it is hoped that it can be useful to improve the quality of students / students [2].

2.BASIC THEORY

In an engine design there are several things that need to be considered, including the rigidity of the engine structure, deflection that occurs at the critical point, the maximum force that can be accepted by the structure, the selection of materials and machining processes. All of these things affect the quality of the products produced by the machine. The following is a literature review that has been carried out by the previous researcher as a reference and reference for carrying out the design and manufacture of these miniature CNC machines:

Stiffness of Machine Structure

Research conducted by Swami, B Malleswara explained that the importance of the rigidity of a structure in a machine. The higher the value of the rigidity of an engine structure, the direct impact on the quality of the products produced by the engine. The rigidity of a machine structure is influenced by several factors including structural material used and structural design. Different structure designs have different rigidity values [3].

According to research conducted by Oegik Soegihardjo, et al. Closed structures have better rigidity when compared with open structures. Closed structures have better stiffness values because each part of the structure is connected in pairs [4].

- **Deflection**

Research conducted by Oegik Soegihardjo, et al. Explained that deflection can occur in machine structures. Deflection affects engine capacity and the quality of the products produced. The greatest deflection occurs in parts that have the longest stretch of load. In that section the critical point of a machine structure. Deflection cannot be eliminated from a structure but deflection can be reduced in several ways, including by strengthening the structure (critical point) and design adjusted to the amount of load given to the structure. The smaller the deflection value that occurs at the critical point, the structure can produce a machine with a good level of precision [4].

- **Type of Structural Material**

In the selection of structural materials determined by several factors including the designation of the machine and the workpiece material to be produced by the machine. The research conducted by Stefanus Andre explained that the selection of structural materials greatly influenced the work capacity and selling price of the machine. Structural materials are generally made of cast iron or cast iron [5]. Cast iron or FCD (dustile cast iron) has a very good character to reduce vibration and has a very high stiffness value, but is constrained by the price of material and the cost of the manufacturing and machining processes which are quite expensive which affects the selling price of the machine. Other structural materials are aluminum 5054, this material has advantages such as easy-to-obtain material, easy machining process, lightweight and affordable material prices, so the machining process costs and the selling price of these machines are very affordable.

- **Machining Process**

The machining process greatly affects the price of the production of the machine. The high production costs of machining processes are determined by several factors, including the complexity of the design of the components to be machined and the material being machined. Both of these are closely related to the length of time for the machining process, the tool to be used, the type of machine tool that will be used to make the structural components. The more complex the design of these structural components, the higher the cost of producing these components. Similarly, the structural component materials, the harder the material is, the higher the cost of the machining process. This is due to the use of the type of tool that will be used. In the machining process carried out for the manufacture of structural components generally use 2 main engines, lathes and milling machines.

- **CNC programming language**

The first CNC machine was made by making command language to drive the motor with the G-Code language. The first G-Code made in 1950 was designed by the Massachusetts Institute of Technology at MIT Servomechanisms Laboratory. The CNC coding standards in Europe use the ISO 6983 standard, although in other countries other standards are used, for example DIN 66025 or PN-73M-55256, PN-93 / M55251 in Poland [6].The presence of a CNC machine cannot be denied is one of the best solutions to meet the increasingly high needs of the community. Because CNC machines can do complex work with a high degree of precision and constant results [7].

- **Drive Motor**

The driving motor consists of several types, namely:

1. Servo Motor
Servo motors have better characters compared to stepper motors. Because the servo motor is a motor with a close loop system. With this system, the rotation of the motor is more precise and the energy released is directly proportional to the level of rotation. But the drawback is the price for expensive servo motors. So it is less economical [8].
2. Stepper motor.
Stepper motors have a large torque character at low speed but the higher the rotation the torque decreases. The system that works on a steeper motor is an open loop system. So that it is necessary to add enconder or sensors on each axis / axis. Recently, steeper motors are increasingly in demand because the prices are more affordable than servo motors. For now there are many choices of motor drivers available with a higher level of accuracy with microstep, so that the precision level is not too different from a servo motor [6].

Each motor has advantages and disadvantages of each, in this study we use a stepper motor to drive the three axes with the reason that the price is cheaper than the servo motor.

3.MATERIAL AND METHODE

3.1.METHODE

The research conducted in this thesis is a miniature design of CNC milling machines. The design of using CAD / CAM assistance and the equipment used is designed according to the needs and has been calibrated, so the experimental data that is carried out is valid and accountable. The steps taken to carry out this research can be seen in the flow diagram of image 3.1.

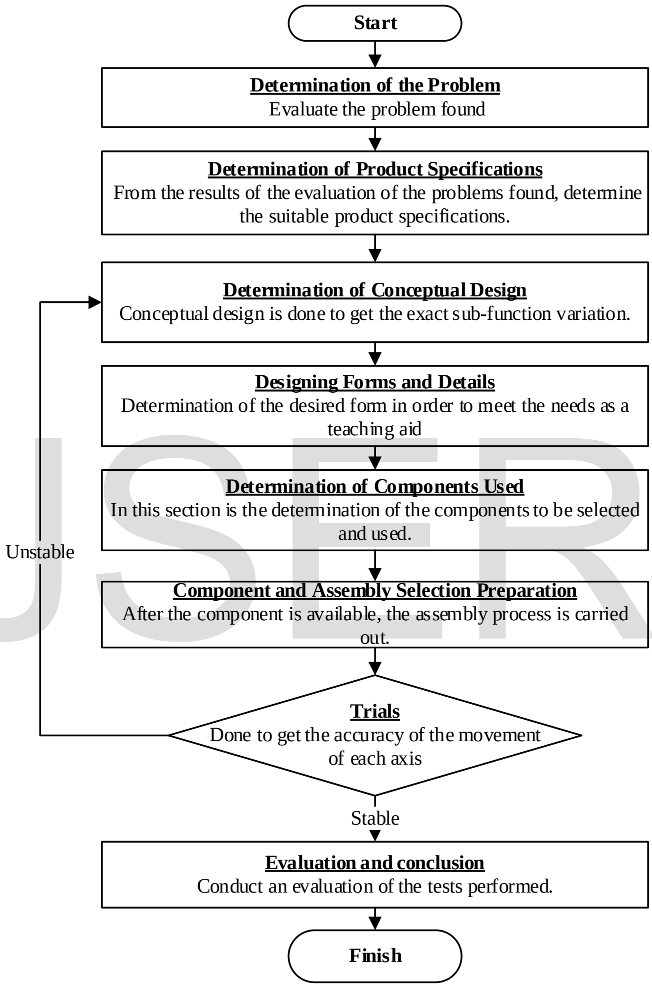

Figure 3.1 Research Flow Chart

3.1.1.By conducting literature studies on the problems that occur in the world of education about the lack of equipment for the practice of students / students. More specifically the lack of props to educate students in this case is miniature CNC milling machines. Therefore, on this occasion the author designed and made a miniature of the PM1035 CNC portable frais machine to overcome this problem.
3.1.2. Determination of product specifications. There are also specifications specified are:
- frame material
- engine dimensions
- step axis

3.1.3. Determination of conceptual design. The overall function of the machine is divided into several sub-functions:
- frame material
- transmission system

- drive motor
- control system

3.1.4. Designing shapes and details. Determination of the desired form in order to meet the needs as a teaching aid. The complement of this stage is to add:

- calculation of critical components
- Engineering drawings

3.1.5. Determination of the components to be used. The specified component is the determination of the design that has been done.

3.1.6. Preparation of component selection and assembly.

3.1.7. Trial. This stage of the test moves each axis to see the accuracy of the CNC milling movement results, this process is at the same time the initial calibration of the milling machine.

3.1.8. Evaluation.

3.2. Equipment used

In this study researchers used several equipment both in the process of making components or from the testing process.

The following are the equipment used during the process of making miniature parts of portable CNC machines PM1035:

The equipment used for conducting the test is as follows:

- Steel bar
- Dial gauge

Figure 3.2.1 Steel bar

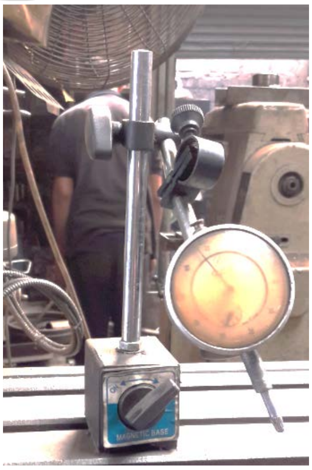

Figure 3.2.2 Dial gauge

3.3.Workpiece Material

The workpiece material chosen is wood with the type of MDF. This material was chosen because it has the ideal characteristics to be used as workpiece material for display machines. In addition to easy material to do the machining process, the material is easily available on the market.

From the selection of the workpiece material, the cost of producing the machine can be more economical, this is because the power needed to perform the work steps on the machine is not too large so that the structural material, drive motor, spindle motor can be adjusted to those needs. The following specifications for MDF wood materials are shown in Table 3.1.

Mechanical properties Board mean values	Unit	Board thickness		
		›12 - 19	›19 - 30	›30 - 40
Density	[kg/m^3]	Plant specific		
Internal Bond strength EN 319	[N/mm^2]	≥ 0,85	≥ 0,80	≥ 0,75
Bending strength EN 310	[N/mm^2]	≥ 35	≥ 31	≥ 26
Modulus of elasticity EN 310	[N/mm^2]	≥ 3200	≥ 3100	≥ 2900
Swelling in thickness 24h EN 317	[%]	≤ 12	≤ 10	≤ 8
Surface soundness EN 311	[N/mm^2]	≥ 1,2		
Screw withdrawal surface	[N]	≥ 1250		
Screw withdrawal edge	[N]	≥ 1080	≥ 1000	≥ 940
Sand content	[%]	≤ 0,02		
Moisture content *1 EN 322	[%]	6±2		
Surface absorption	[mm]	180		
Formaldehyde content *2 EN 120	[mg/100g]	E1		

Table 3.3. 1 Properties of MDF Wood [12]

4.TESTING AND ANALYSIS

In this activity the researcher conducted several tests and analyzes to obtain complete data about the performance of portable CNC milling machines. The tests performed are as follows:
CNC machine calibration. Calibration is done on all three axes: x, y, z

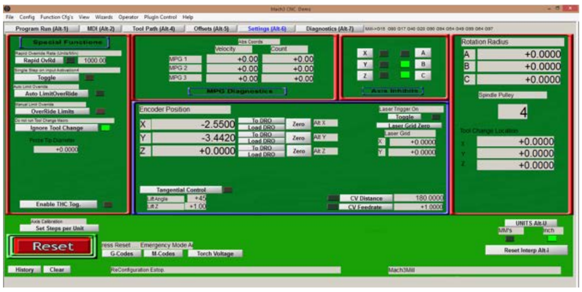

Figure 4.1. Display of the Calibration Menu screen

Figure 4.2 Screen Display of the Axis Selection Menu to Be Calibrated

ISSN 2229-5518

In performing the calibration, the Mach3 software performs automatic calibration using tuning motor parameters to adjust the movement of each axis.

Figure 4. 3 Screen display for Motor Tuning

Dimensions and cruising power.

After the engine movement has been calibrated, the CNC machine is run on each axis to get maximum movement data. From the tests carried out the data obtained are as follows:

* x axis = 100mm

* y axis = 100mm

* z axis = 35mm

From each axis movement there is a size deviation of +/- 0.02mm, the size deviation that occurs is caused by the use of a lead screw transmission system. The deviation occurs because of the backlash on the tolerance of the size between the nut and the bolt. The overall dimensions of the PM1035 CNC milling machine are as follows:

Length = 210mm

Wide = 195mm

Height = 280mm.

The test is continued by doing a work simulation. In the work simulation working on CAD designs that have been converted into G code. The material used is MDF wood plate with a thickness of 20mm

Figure 4.4 Processes Running a CAM Program with G code MDF wood material.

5.CONCLUSION

From the tests carried out there was a slight shift in size caused by the use of lead screw (the occurrence of backlash). In the use of lead screw there is a deficiency that is the tolerance of the size between the nut and the threaded axle which is quite large so that there is a delay in the transmission response of movement on each axis. Therefore there is a measurement inaccuracy of 0.02mm at each movement of the command in the output of the workpiece. These problems can be overcome by using a ball screw for the transmission system, using ball screw so that the backlash that occurs is very minimal so that the effect on the size deviation that occurs can be reduced.

In this study there are still opportunities for further research. The suggestion for the next research is to use ball screw to minimize backlash

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