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Effectiveness of CNC Turning and CNC Milling in Machining Process

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ABSTRACT
Technological developments and advances in the digital era are currently growing rapidly along with the times, so that they have an impact in all sectors including the manufacturing industry sector. Competition in the manufacturing industry is getting higher, both in the field of supporting equipment technology and in the production sector. This makes all interested parties and companies compete to create more technical and practical equipment. The manufacture of equipment, parts, components and manufactured products in the past still used conventional machines such as lathes, milling machines, scrap machines and other machines in general and are still used today for certain jobs. The manufacture of parts such as shafts, factory components, heavy equipment components, car components, aircraft components and other engineering equipment components still uses conventional machines in a small part of the manufacture of parts and components. In jobs that require high production rates, short production times and high and uniform quality, using conventional machines is not recommended. Machines with CNC technology with computer-assisted numerical control or the like have been the solution for decades. In this paper, we will discuss the effectiveness of CNC machines, especially the TU-3A EMCO CNC milling as an illustration by developing G, M code programming, and product examples.

Keywords: CNC Technology, CNC Turning and Milling, Machining.

INTRODUCTION

Technological developments and advances in the digital era are currently growing rapidly along with the times, so that they have an impact in all sectors, especially in the manufacturing industry sector. In this era, competition in the manufacturing industry is getting higher, both in the field of supporting equipment technology and in the manufacturing production sector. This makes all interested parties and companies compete to create more technical and practical equipment. In the end, the role of conventional machines will be eroded by dependence on automation and control machines. Technological developments play a role in it, so all are required to be able to understand it and balance it. Changes in production strategy according to technological developments and the current industrial era in the manufacturing industry to be able to keep up with competition in the domestic market as well as the international market.

The development of technological machines, where these machines are created through the use of computer technology to advance human activities, thus impacting the use of control and automation systems. Control and automation systems are technologies related to the application of mechanical, electronic, and computer-based systems. The impact when using this system, manual tasks can be completed automatically. This makes work simpler, easier and saves time and labor. The control technology that is developing and used is of many variations and kinds, it becomes easier to choose according to needs.

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Volume 2 Number 2 page 575-583

LITERATURE REVIEW

The manufacture of equipment, parts, components and manufactured products in the past still used conventional machines such as lathes, milling machines, scrap machines and other machines in general and are still used today for certain jobs. The manufacture of parts such as shafts, factory components, heavy equipment components, car components, aircraft components and other engineering equipment components still uses conventional machines in a small part of the manufacture of parts and components. Jobs that require high productivity per unit of time, high quality and uniformity of quality occur cannot be done using conventional machines. Need a machine that can answer the solution to these problems.

In the early development of the machines used for machining such as lathes, milling machines, scrap machines and others, they were still in the form of conventional simple machines operated by the machine operator. The quality of products using conventional machines is still very dependent on the experience of the machine operator. Quality variations are also very diverse with these conventional machines. In jobs that require high production levels, relatively minimal production time and high and uniform quality, using conventional machines is not recommended. Machines with CNC technology with computer-assisted numerical control or the like have been the solution for decades.

The development of Information and communication technology or ICT has begun several decades ago and at this time computers have entered various fields of human activity, such as the fields of medicine, economics, agriculture, engineering and others. Various computer programs were developed to fulfill the lessons in this field. One of the things that stands out in the development of computers in this millennium era is as a basis for control (control) on production machines. In the field of systems that were previously handled by humans, in the sense of being human, we see further technological developments with robotics systems. Its operation requires human resources who have knowledge in the field of control systems. Machines that use computer control systems provide convenience in the production of machine tools in bulk form or in the form of starting complex (complicated) workpieces. This control system using a computer is known as CNC (Computer Numerial Control). CNC machines play a very important role in the metal cutting process, especially to increase the accuracy of the workpiece produced. Machining cost savings and quality improvement, by using a CNC machine, various complex workpiece surface shapes can be done easily.

Machining Process

Machining is the process of making workpieces according to the planned design by carrying out facing, roughing, finishing, cutting, slashing shapes and others using machines that can do the work such as lathes, milling machines, scrap machines and others. The machining process requires the main equipment for the process, but supporting equipment and tools are needed. This is common in every production process and manufacturing process. Machining in the early days of technology development was done predominantly with conventional machines, but in the current industrial revolution machining is done predominantly with automatic CNC machines assisted also with conventional machines according to the job specifications if needed.

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Volume 2 Number 2 page 575-583

CNC Turning

The use of computer numerical controlled (CNC) lathes with high speed and good dimensional accuracy, thus using less manpower. The use of CNC machines is increasing rapidly along with factory automation (Eddy et. al, 2020). CNC turning machines in the early technology generation with 2 axes but at this time it has developed into 2.5 axes, 3 axes, 5 axes horizontally, vertically and others (Figure 1). Initial design planning needs to be done by recording the dimensions of the workpiece before machining, after machining (Figure 2), the material used, the tool, the planned quality, the machine used and others.

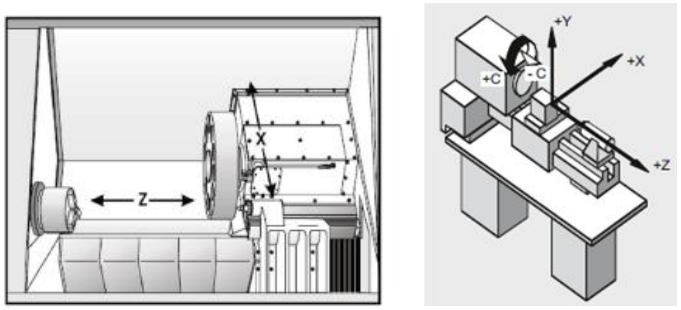

Figure 1. Axis system for turning process
(Muhammad Syafik dan Abd Khahar, 2018)

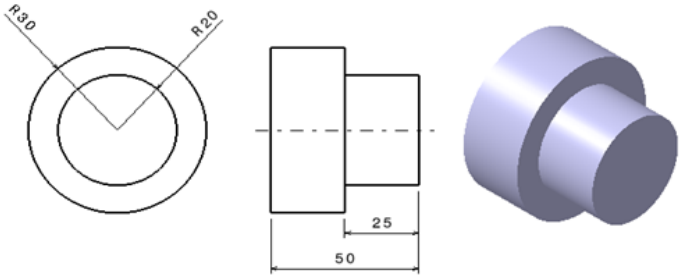

Figure 2. Step Design of CNC Turning

The design planning of workpiece for the turning process, simulation for G, M code for those who have simulation software or CAD-CAM can be done first to develop the programming code, tool path and effectiveness (Figures 3, 4) and then execute the machining directly so that into a product (Figure 5). Perform machining with CNC Turning machines without CAD-CAM or simulators, it is necessary to plan the x and z data first (for turning) after which a CNC program simulation is developed and then a toolpath simulation drawing is produced from the CNC turning machine plotter.

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Volume 2 Number 2 page 575-583

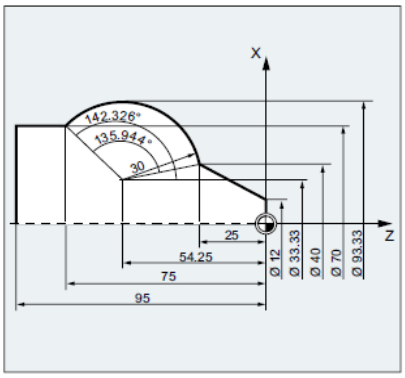

Figure 3. Design of CNC Turning

Program code	Comment
N.. ...	
N120 G0 X12 Z0	
N125 G1 X40 Z-25 F0.2	
N130 G3 X70 Y-75 I-3.335 K-29.25	; Circle end point, center point in incremental dimensions
N130 G3 X70 Y-75 I=AC(33.33) K=AC(-54.25)	; Circle end point, center point in absolute dimensions
N130 G3 X70 Z-75 CR=30	; Circle end point, circle radius
N130 G3 X70 Z-75 AR=135.944	; Opening angle, circle end point
N130 G3 I-3.335 K-29.25 AR=135.944	; Opening angle, center point in incremental dimensions
N130 G3 I=AC(33.33) K=AC(-54.25) AR=135.944	; Opening angle, center point in absolute dimensions

Figure 4. CNC Turning Code

Figure 5. Product CNC Machining

CNC Milling

The design planning of workpiece for the turning process, simulation for the G, M code for those who have simulation software or CAD-CAM can be done first to develop the programming code, tool path and effectiveness (Figure 6) after that it is then executed directly by machining so that it becomes product. Performing machining with CNC Turning machines without CAD-CAM or simulators, it is necessary to plan first the x, y, z data (for milling) and then develop a CNC program simulation and then output a toolpath simulation drawing from

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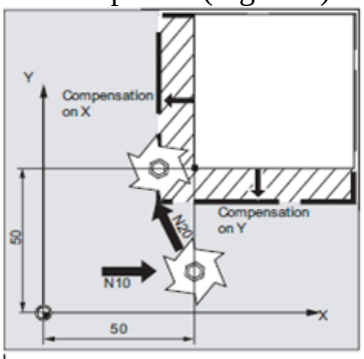
url: https://jurnal.ceredindonesia.or.id/index.php/injects
Volume 2 Number 2 page 575-583

the CNC milling machine plotter (Figure 7).



Program code	Comment
N10 G0 X50 T1 D1	; Only tool length compensation is activated. X50 is approached without compensation.
N20 G1 G41 Y50 F200	; Radius compensation is activated, point X50/Y50 is approached with compensation.
N30 Y100	
...	

Figure 6. Proses Milling (Muhammad Syafik dan Abd Khahar, 2018)

Figure 7. Machining Toolpath of "UMSU" (Rahmatullah, et al, 2021)

METHODS

In this paper, we will discuss the effectiveness of CNC machines, especially the TU-3A EMCO CNC milling as an illustration by developing G, M code programming, and product examples. First design the product plan drawing (Figure 8) to be a reference for the development of CNC milling programming. In this paper, it is planned that the machine used is a TU-3A CNC Milling machine with the aim of getting basic level CNC experience which requires us to look for conventional G, M, x, y, z data codes and experience inputting that data into the machine and simulating it. This basic knowledge should be possessed first before operating to a higher level CNC machine.

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Volume 2 Number 2 page 575-583

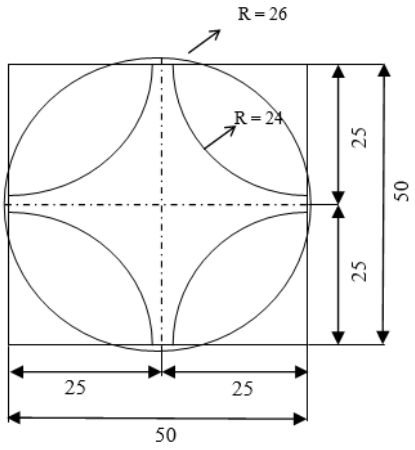

Figure 8. Workpiece desain

The data on the machine used, the material and size of the workpiece, the milling cutter, the setting distance and others in the discussion here are as shown in Table 1.

Table 1. Data mesin, benda kerja dan pisau frais

No.	Data	Information
1.	Machine	CNC TU-3A (EMCO)
2.	Tool diameter	18mm
3.	Workpiece material	Aluminium
4.	Workpiece dimension	50x50x20mm
5	Setting distance	2mm

The TU - 3A CNC machine (Figure 9) is a computer controlled milling machine. A milling machine is a machine tool that can perform straight, inclined, radius cutting and make holes. The TU – 3A CNC machine performs the production of parts by releasing metal when the workpiece is exposed to a rotating cutting tool (chisel). The milling cutter has a row of cutting edges around each of which acts as a separate cutter on the turn.

When viewed from the way it works, the TU-3A CNC machine is a machine that has the following capabilities:

1. Working with numbers and letters (Input Data)
2. Can process data (Process Data)
3. Work according to orders
4. Always follow Instructions

The TU-3A CNC machine is the most versatile of all machine tools. Both flat and grooved surfaces can be machined with exceptional finish and precision. Using a CNC machine, an economical production process will be obtained, this is due to:

- High production rate
- Less wastage on components
- Less operator use
- For mass and uniform production the cost is cheaper.

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Volume 2 Number 2 page 575-583

Figure 9. CNC TU-3A Machine

The original workpiece before being machined and the workpiece after being finished are as shown in Figures 10 and 11. The G code and M code and CNC programming for the manufacture of the planned workpiece are as in Figure 12.

Figure 10. Workpiece before machining

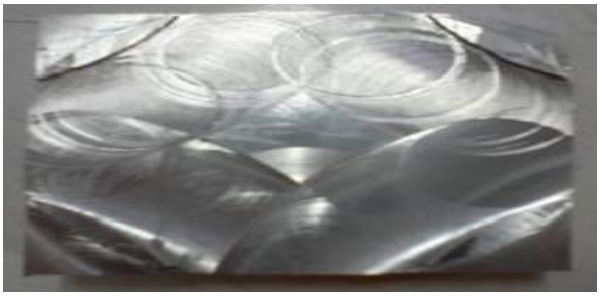

Figure 11. Workpiece after machining

International Journal of Economic, Technology and Social Sciences
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Volume 2 Number 2 page 575-583

N	G	X	Y	Z	F	Keterangan
00	92	3600	3600	200		
01	M03					
02	00	3600	1600	00		
03	01	-3600	1600	00	100	
04	00	-3600	00	00		
05	01	3600	00	00	100	
06	00	3600	-1600	00		
07	01	-3600	-1600	00	100	
08	00	-3600	00	00	100	
09	00	-3600	00	-100	100	
10	02	00	3600	-100	100	
11	02	3600	00	-100	100	
12	02	00	-3600	-100	100	
13	02	-3600	00	-100	100	
14	00	-3600	00	-200		
15	02	00	3600	-200	100	
16	02	3600	00	-200	100	
17	02	00	-3600	-200	100	
18	02	-3600	00	-200	100	
19	00	-3600	00	-200		
20	03	00	3600	-100	100	
21	03	3600	00	-100	100	
22	03	00	-3600	-100	100	
23	03	-3600	00	-100	100	
24	03	3600	00	-100		
25	00	3600	3600	200		
26	M30			200		

Figure 12. G, M Code

RESULTS AND DISCUSSION

Results

Some of the things that have been discussed above such as the discussion about determining the G code and M code and the quantities x, y, z then there are some other technical things that must be considered for the appropriate results expected at this level. These are as described below:

1. The machining result is highly dependent on the milling blade, depth, cutting speed and the type of workpiece material.
2. When binding the workpiece to the chuck, it must be really strong because otherwise it will cause the workpiece to move during feeding which may damage the workpiece.
3. Errors in determining the size of the numbers x, y, z will cause the CNC program to not match the shape of the workpiece we want.
4. In order to get the feed rate, the program that is made must be thoroughly researched (plus and minus).
5. As a correction to the program made, the results of the programming must be simulated first (by plotter).

Discussion

The discussion about CNC milling programming with the design shown above, here only discusses setting and facing.

For Setting X = Workpiece + tool radius + setting distance
= 2500 + 900 + 200
= 3600

International Journal of Economic, Technology and Social Sciences
url: https://jurnal.ceredindonesia.or.id/index.php/injects
Volume 2 Number 2 page 575-583

Y = Workpiece + tool radius + setting distance
= 2500 + 900 + 200
= 3600
Z = 200

Facing

Facing is the process of cleaning specimens from surface irregularities. Facing is done when the specimen size is close to the expected size. If the specimen size is far from the expected size, facing is not necessary. Programs N00 to N08 are programs that are planned for facing.

Other information for the entire CNC milling program is shown in Figure 12 above which explains about G, M, code and data, y, z.

CONCLUSION

The use of CNC machines at this time is absolutely dominant. This is due to the demands of competition, both domestic and international competition. The main competition is time to market efficiency competition, product quality produced according to existing standards, uniformity of quality and general costs incurred. This is a concern of all sectors of the manufacturing industry both at home and abroad. Basic knowledge about CNC machines is still needed for the CNC machine operators so that they can further develop their knowledge.

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