THE UTILIZING CUTTING FLUID AND FEEDING RATE EFFECT TO THE SURFACE HARDNESS AND PRECISSION OF ALUMINUM MATERIAL USING CNC MILLING MACHINE

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Keywords :

Cutting Fluid
Feed Rate
Surface Roughness
Precision

Abstract :

There are many factor affecting the quality of product that are produced from milling machine process. The quality is mostly about surface roughness and precision. Those affecting factors are the selection of cutting parameter and use of cutting fluid. The research is done in order to know the effect of using cutting fluid and feed rate to aluminum on surface roughness and precision using Milling CNC machine. This research uses milling CNC Mitsubishi M70 machine. The free variables of feed rate are 20, 32, 45, 69, 108 mm/min. Each feed rate variations are given cutting fluid and no- cutting fluid treatment. The cutting fluid used is bromus oil which is mixed with water. The tests performed were surface roughness test, precision test. The result of this study shows that feed rate is in line with surface roughness. The use of cutting fluid affects surface roughness. The surface roughness score at feed rate variation using coolant treatment are 20, 32, 45, 69, 108 mm/min shows the surface roughness score of 0,442; 0,484; 0,553; 0,643; 0,797 µm. surface roughness score without cutting fluid treatment reveals the score of 0,470; 0,517; 0,582; 0;662; 0,847 µm. According to statistical analysis result using two way ANOVA, it can be concluded that the use of cutting fluid and feed rate affect precision at 95% trust rate. The measurement of A dimension using cutting fluid in the variation of feed rate 20, 32, 45, 69, 108 mm/min shows the precision rate of 99,999348; 99,99929; 99,999304; 99,999261; 99,9992 %. While, the variation without cutting fluid treatment reveals the precision rate at 99,999188 ; 99,999184; 99,999037; 99;998884; 99,998684 %.

PENDAHULUAN

The development of science and technology nowadays, esspecially manufacturing industry is required to improve product quality, production speed, and production costs in order to compete with others. It requires a solution to solve the problem. One of them with a CNC machine. CNC machine is a machine which controlled by a computer using numerical language (command data with the code numbers, letters, and symbols) according to ISO standards. CNC technology working systems will be more syncronized between computers and mechanics. Therefore, when it compared with similar machine tools, CNC machine tools, more accurate, more precise, more flexible, and suitable for mass production. A designed CNC machine is to support the production of which requires a high level of complexity.

The ideal geometry characteristics of a product or a component of which is precision and smooth surface. A surface smoothness and precision are an important role in component planning which related to the friction lubrication problems, worn-out, and fatigue resistance. In [1] study exhibited that the feed rate is the most influential parameter toward the end of the surface roughness on the aluminum samples. Besides the feed rate, cutting fluid applications also assessed affect the surface roughness.

From the above background, it is necessary to expand research on the effects of cutting fluid application and feed rate selection to the surface roughness and the accuracy level. This study is expected to recognize the manufacturing process utilizations and election.

LITERATURE REVIEW

[2] conducted a study on the cutting fluid operation in machining process. Various methods have been used to protect the chisel from the heat which generated during the machining process. The coated cutting tool selection is an expensively alternative and generally suitable for some materials such as titanium alloys, heat-resistant alloys, etc. Another alternative is to implement the cutting fluid utilization in engine operation. Cutting fluid is used for lubricating and fluid cutting effect between

cutting tool and workpiece, chisel and chips during the engine is operated. Therefore, the heat generated effect on the cutting tool can be prevented. The research producesd the cutting fluid selection for the machining process which generally provides benefits such as extending its service life and chisel, improve the surface finishing quality and dimensional accuracy better.

[3] performed a research on the spindle speed effect, feed rate, and the chisel slope using an end mill chisel to surface roughness. It was using a milling machine, the independent variable was 700, 800, 900 rpm of spindle speed, 100, 200, 300 mm/ min of feed rate, and 10, 30, 50 of tilt angle. It was employing a ball nose end mill chisel of diameter 10 mm. These studies were concluded that the larger feed rate, the greater surface roughness (propotional). While the greater spindle speed and slope, the smaller surface roughness was obtained (inversely). The lowest surface roughness parameters was obtained at 9 rpm of spindle speed, 100 mm/ min of feed rate, and the slope of cutting tool was 50 with 0.58667 harshest lm.

Cutting Fluid

Cutting fluid was exploited in metal cutting or machining process for several reasons, for instance, to extend tool life, reduce the workpiece deformation due to heat, improve the surface quality machining results, and clean growled from cut surfaces. It was utilized that can be categorized into four types::

a. Straight oils
b. Soluble oils
c. Synthetic fluids
d. Semisynthetic fluids

Surface Roughness Parameters

To producing a surface profile, sensor/ feeler (stylus) measurement tool must be moved to follow the trajectory was a straight line with a predetermined distance in advance. The path length was referred to the transversing length. Shortly after needle was moving and it stopped shortly before the electronic measuring instruments perform calculations based on the data detected by needle probe. Length measurements section where the surface profile analysis referred to the sample length. Actual reproduction profile is as shown in Figure 1:

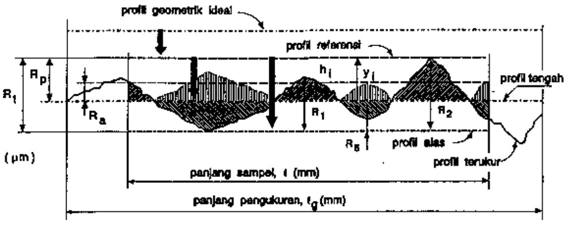

Figure 1. A surface profile [4]

Based on the profiles described above, it can be defined that several parameters of the surface, which are related to the dimensions in the direction vertical and horizontal direction. Vertical dimension is known for some parameters, namely:

Total roughness, Rt (μm).
Is the distance between the reference profile with a profile board.

Arithmetic average roughness, Ra (μm).
Is an arithmetic average value from absolute value of the distance between the profiles that measured by the middle profile.

$$Ra = \sqrt{\frac{1}{l}\int_0^l hi^2 \, dx} \qquad (1)$$

Total roughness mean, Rz (μm).
Is the pedestal profiles average distance to measured profiles on the five highest peaks, which reduced by pedestal profile average distance to measured profiles on five lowest valleys.

$$Rz = \frac{\sum[R1 + R2 + ...+ R5 - R6 - ...... - R10]}{5} \qquad (2)$$

Precision

Precision shows value how close the difference at the time of measurement repeatability. Although, the measurement accuracy results indicates closeness to the true value. The definition can be described in the following illustration.

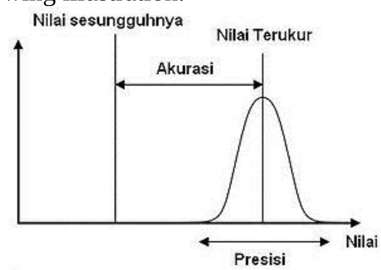

Figure 2. Precision and Accuracy Ilustration

In the field of science, industrial engineering, and statistics, the accuracy measurement system is a measurement of the closeness level to the true value. Precision measurement system, also called reproducibility or repeatability is the extent to which measurement repeated in an unchanging state get the same results. A measurement can be accurate and precise, or accurate but not precise or accurate but not precise, or the inaccurate and imprecise [5].

RESEARCH METHODOLOGY

This research was conducted at Laboratory of National Electric Car, Mechanical Engineering, Universitas Sebelas Maret, Surakarta.

The material which used in this study was Aluminium. Chisel was used with carbide cutting tool material with a chisel type and diameter as follows:

1. Endmill carbide 20 mm (facing).
2. Endmill carbide 10 mm (profil).
3. Drill chisel diameter 5 mm.
4. Chisel thread M06x1.

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Independent Variable

The independent variable is a variable which determined by investigators and the value can be changed by a certain method to get the dependent variabel amount of the research object, to obtain correlation between them. In this research, there two independent variables were cutting fluid (with and without) and feed rate (20, 32, 45, 69, 108 mm/ min).

Dependent Variable

The dependent variable is a variable whose value depends on the independent variables and identified after an investigation. The corelation between independent and dependent variables will produce changes of dependent variable value. The dependent variable in this study was the result of surface roughness and precision machining processes

Controlled Variable

Controlled variable is a variable whose value is kept constant during the study. It were kept constant during this study include 800 rpm of spindle rotation (facing) and 1600 rpm (profile), and 1 mm of feeding depth.

The initial stage of this study was began by creating 3D modeling using solidworks software. The design was made that the motor vehicle spare parts named Engine Kill Switch. Work piece design is shown in Figure 3.

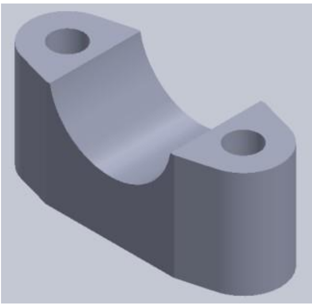


Figure 3. Work piece cross section design.

Experiments simulation was using solidcam software, and from the simulation results will be obtained which employing the NC-Code with post processor that suitable with CNC machines was used, MITSUBISHI M-70.

An initial machining process by employing a CNC milling machine which was facing process that using independent variables that have been determined. After it completed, followed by surface roughness measurements, using Surface Roughness Tester SJ-201 series. At the time of data capture, sensors position constantly moved which suitable with horizontal axis and parallel to the test object (that were in a straight line).

The next machining process was profile manufacturing process with the same independent variables treatment. Afterthat, data collection was performed to determine the dimensions of precision. Each workpiece measurement was done in four different positions as shown in Figure 4.

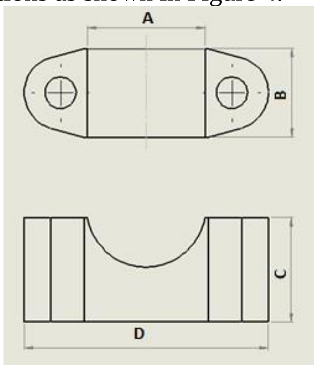


Figure 4. Workpiece measurement dimensions area

RESULT AND DISCUSSION

The surface roughness testing results of cutting fluids application and selection of feed rate can be seen in Figure 5.

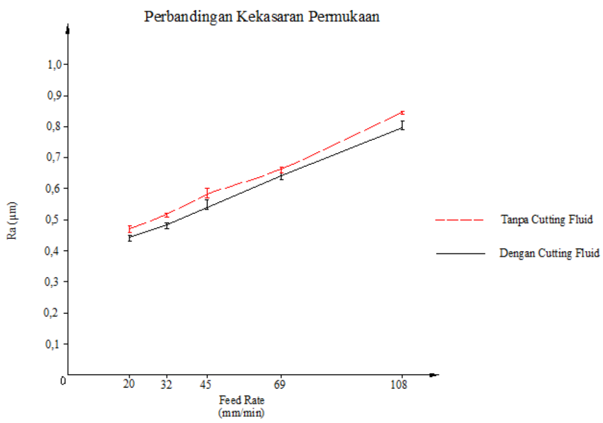


Figure 5. Diagram of feed rate variations with and without cutting fluid to surface roughness correlation

Figure 5 portrays in feed rate variations with and without cutting fluid to the surface roughness correlation of the workpiece. The testing result which was using cooler showed graphs that the surface roughness of each variation of the feed rate was raised. Roughness values on variations of 20, 32, 45, 69, 108 mm/ min of feeding rate which empolying a cutting fluid, it was demonstrating by 0.442; 0.484; 0.553; 0.643; 0.797 lm respectively. On the other treatments, ie without a cutting fluid testing the surface roughness as shown in Figure 3. It displays an the surface roughness of each variation of the feed rate of the feed rate low to high feed rate was increased. The surface roughness variations of 20, 32, 45, 69, 108 mm/ min of feeding rate without using a cutting fluid exhibits 0,470; 0,517; 0.582; 0; 662; 0.847 lm of roughness. From Figure 5 above demonstrates that feeding rate was directly proportional to the surface roughness. The greater feeding rate, the larger surface roughness was obtained which was practicing with or without it. This was convenient to [6] research which was stated that the higher feeding rate, the huge machining process surface roughness of CNC milling, as the same as low feed rate, the surface roughness will be smaller.

The cutting fluid application on a CNC milling process was performed on the aluminum material which effected on the surface roughness. This is shown in the graph in which the roughness value variation of 20, 32, 45, 69, 108 mm/ min of feeding rate that using a cutting fluid, establishing the roughness value by 0.442; 0.484; 0.553; 0.643; 0.797 lm respectively. The surface roughness values without using cutting fluid demonstrated 0,470; 0,517; 0.582; 0; 662; 0.847 lm of roughness. Workpiece which was using cutting fluid treatment has a less roughness than without treatment. One of the cutting fluid functions was to reduce built-up edge. It is one of the major contributing factors in the natural surface roughness. It can be continuously formed and broken, the fault will be borne particles below the surface of the chip and the new workpiece surface. Therefore, chip that was formed will be larger, it will produce a rougher surface. By reducing built up edge, then the resulting surface will be finer [7]. The basis of the theory stated that the cutting fluid utilization have an effect on the workpiece. Ie, the workpiece surface was produced become finer [8]. This was suitable to research which conducted by [1] which tells that cutting fluid application will affect the final surface output. There was also a study of [3] which declares that the greater feeding rate, the greater surface roughness (proportional).

Dimensional measurements was engaging calipers measuring devices with an accuracy of 0.01 mm. Dimensional measurements was carried out 30 times against 10 different workpieces, each workpiece 4 times measurements at different positions. The data obtained in this test data was contained data dimensions of the measurement position A, B, C, D.

The measurement results were then analyzed using Variance two-way (two way ANOVA) analysis to investigate whether there was any difference some treatments effects (the cutting fluid utilization and feeding rate) on the dependent variable (data precision) using SPSS (Statistical Product and Service Solution) version 22 ,

On entering the data in the table to be analyzed, the researchers exploited the distance between dimensions measured data with an overall average of each sample. The distance between the average measured dimensions can be defined as following formula:

$$d_n = -(x_n - \bar{x})^2 \qquad (3)$$

Where:

Where:

d_n : Input data (average measured dimensions)
x_n : Spot sample each measurement
$\bar{x}$: Average measurement each sample

Based on SPSS program calculations was obtained the following results :

Table 1. Program SPSS Dimension A Results Analysis

Tests of Between-Subjects Effects

Dependent Variable: dimensiA

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	3,585E-5[a]	9	3,983E-6	6,399	,000
Intercept	9,611E-5	1	9,611E-5	154,418	,000
feedrate	1,286E-5	4	3,215E-6	5,165	,000
cuttingfluid	1,381E-5	1	1,381E-5	22,195	,000
feedrate * cuttingfluid	9,174E-6	4	2,294E-6	3,685	,006
Error	,000	290	6,224E-7		
Total	,000	300			
Corrected Total	,000	299			

a. R Squared = ,166 (Adjusted R Squared = ,140)

Table 2. Program SPSS Dimension B Results Analysis

Tests of Between-Subjects Effects

Dependent Variable: dimensiB

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5,320E-6[a]	9	5,911E-7	16,248	,000
Intercept	9,910E-6	1	9,910E-6	272,401	,000
feedrate	2,266E-6	4	5,665E-7	15,571	,000
cuttingfluid	2,108E-6	1	2,108E-6	57,957	,000
feedrate * cuttingfluid	9,455E-7	4	2,364E-7	6,498	,000
Error	1,055E-5	290	3,638E-8		
Total	2,578E-5	300			
Corrected Total	1,587E-5	299			

a. R Squared = ,335 (Adjusted R Squared = ,315)

Table 3. Program SPSS Dimension C Results Analysis

Tests of Between-Subjects Effects

Dependent Variable: dimensiC

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2,325E-5[a]	9	2,583E-6	9,227	,000
Intercept	3,815E-5	1	3,815E-5	136,275	,000
feedrate	5,634E-6	4	1,409E-6	5,032	,001
cuttingfluid	1,457E-5	1	1,457E-5	52,049	,000
feedrate * cuttingfluid	3,042E-6	4	7,606E-7	2,717	,030
Error	8,118E-5	290	2,799E-7		
Total	,000	300			
Corrected Total	,000	299			

a. R Squared = ,223 (Adjusted R Squared = ,198)

Table 4. Program SPSS Dimension D Results Analysis

Tests of Between-Subjects Effects

Dependent Variable: dimensiD

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2,562E-5[a]	9	2,846E-6	9,663	,000
Intercept	4,219E-5	1	4,219E-5	143,256	,000
feedrate	7,850E-6	4	1,963E-6	6,663	,000
cuttingfluid	1,405E-5	1	1,405E-5	47,697	,000
feedrate * cuttingfluid	3,717E-6	4	9,292E-7	3,155	,015
Error	8,542E-5	290	2,945E-7		
Total	,000	300			
Corrected Total	,000	299			

a. R Squared = ,231 (Adjusted R Squared = ,207)

Based on SPSS analysis table result shows that the significance level of feeding rate correlation to accuracy was <0.05 (significance level has been determined) so H_{0A} was rejected. Therefore, the H_{1A} decision test, which means there was influence between feeding rate to precision. Significance value of the precision correlation to cutting fluid was <0,05 so H_{0B} was also rejected. It can be concluded that there was influence between the cutting fluid applications to precision. Similarly, the significance value level of feeding rate correlation and cutting fluid <0.05. Thus, H_{0AB} was rejected and accepted H_{1AB} which means there was an interaction between feed rate and cutting fluid toward precision.

To find the deployment of data, researchers determined the standard deviation in each dimension in a variety of independent variables. The smaller standard deviation, the deployment of data was taken increasingly accumulate. Futhermore, standard deviation can be determined using the formula:

$$S = \left[\frac{\sum_{i=1}^{i=n} \left(x_n - \bar{x}\right)^2}{n-1} \right]^{1/2} \quad (4)$$

Once distributing data was known on each sample, and then look for accuracy value using the formula:

$$\text{Precision} = \left(100\,\% - \sum_{i=1}^{i=n} \left| \frac{x_n - \bar{x}}{\bar{x}} \times 100\,\% \right| \right) \quad (5)$$

The graph of feeding rate to cutting fluid application variations to the accuracy level of observation results are shown in the following figures:

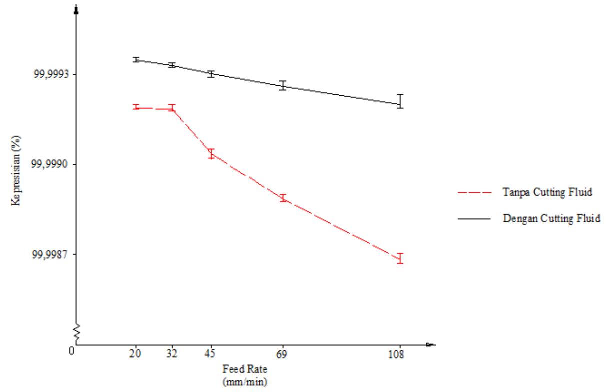


Figure 6. Feeding Rate to Precision Correlation Graph of a Half Circle Observation Results Data (A)

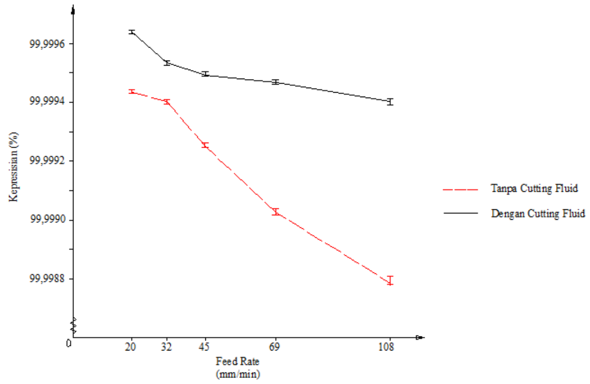
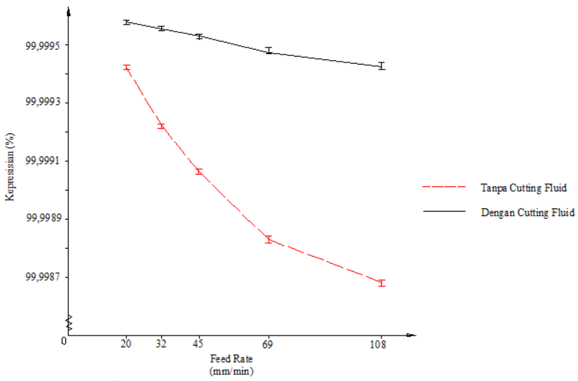


Figure 7. Feeding Rate to Precision Correlation Graph of Width Dimensions Observation Results Data (B)



Graph of Height Dimensions Observation Results Data (C)

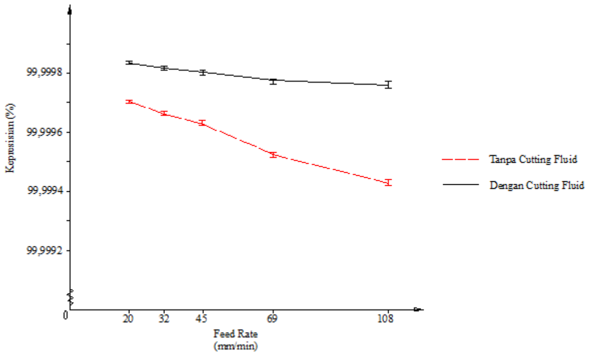


Figure 9. Feeding Rate to Precision Correlation Graph of Lenght Dimensions Observation Results Data (D)

From the graphs above show the cutting fluid effect and feeding rate variations on precision. The higher feeding rate, the lower the precision level. It may be caused of the vibration which generated by the friction between cutting tool to the workpiece. The greater feeding rate, the huge vibration was obtained [6]. If the vibrations was produced high, the workpiece precision will be decreased. The cutting fluid applications variations, indicating that it showed a higher level of accuracy than without employing it. One of the cutting fluid utilization was to reduce built-up edge. Built up edge is one of the major contributing factors in the natural surface roughness and precision. Built up edge can be continuously formed and broken, the fault will be borne particles below the surface of the chip and the new workpiece surface. Therefore, chip that was formed will be larger, it will exhibit a rougher surface and precision. By reducing built up edge, then the resulting surface will be better [7]. These results were suitable with studies that conducted by [2] suggested that cutting fluid employment for the machining process generally provides benefits to improve the surface finish quality. It was also consistent with the theory that one of the cutting fluid operation benefits of which was the workpiece surface to be better [8].

CONCLUSION

Based on data analysis and discussion could be taken several conclusions as follows:

1. The higher feeding rate, the greater surface roughness. The cutting fluid application has a positive influence on the surface roughness was denoted by the roughness 20, 32, 45, 69, 108 mm/min of feeding rate of it, demonstrating the roughness value by 0.442; 0.484; 0.553; 0.643; 0.797 μm respectively compared with the same feeding rate without it displays 0,470; 0,517; 0.582; 0; 662; 0.847 lm of surface roughness value.
2. The cutting fluid and feeding rate variations was known to affect the precision of the test two way ANOVA hypothesis with 95% of satisfaction level. The higher feeding rate, the accuracy level was getting lower. The cutting fluid utilization caused a higher level of precision.

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