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VARIATION OF CUTTING PARAMETERS IN THE PROCESS OF TURNING AISI 4340 STEEL ON SURFACE ROUGHNESS

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Abstract -- *In the metal machining process, cutting speed and feed rate are cutting parameters that affect the surface quality of the workpiece produced. The use of improper cutting parameters can cause the workpiece surface to be rough, and the cutting toolage to be shorter. This study was conducted to determine the effect of cutting parameters and the use of carbide tools on the surface roughness of metal steel workpieces. The research was carried out using the experimental method of AISI 4340 steel metal workpiece turning using cutting tool coated. Five variations of cutting speed used are: 140 m/min, 150 m/min, 160 m/min, 170 m/min, 180 m/min and three variations in feed rate: 0.25 mm/rev, 0.3 mm/rev, 0.35 mm/rev. After the turning process, the surface roughness of the workpiece is measured using a surface tester. From the results of the study, it was found that the surface roughness value was directly proportional to the feed rate and inversely proportional to the cutting speed. The smallest surface roughness value is 9.56 µm on cutting speed 180 m / min, and feed rate is 0.25 mm/rev.*

Keywords: *Machining process; Cutting parameter; Cutting speed; Feed rate*

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INTRODUCTION

In the metal machining process, the quality of the product depends on the parameters and cutting tool that be used. Generally, machining parameters that determine on machining process is feed rate that means feeding speed by cutting machine, and cutting speed (Yang et al., 2019; Tuysuz & Altintas, 2019).

The research carried out by Handoko & Mudjijana (2012) on optimization parameters for machining of Ductile Iron Materials, states that the cutting parameter optimization is determined by the ratio of the parameter comparison to obtaining the optimization parameters (Mikoleizig, 2015). Hard turning operations involve the cutting of materials with hardness ranging from 58 to 68 Rockwell C (HRC) (Ferreira et al., 2016).

AISI 4340 medium carbon (0.4% C) high strength martensitic steel is one such desirable material used very frequently to manufacture critical components in aerospace engineering and automotive transmissions, including the manufacture of bearings, gears, shafts, and cams, which require higher geometric tolerances, longer service life, and excellent surface finish (Rashid et al., 2013). Many aerospace and automotive systems require structural parts presenting high in-service performance. Gears and crankshafts are among these components, whose surface (Jomaa et al., 2016) and subsurface characteristics play a crucial role in controlling their service life.

The major problem during hard turning is the high heat generation due to friction between a chips-tool interface that causes a higher wear rate, low surface quality, and shorter tool lives. Therefore, tool life and surface quality of the components can be improved by controlling the temperature of the cutting zone (Kumar et al., 2017). In its current state, hard turning differs from conventional turning on account of several factors including the cutting tool, workpiece, or the process itself, all of which may influence the machining outcome (Agrawal et al., 2015).

Using various cutting parameters is done to determine the surface of the workpiece made and also to determine the age of the cutting tool. Of course, in the machining process, right surface conditions are desired. Good surface conditions are determined based on the surface roughness produced according to the plan. Learning the proper cutting speed can provide a good workpiece surface. In general, the value of cutting speed and feed can be obtained through the table presented by Kalpakjian & Schmid (2016). But specifically, each cutting tool provides recommendations for the use of cutting parameters that are effective in reducing each workpiece. However, no information on the use of cutting speeds that results in an excellent surface roughness value is obtained. Therefore, it is necessary to conduct a scientific study on the use of various cutting parameters in the AISI 4340 steel turning process using carbide cutting tools to determine the surface conditions of the resulting workpiece AISI 4340 (medium carbon (0.4 % C) having 1.8 % nickel–chromium–molybdenum) is a high strength martensitic steel. It is generally supplied hardened and tempered in the tensile range of 0.9 to 1 GPa, but further improvement in the mechanical properties beyond pre hardening and tempering is possible through surface hardening by flame or induction hardening and by nitriding. It is used for manufacturing critical components for aerospace engineering, automotive transmissions (e.g., manufacturing of bearings, gears, heavy-duty shafts, axles, spindles, couplings, Pins, and cams which require tighter geometric tolerances, longer service life and excellent surface finish), and metal forming moulds where severe dynamic load imposes strict conditions on surface quality (Rashid et al., 2016).

MATERIAL AND METHOD

Material

Experimental process of AISI 4340 steel turning using Mazak CNC lathes. Evaluated the performance of coated cemented carbide inserts during machining of hardened AISI 4340 steel. The analysis of results concluded that low feed rate, little depth of cut, and high cutting speed were beneficial for minimizing the cutting force. However, lower cutting speed and feed values were useful for reducing (Pal et al., 2014).

AISI 4340 alloy steel is selected as the workpiece material. It is being used in manufacturing industries where high tensile and yield strength are required. Components made of AISI 4340 steel are widely used in aircraft, automotive and general engineering industries, e.g. rotor shaft, propeller shafts, connecting rods, gear shafts, and other automobile parts (Kumar et al., 2017).

The tool wears the cutting tool used is a TNMG carbide coated type. Fig. 1 shows a carbide coated. The chemical composition, the properties of materials, and the dimension of AISI 4340 Steel are shown in Fig. 2.

Figure 1**.** Carbide Coated

Chemical Composition of AISI 4340 Steel

Element	**Content (%)**
Iron, Fe	95.195-96.33
Nickel, Ni	1.65-2.00
Chromium, Cr	0.700-0.900
Manganese, Mn	0.600-0.800
Carbon, C	0.3700-0.430
Molybdenum, Mo	0.200-0.300
Silicon, Si	0.150-0.300
Sulfur, S	0.0400
Phosphorous	0.0350

Properties of Material

Properties	**Metric**
Tensile strength	745 MPa
Yield strength	470 MPa
Bulk modulus (typical for steel)	140 GPa
Shear modulus (typical for steel)	80 GPa
Elastic modulus	190-210 GPa
Poisson's ratio	0.27-0.30
Elongation at break	22%
Reduction of area	50%
Hardness, Brinell	217

Figure 2. AISI 4340 Steel

AISI 4340 steel is a difficult to machine material because of its high hardness, low specific heat and tendency to get strain hardened. It is known for its toughness and capability of developing high strength in the heat-treated condition while retaining good fatigue strength. Machining is best done with this alloy in the annealed or normalized and tempered condition.

AISI 4340 has good ductility in the annealed condition, and most forming operations are carried out in that condition. It can be bent or formed by spinning or pressing in the annealed state. AISI 4340 is high tensile strength general engineering steel ideal for automotive and aircraft components. Axles & axle components, arbors, extrusion liners, lines extrusion, magneto drive coupling, shaft & wheels, pinions & pinion shafts are the application range of AISI 4340 alloy steel. AISI 4340 is a more robust and more ductile material than EN-19 due to the Ni and Chrome alloying additions (Das et al., 2013).

Measurement of the surface roughness of the workpiece using a surface tester Mitutoyo type 211. A surface tester Mitutoyo type 211 is shown in Fig. 3. The mechanism of the cutting process in CNC Turning is depicted in Fig. 4.

Figure 3. Surface Tester Mitutoyo 211

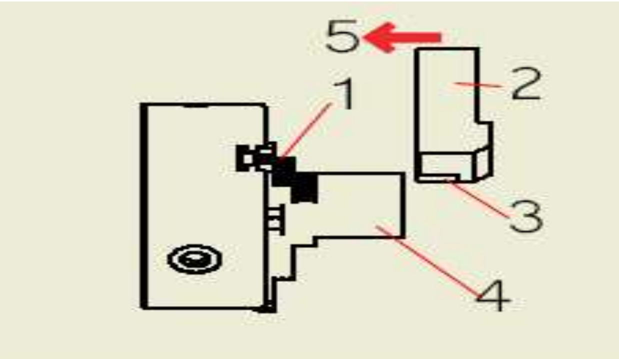

Figure 4. Mechanism of Cutting Process in CNC Turning. (1. Chuck, 2.Tool holder 3.Cutting tool insert, 4. Workpiece 5. Cutting motion)

Method

This research was carried out by an experimental approach; the experiment was carried out with variations in cutting speed and cutting conductivity. The workpiece is gripped on the lathe chuck; the carbide insert cutting tool is attached to the tool holder and attached to the lathe. Cutting speed and cutting conductivity are determined on the machine. The cutting tool is then moved close to the surface of the workpiece. The spindle rotates, and the cutting tool moves towards the workpiece surface to carry out the cutting process. The Cutting process is carried out so that it reaches the specified cutting length limit. Then the machine is stopped, then the surface roughness tester is placed above the surface of the workpiece then the observation and surface roughness of the workpiece is carried out.

The surface roughness of any material during turning depends on cutting speed, feed rate, depth of cut, and approach angle (Kumar & Chauhan, 2015).

All output parameter always show the linear relation with a depth of cut. In this machining process is done without using coolant. The value of the surface roughness obtained is then inserted into the table to be further made into the graph and analyzed. After taking the data of surface roughness values, the turning process is carried out again by changing the combination of cutting speed and cutting conductivity that has been designed.

The cutting speed and feed rate are the essential machining parameters on the surface roughness. At low cutting speeds (80 m/min) there is a large quantity flow of material on the cutting edge that caused the large surface roughness due to high friction. At high cutting speeds (170 m/min), it is monitored that the matrix material deformed to a lesser extent causing the surface roughness is reduced to 0.48μm (Kumar & Chauhan, 2015). After every turning operation, specimens were cleaned, and surface roughness was measured with a suitable clamping arrangement.

The surface roughness was measured at three points on the specimen and average of that measurements was taken as the final roughness value (D'Addona & Raykar, 2015). The surface roughness value for the gear surface quality standard is 1.04 μm (Handoko & Mudjijana, 2012), as shown in Fig. 5.

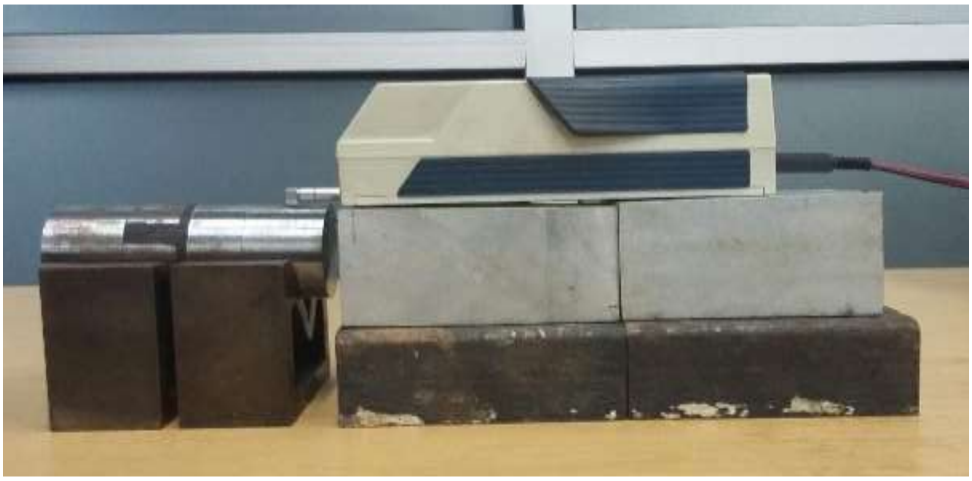

Figure 5. Surface Roughness Measurement

RESULTS AND DISCUSSION

The surface roughness values obtained in each machining parameter used are listed in Table 1.

Table 1. Surface Roughness AISI 4340 Steel

Cutting parameter	**Surface roughness (Ra) (μm)**				
	Vc1	**Vc2**	**Vc3**	**Vc4**	**Vc5**
F1	10,04	9,986	9,746	9,562	8,848
F2	18,538	17,60	17,29	17,14	16,97
F3	26,9	26,67	26,10	25,43	25,41

Where:
Vc1 is 140 m/min, Vc2 is 150 m/min,
Vc3 is 160 m/min, Vc4 is 170 m/min
Vc5 is 180 m/min
F1 is 0.25 mm/rev, F2 is 0.30 mm/rev,
F3 is 0.35 mm/rev

The effect of cutting speed on the value of surface roughness of the workpiece resulting from cutting can be seen in Fig. 6. The effect of cutting feed on the value of the surface roughness of the workpiece resulting from cutting can be seen in Fig. 7.

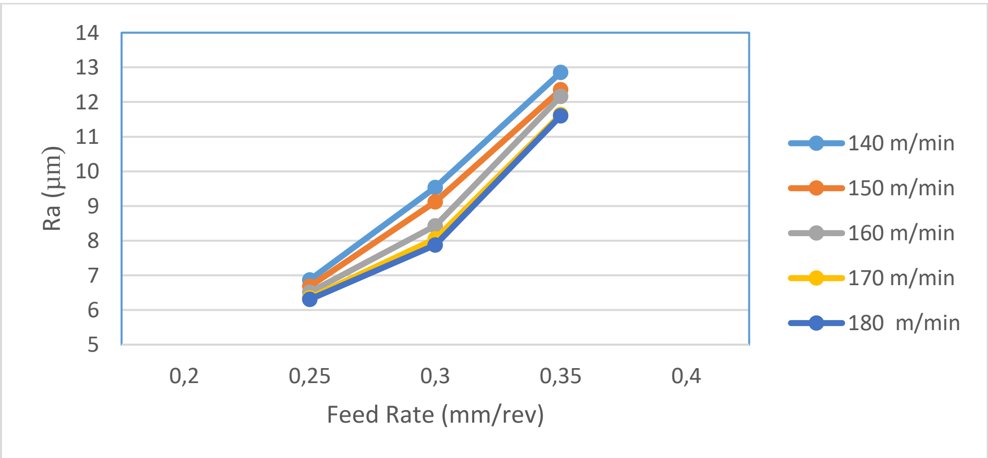

Figure 6. Graphic Feed Rate Vs. Surface Roughness Source

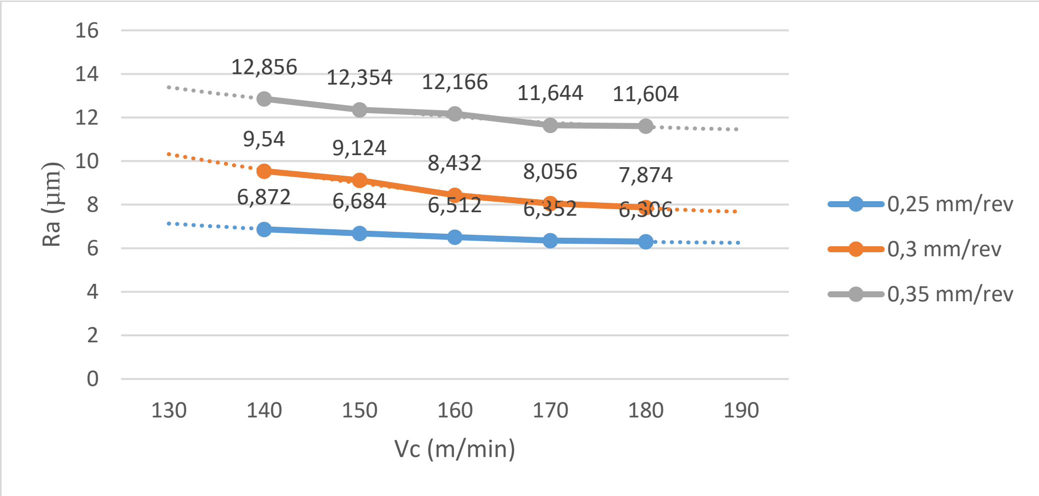

Figure 7. Graphic Cutting Speed Vs. Surface Roughness

Feed Rate Effect on Surface Roughness

In Fig. 6 can also be seen that the increase in the feed rate value affects changes in the amount of the surface roughness of the workpiece, the value of the surface roughness of the workpiece is higher. This phenomenon is happening because the feed rate is a cutting motion that causes the cutting tool's tip to move to the surface of the workpiece, which scratches the surface of the material with cutting speed. The smaller the feed rate value is used, the feeding speed becomes slower, which results in a tighter all parts of the workpiece surface uniformly. However, if the feed rate is high, swipe that occurs per rotation faster so that it does not touch the entire surface of the workpiece in one rotation. This case causes an uneven surface to appear and has a higher surface of the workpiece.

Cutting Speed Effect on Surface Roughness

Based on observations made, obtained the value of cutting speed affects the results of the quality of the workpiece surface. There are differences in the results of the surface roughness level on variations in cutting speed. The higher the cutting speed used, the smaller the surface roughness value in other words, the better the surface quality of the workpiece. High cutting speed results in a decrease in the cross-sectional area of the sliding city. When the spindle rotation is high, the cutting speed is also high, and the cutting tool moves quickly to scratch the workpiece surface. This process results in a narrower cross-sectional area resulting in narrowing of the cross-sectional area resulting in better surface quality. It circumstances are also seen that the variation in cutting speed changes in surface quality.

The use of cutting speed variations results in differences in the level of surface roughness produced. The lowest surface roughness was obtained at the highest cutting speed of 180 m / min, and the most economical feed rate was 0.25 mm/rev. The use of low cutting speed and a high feed rate results in larger surface roughness values.

The condition of cutting speed variation has limitations, meaning that the higher the cutting speed used, it can lead to narrowing of the cross-section area. The reduction of the cross-sectional area affects the surface quality

CONCLUSION

The conclusions obtained from the experiment and data analysis are as follows. Ra value is directly proportional with feed rate, while inversely proportional with cutting speed (Vc). Then, to get a low surface roughness value or smooth need a high cutting speed and flat feed rate. Cutting tool coated also has a resilience when doing a machining process without coolant. The smallest surface roughness value is 9.56 µm on cutting speed 170 m/min, and the feed rate is 0.25 mm/rev.

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