Surface Roughness Analysis of Turning Results with Variations of Spindle Speed, Feeding, And Depth of Cut Using AISI 1040 Steel

[1]Sumardi Sumardi, [2]Mawardi Mawardi, [3]Ilyas Yusuf, [4]Dailami Dailami, [5]Hamdani Hamdani, [6]Sariyusda Sariyusda

[1,2,3,4,5,6]Department of Mechanical Engineering
[1,2,3,4,5,6]Lhokseumawe State Polytechnic, Lhokseumawer, Indonesia

***Abstract*— The quality of the turning results specially on surface area strongly influenced by three parameters, spindle speed, feed, and depth of cut. Level of surface roughness is much influential on the workpiece results after processing on the lathe machine. Based on experience in the field, in the turning process in order to obtain a good surface roughness quality of the workpiece, it is necessary to choose good components as well. The selection of the components in question is those that have a significant effect on the workpiece feeding results. The turning tool is a major component in machining process in addition to lathe machine and workpiece. Aim of this study was to determine surface roughness value of AISI 1040 steel with variations in spindle rotation and depth of cut in lathe process. This test was carried out with a lathe machine model PL-1000 G with AISI 1040 steel specimens. Surface roughness test tool used was the Mitutoyo SJ-310. Results obtained are best surface roughness value at 275 rpm spindle rotation value of 2.173 µm at 0.2 mm infeed of depth. Best surface roughness value at 550 rpm spindle rotation of 1.625 µm at 0.2 mm infeed of depth. The best surface roughness value at 1020 rpm with spindle rotation of 1.663 µm.**

***Index Terms*— Depth of Cut, Surface Roughness, Carbide Chisel.**

I. INTRODUCTION

The quality of the machining results specially on the surface of an object greatly influenced by three parameters, it is the spindle speed, feeding, and depth of cut [1]. To obtain good workmanship of a product, of course there are several factors that must be met, namely the surface roughness level (N) must be achieved. The level of surface roughness of product, for example: machine components from machining processing could affect their various functions, including due to interface friction, heat generating and wear. Where the smoother surface of a product, the smaller friction that occurs, and also the smoother surface then more evenly heat transfer distributed [2].

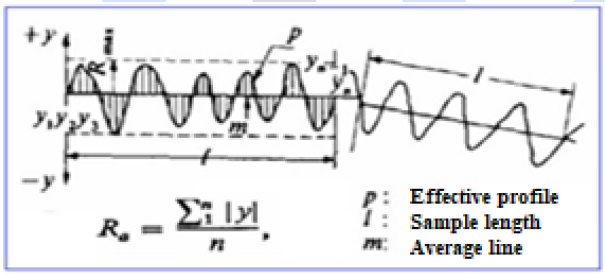

Figure 1. Deviation of arithmetic mean Ra from profile line mean.

Based on references in general type, AISI 1040 material was often use as material for manufacture of gears, crankshafts, and other main machining components.

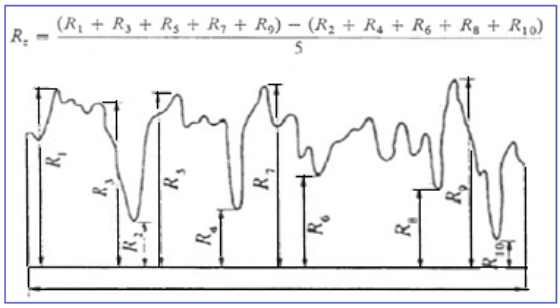

Figure 2. The 10 Rz point elevation of the unevenness

This carbon steel has a composition of 96.8% Fe, 0.4% C, and 0.75% Mn and classified as medium carbon steel [4]. Following shows a picture of machine components that has been produced.

Figure 3. Manufacturing Products from Mat'l AISI 1040

II. Tools and Materials

Types of equipment for working on specimens used in this study are as follows:

1. Chainsaw
2. Lathe machine model PL-1000G
3. Carbide chisel (cutter)
4. Dead center
5. Vernier calipers
6. Safety glasses
7. Brush
8. Chuck key
9. Tool post key
10. Surface Roughness Tester tool

The specimen material used in this study is AISI 1040 steel.

III. Research Stages

1) The process of forming a specimen
   1. Cut the material with a saw cut as much as 6 pcs with p x d = 35 mm x 40 mm.
   2. Perform rough turning with infeed thickness of 0.5 mm 10 times.
   3. Measure specimens for precise results.
   4. Carry out the turning process with the variations that have been determined.
   AISI 1040 steel material can be seen in Figure 4 below.

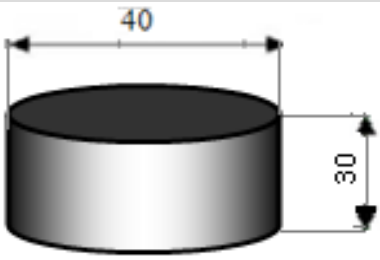

Figure 4. Specimen Formation

2) Determine the variables in the lathe process

Parameters that must be done are spindle rotation (n), depth of cut (a). As for measurement variations there are three variations of spindle rotation and two depths of cut. Then the turning process of specimens will be carried out as many as six specimens with different spindle rotation and depth of cut, as shown in Table 1.

Table 1. Number of Samples for Each Process

Sampl eCode	Spindle speed (rpm)	Depth of cut (mm)	Number of Specimens
A1	275	0.2	1
A2	275	0.4	1
B1	550	0.2	1
B2	550	0.4	1
C1	1020	0.2	1
C2	1020	0.4	1

IV. Test Method

Tested steps as follows:

1. Prepare and calibrate the Mitutoyo SJ -310 surface roughness tester.
2. Place specimen under test tool stylus.
3. Starting specimen surface roughness test stage.
4. Print data of roughness test results

Figure 5. Surface Tester Tool

Figure 6. Surface roughness test specimens

V. Test Equipment Set-Up

1. Use hand gloves before measuring test specimen.
2. Check equipment completeness, put all equipment in their respective positions and then turn on the tool by pressing "on" position button.
3. Set position of sensor and do the calibration.
4. Prepare specimen to be tested and adjust position of sensor after specimen.
5. Adjusted sensor so that tip of the sensor is in a stable position (in the middle of scale) on reading of pressure scale against the surface of measuring object.
6. Before the tool turn on, factors such as surface length of object you want to examine, the standard you want to use (Ra, Rq, Rz, Rmax, and other parameters) are first entered.
7. At the time of data collection, position of sensor moves constantly according to horizontal axis and parallel to object tested (in a straight line).
8. Furthermore, from the results of surface roughness test, we can print out test results on tool. With an accuracy of 0.01 µmm this tool also produces in form of a graph, showing the appropriate quantities of Ra, Rz, Rq, Rmax with desired standard.

The surface of workpiece from results of machining and others will certainly have a roughness level value on surface object, both wavy and averages. Among them, shape factors of surface object from results of the machining process, it will show the achievement level of surface roughness with criteria: rough, medium and smooth.

The roughness curve is shown as Y = F(x) with curve length of 1m, where the axis of surface roughness curve as x-axis and magnification in vertical direction as y-axis, roughness value (Ra) can be calculated by the equation:

$$\boxed{Ra = \frac{1}{1m} \int_{x=0}^{x=1m} F(x)dx} \qquad Ra = \frac{.m}{1m}$$

Or roughness value (Ra) can be determined by adding up shaded area above and below the axis of surface roughness curve and divided by length of curve measured. Where:

M = Total area of the shaded area above and below the axis line (area of the shaded area).

1m = Length of the measured curve.

Ra = Surface roughness value

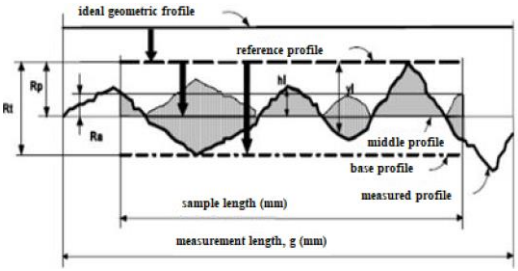

Figure 7. Profile for surface roughness sample length.

VI. Implementation of Research Activities

Broadly speaking, the stages of the research process are carried out as in the flow diagram below:

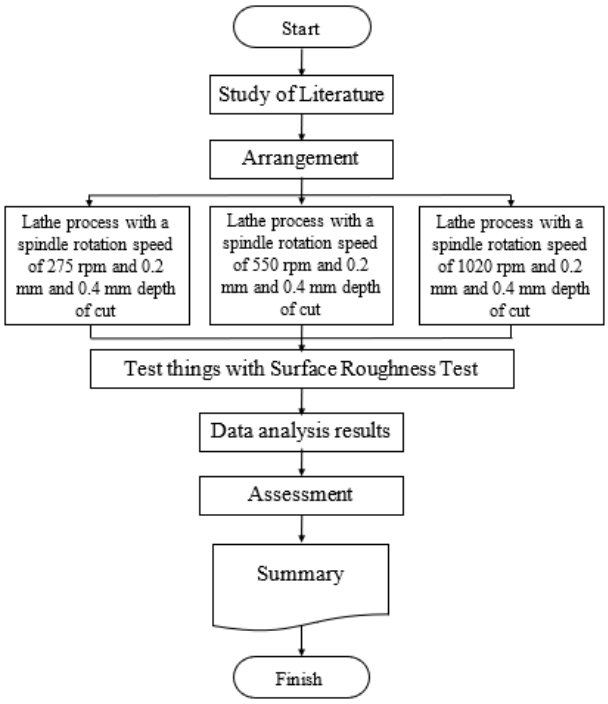

Figure 8. Research flow diagram

VII. Results and Discussion

1. Specimen forming process.
   Forming process (work on) specimen using lathe machine, then machining result of specimens test are measured using surface tester tool.
2. Surface roughness test result data and discussion.

On 1020 rpm spindle rotation at 0.4 mm depth of cut, high roughness value is due to high cutting forces and loads occurred, so results from surface would be worse. The higher rotary speed, cutting speed and greater ratio of the depth of cut, then, the lower result roughness value (smoother) because it is caused by smaller cutting force and non-breaking of cutting in turning process which affects surface roughness level of workpiece. In specimen C, the roughness value is high, this is due to the worn out chisel so that chisel not able to withstand large loads from high spindle rotation. In this study only one chisel was used so that in specimen C, the chisel was worn out and caused a high roughness value.

Figure 9. Data retrieval of test results

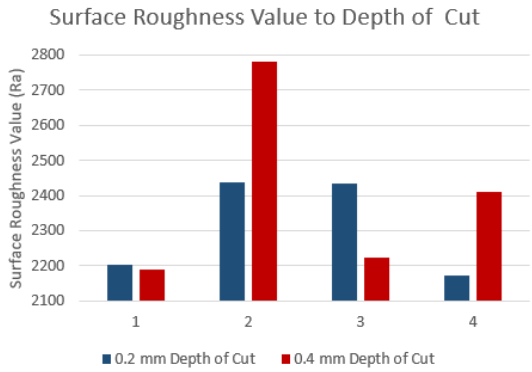

Figure 10. Surface roughness value Ra at 275 rpm spindle rotation.

Table 2. Surface Roughness Level of Specimens A1 and A2.

Sample Code	Test Point	Roughness Value (Ra)		Roughness Level Number
		µm	µinch	
A1 (0.2mm)	1	2203	87	N7
	2	2438	96	N8
	3	2436	96	N8
	4	2173	86	N7
A2 (0.4mm)	1	2188	86	N7
	2	2781	109	N8
	3	2223	88	N7
	4	2411	95	N8

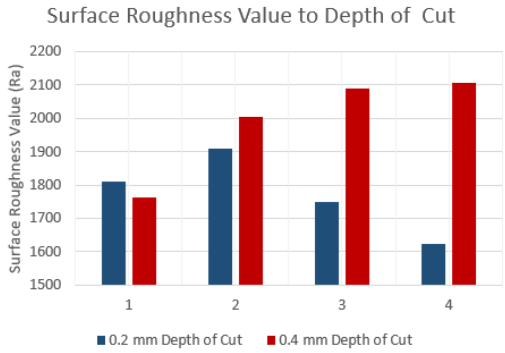

Figure 11. Surface roughness value Ra at 550 rpm spindle rotation.

Table 3. Roughness Level of Surface Roughness on the Specimens B1 and B2.

Sample Code	Test Point	Roughness Value (Ra)		Roughness Level Number
		µm	µinch	
B1 (0.2mm)	1	1812	71	N7
	2	1909	75	N7
	3	1751	69	N7
	4	1625	64	N7
B2 (0.4mm)	1	1763	69	N7
	2	2004	79	N7
	3	2090	82	N7
	4	2106	83	N7

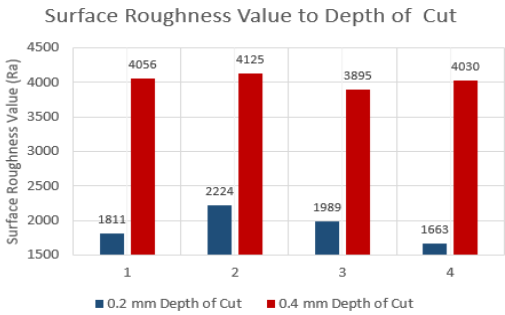

Figure 12. Graph of surface roughness values at 1020 rpm spindle rotation.

Table 4. Roughness Level of Surface Roughness on the Specimens C1 and C2.

Sample Code	Test Point	Roughness Value (Ra)		Roughness Level Number
		µm	µinch	
C1 (0.2mm)	1	1811	71	N7
	2	2224	88	N7
	3	1989	78	N7
	4	1663	65	N7
C2 (0.4mm)	1	4056	160	N8
	2	4125	162	N8
	3	3895	152	N8
	4	4030	159	N8

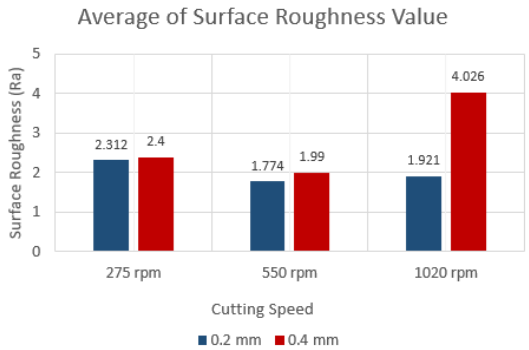

Figure 13. Graph of average surface roughness value.

VIII. Conclusion

1. Surface roughness value at 275 rpm spindle rotation with 0.2 mm depth of cut has an average value of 2.312 µm. At 0.4 mm depth it is 2.400 µm. Surface roughness value at 550 rpm spindle rotation with 0.2 mm depth of cut has an average value of 1.774 µm. At 0.4 mm depth of cut, it is 1.990 µm. Surface roughness value at 1020 rpm spindle rotation with 0.2 mm depth of cut has an average value of 1.921 µm. and at 0.4 mm depth of cut, it is 4.026 µm.
2. The best surface roughness value was at spindle rotation of 275 rpm with 0.2 mm depth of cut, it is at point 4 with value of 2.173 µm. At a depth of cut of 0.4 mm at point 1 with a value of 2.188 µm. Best surface roughness value at 550 rpm spindle rotation at a depth of cut of 0.2 mm, namely at point 4 with a value of 1.625 µm. at a depth of cut of 0.4 mm at point 1 with a value of 1.763 µm. The best surface roughness value is at 1020 rpm spindle rotation at a depth of cut of 0.2 mm, namely at point 4 with a value of 1.663 µm. at a depth of cut of 0.4 mm at point 3 with a value of 3.896 µm.
3. In this study only one chisel was used to, so at specimen C, the chisel was worn out and caused a high roughness value.

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