IJoASER (International Journal on Advanced Science, Education, and Religion)
E-ISSN: 2614-8862 & P-ISSN: 2565-0836
Volume 4, Number 3, November 2021

Design and Simulation of CNC Milling Machine on Matlab

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ARTICLE INFO
Article history:
Received November 16, 2021
Revised November 23, 2021
Accepted November 25, 2021

ABSTRACT

The development and revision of milling machines and components are continuous. With the help of computer technology, we can simulate some activities in a manufacturing system. The main purpose of a simulation is to understand and imitate the behavior of a particular manufacturing system on a computer, before hardware creation, thereby reducing the amount of testing and experimentation in the field. By using a virtual system, less material is wasted and the constraints on the actual operation of the machine in the field can be minimized. In the field of milling machinery, various modeling and simulation methods have been introduced so far. Today, the manufacture of a machine tool can no longer use the time-consuming and costly manufacturing and testing of physical prototypes to detect weak points and then optimize the design. In contrast, the current machine tool design process uses "virtual prototyping" technology to reduce the cost and time of hardware testing and iterative improvements to physical prototypes. The model of a milling machine can be simulated in Matlab simulations through analytical methods using various compositions. The presented virtual modeling methods and milling machine tool simulations make it possible to design, perform complex analyses, test, optimize, and use various types of control structures. in the computer simulation.

Keywords: *Milling Machine, CNC Miling Machine, Matlab*

How to cite: Gumono, G., Mira, M., & Hadi, S. (2021). Design and Simulation of CNC Milling Machine on Matlab. *IJoASER (International Journal on Advanced Science, Education, and Religion), 4(3)*. 164-169. https://doi.org/10.33648/ijoaser.v4i3.156
Journal Homepage: https://ojs.staialfurqan.ac.id/IJoASER/

INTRODUCTION

The milling machine was invented and developed by Eli Whitney. This milling machine can help humans maintain accuracy and uniformity while duplicating parts that cannot be made using files. The development and revision of milling machines and components continued, leading to the manufacture of heavier arbors and high-speed steel and carbide cutters.These components can be used by the operator to change or shape metal faster, and more accurately, compared to previous machines. Alteration milling machine is also raised to carry out the workpiece cutting more especially. During this time, computerized machines have been developed to reduce errors and produce better quality in the finished product.

The paradigm shift from real to virtual creation has created an increase in research attention in the field. With the help of computer technology, we can simulate some of the activities of the body manufacturing system. The main purpose of simulation is to understand and imitate the behavior of a particular manufacturing system on a PC prior to hardware creation, thereby reducing the amount of testing and experimentation in the field.

By using a virtual system, less material is wasted and problems in operating the real machine in the field can be minimized, Venkata Ramesh (2016), Sanjay Kumar, Shabana Naz (2017). In the field of milling machinery, various modeling and simulation methods have been introduced so far. They are very important for revision and cost reduction in creation, Karmijit Singh, IbrahimA. Sultan (2018), Mwinuka T.E., Mgwatu M.I (2015)

The goal of modern manufacturing technology is to create a tool from scratch correctly and in the shortest period and a very cost-effective method. As product complexity increases and competitive product life cycle times decrease, the construction and testing of hardware prototypes is a major obstacle to the creation of successful and economically viable modern machine tools, Tadele Belay, Andrea Cesarini (2019)

Today, the manufacture of a machine tool can no longer use the time-consuming and costly manufacturing and testing of physical prototypes to detect weak points and then optimize the design. In contrast, the current machine tool design process uses "virtual prototyping" technology to reduce the cost and time of hardware testing and iterative improvements to physical prototypes.

A virtual machine tool prototype is a computer simulation model of a physical product that can be presented, analyzed, and tested like a real machine. Repeated changes to the virtual machine tool model during the design process and running design variations until performance requirements are met reduces overall product development time and costs significantly.

Models of a milling machine can be simulated in Matlab simulations through analytical methods using various compositions. The presented virtual modeling methods and milling machine tool simulations make it possible to design, perform complex analysis, test, optimize, and use various types of control structures in a computer simulation environment. This can significantly help reduce the development and design time of various construction variants of the milling machine system virtually

METHOD

2.1. Block Diagram

The working principle of the milling machine simulation can be seen in the block diagram as follows.

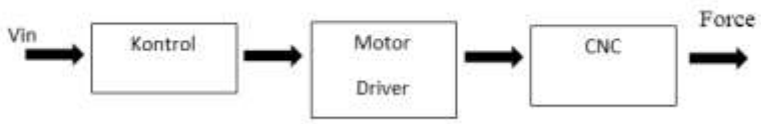

Figure 1. Block Diagram

In Figure 1 three main circuits will be used in this milling machine simulation. The first block is a simulation that functions as a control that will act as a controller of the machine. The second is the driver circuit of the motor, while the third is a simulation of the CNC machine circuit. The output of this tool is in the form of movement and the resulting force. While the input is a voltage that can be adjusted its value

2.2. CNC Machine Simulation on matlab

The simulation of the milling machine was made using the Matlab Simulink program as shown in Figure 2 below

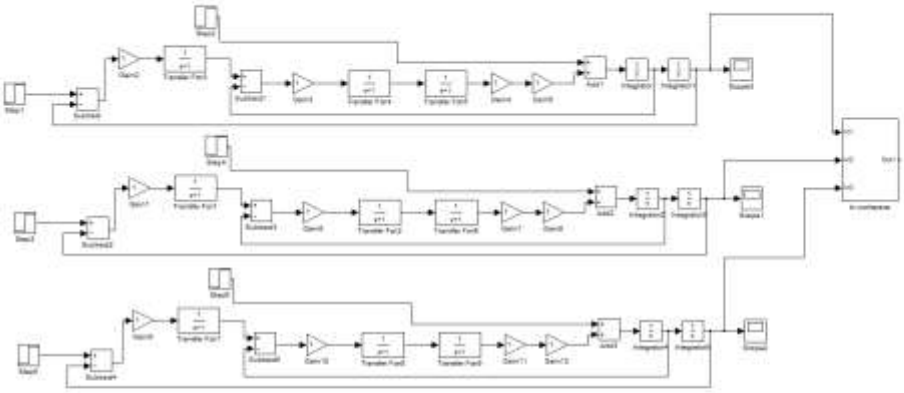

Figure 2. Simulation circuit

The series of the milling machine consists of 3 main circuits, namely the control circuit, the driver/amplifier circuit, and the stepper motor circuit. The control circuit serves to provide input/commands so that the CNC machine works according to the parameters entered. The driver/amplifier circuit serves to supply the current required by electronic devices. While the stepper motor functions as an actuator / produce mechanical rotation. There are three stepper motors, each of which functions as a mechanical rotation of the X-axis, Y-axis, and Z-axis

2.3. Data collection technique

Data collection techniques are carried out by entering various parameter values in the simulation to obtain the characteristics of each of these parameters so that it can be seen which parameters have the most influence on the output.

RESULT AND DISCUSSION

By entering the shaft speed value (n) of 600 (rev/min), the number of teeth (N) 2, and changing the value of the motor gain (A), the following results are obtained

Table 1. Fout value obtained by changing the parameters of the motor gain

Motor Gain A	Gain Total, K	Cutting power (F)
10	0.008	1.143
20	0.016	1.143
30	0.025	1.143
40	0.033	1.143
50	0.041	1.143

60	0.05	1.143
70	0.058	1.143
80	0.0666	1.143
90	0.075	1.143
100	0.083	1.143

Based on the experimental data in the table above, there is no significant change in the resulting cutting strength (F) to variations in the change in the value of Motor Gain, (A)

By entering the constant cutting value Kc of 1760 (N/mm), depth of cut, ap of 2 (mm), feed load fz of 2 (mm/rev), and changing the parameters of the cutting strength m, the following results are obtained.
Table 5. The f out value obtained by changing the cutting strength parameter m

Table 2. Data with a change in value m

Indeks eksponen, (m)	kc*ap*(f^m)	cutting power (F)
0.1	3772.642	3.395
0.2	4043.418	3.639
0.3	4333.628	3.900
0.4	4644.667	4.180
0.5	4978.031	4.480
0.6	5335.322	4.801
0.7	5718.256	5.146
0.8	6128.675	5.515
0.9	6568.552	5.911
1	7040	6.336

Based on the experimental data in the table above, it can be concluded that the greater the value of the exponent index (m), the greater the shear strength (F) will be.

Table 3. Data with fz value change

Feed Load fz (mm/rev)	kc*ap*(f^m)	Cutting Power (F)
1	3520	7545.300
2	5718.256	8086.580
3	7594.995	8667.500
4	9289.335	9289.300
5	10859.795	99561.000
6	12338.107	1.067
7	13743.941	1.143
8	15090.570	1.225
9	16387.489	1.3137
10	17641.790	1.408

Based on the experimental data in the table above, it can be concluded that the greater the value of the feed load per rotation (fz), the greater the cutting force (Fout) will be.

CONCLUSION

Models of a milling machine can be simulated in Matlab through analytical methods using various non-direct cutting compositions, and model expositions can vary according to cutting depth, shaft speed, workpiece and material, cutter shape, and time. For the model, the discrete functions will be different when the inspecting period is different. The presented virtual modeling method and milling machine tool simulation make it possible to create designs, perform complex analyses, tests, optimize and use various types of control structures in a computer simulation environment. This can significantly help reduce the development and design time of various construction variants of a virtual milling machine system.

ACKNOWLEDGMENT

We express our gratitude and appreciation for the support that has been given by Politeknik Negeri Malang, Indonesia.

AUTHOR CONTRIBUTION STATEMENT

The research had done by Gumono, Mira and Samsul Hadi. They finished processing the finding, evaluation of research, and finishing review process.

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