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Effect of Feed Depth on the ProcessMilling Against Surface Roughness Steel 4140 Carbide Endmill Applications

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Abstract

In the metal cutting industry today, milling process applications are still carried out using cutting fluids. One of the criteria for determining machining quality is surface roughness. Surface roughness as a dependent variable is influenced by machining parameters, namely feed depth, cutting speed and feed speed as independent variables. Research activities with the aim of obtaining machined surface roughness of 4140 low alloy steel workpieces due to spindle rotation speed and feed depth using carbide endmill cutting tools. Research activities were carried out with 9 specimens for the vertical milling process using cutting fluid through variations in machine spindle rotation of 1200 rpm, 1400 rpm and 1600 rpm and feed depths of 0.5 mm, 0.75 mm, 1 mm. Data processing was carried out using experimental methods to obtain surface roughness data. To obtain machined surface roughness data, it is measured using a Surface Test measuring instrument. The optimal surface roughness obtained from machining for the vertical milling process is 1,587 µm, 2,639 µm and 2,800 µm at a machine spindle rotation speed of 1600 rpm. So the vertical milling process uses cutting fluid to obtain surface roughness values with the smallest roughness Ra = 1.602 µm at a feed depth of 0.5 mm. As the depth of burial increases, the roughness Ra also increases, as shown in Figures 8, 9 and 10.

Keyword: **Surface Roughness,Depth of Feed, Type 4140 Steel, Vertical Milling Process**

INTRODUCTION

One machine tool that also has an important role in the machining and manufacturing industry is the vertical type milling machine. It is said to be a vertical milling machine if the machine spindle axis is perpendicular to the surface of the machine table.

Machining through a vertical milling process where the shape of the flat surface will experience a reduction in the workpiece due to the contact of the rotating cutting tool with the workpiece. The quality of a workpiece surface is a very urgent matter which must be considered in relation to surface roughness. Every workpiece that is machined using a vertical milling process should have a surface quality level that must be met. Fabrication of a workpiece as a test specimen uses a vertical milling machine with an endmill cutter rotating perpendicular to the surface of the workpiece, each tooth makes a cut where the cutting direction will influence the level of surface roughness in the milling process. Until now, observation and evaluation of surface roughness have been developed, where measuring surface roughness is carried out using various different measurement systems.
To obtain the desired component surface quality through milling, a type of carbide endmill is used. The selection of cutting parameters must be well controlled during machining, including cutting speed, feed rate and also feed depth. Improper selection of machining parameters will cause the cutting tool to wear out quickly and become damaged. There are a number of processes that can be used to produce raw materials in any desired form from the initial stage to the final stage. Among various machining processes, end milling is one of the most widely used material removal processes in industry.

Endmill cutter cutting tools have a big influence on the level of surface roughness. The number of flutes and endmill material are taken into account to obtain a good roughness level. Spindle rotation speed and feed depth affect surface roughness. The higher the surface quality produced. Therefore, to obtain quality products in the form of a high level of precision and good surface roughness, it needs to be supported by appropriate machining processes.

From the explanation above, it is deemed necessary to conduct a surface study of machining results, especially AISI type 4140 steel material which is usually applied as shafts, gears, bolts, clutches, spindles, piston pins, hydraulic machine shafts and others. By using test statistics, an optimum vertical milling process can be obtained and the study carried out includes surface roughness which can define the surface roughness value as a function of cutting parameters which are independent variables.

In the workshop business, vertical milling machines are widely used compared to horizontal milling processes because this machine has many functions, namely for angular surfaces, flat surfaces, grooves, waves, and can work on circular or round surfaces. The working principle of this milling process in cutting is using a cutting tool (milling cutter) which rotates perpendicular to its axis, where the process of cutting objects can be done easily, namely forming objects into certain models according to the pattern desired by the user.

Steel for type 4140 is a low alloy steel class. Low alloy steel relies on elements other than iron and carbon to improve its mechanical properties. In type 4140 steel, the addition of chromium, molybdenum and manganese is used to increase the strength and hardenability of the steel. The test object material used is type 4140 steel, recommended for landing gear on aircraft, transportation and defense equipment made from tool steel.

- Endmill Cutter

One type of cutting knife for milling machines is the endmill cutter, which varies in size and type. This type of cutting knife is usually made from high-speed steel but is also made from carbide. This knife has 2 or more grooves (Flutes) which are usually used to level the surface or can also be used to make grooves on a flat plane. This knife is generally installed in an upright (vertical) position, but under certain conditions it can also be installed in a transverse (horizontal) position depending on the workpiece itself. Endmill cutter has a big influence on the roughness level. Then the number of flutes and endmill material to obtain a good level of machined surface roughness is taken into account.

- Surface Roughness

Usually the problem of explaining surface roughness can be done using two methods, namely: the arithmetic mean value Ra and the root mean square value Rq. Surface roughness measurements can be obtained using the equation:

$$Ra = (a + b + c + d + ...) / n \quad ....(1)$$

In the equation above, a, b, c, d and so on are the values of the ordinate points on the surface profile as measured from the center line that corresponds to the profile.

Meanwhile, the empirical formula is:

$$Ra = \frac{0{,}0321.f^2}{rc} \text{ (µm)} \quad ....(2)$$

In the equation above, a, b, c, d and so on are the values of the ordinate points on the surface profile as measured from the center line that corresponds to the profile. Figure-2, use of coordinate points in measuring surface roughness.

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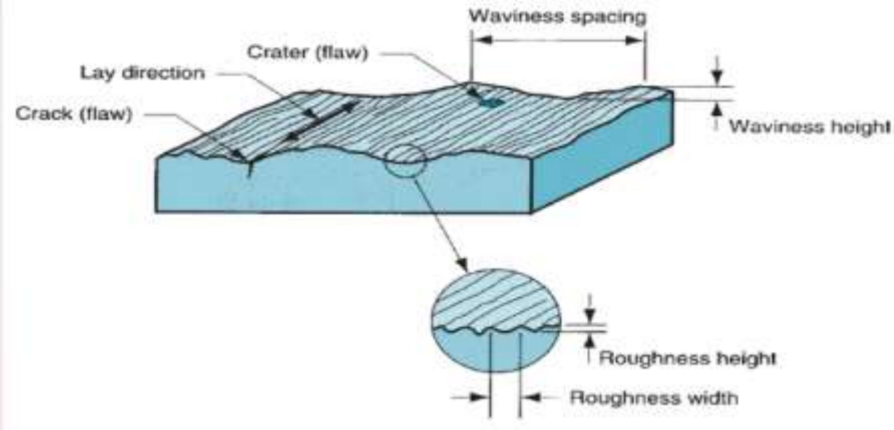

Figure-1 Standard terminology on specimen surface

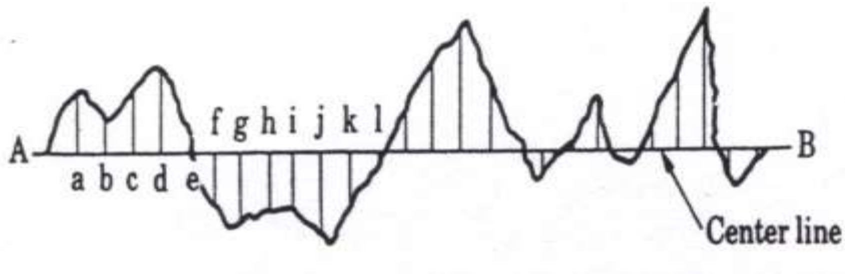

Figure-2 Use of coordinate points in surface roughness measurement

RESEARCH METHODS

Materials, tools and methods used in testing are :

Figure-6. AISI 4140 steel material diameter dimensions D=30

Table-1. Chemical Composition and Properties Mechanical Steel type 4140

Komposisi kimia (%)		Sifat Mekanik	
Cr	0.88-1.10	Density kg/m3	7700-8030
Si	0.15-0,30	Modulus young (Gpa)	190-210
Mn	0.75-1,00	Tensile strength (Mpa)	655
P	0.035	Yield strength (Mpa)	450
S	0.04	Brinell Hardness (HB)	197
C	0.38-0.43		
Mo	0.15-0,25		

Figure-3. Vertical milling machine

Figure-4. Roughness measurement with Surface Test

Figure-5. Carbide Endmill 12 mm 4 flutes

Testing of steel workpieces as test specimens was carried out experimentally. To carry out the cutting process, it is carried out by milling the surface of a cylindrical workpiece for type 4140 steel. The cutting of the workpiece is given variations in the rotation speed of the machine spindle depth of feed. The first, second and third tests were carried out each with 3 cuts for spindle rotation speeds of 1200 rpm, 1400 rpm and 1600 rpm with an ingestion depth of 0.5 mm; 0.75mm; 1mm. So there are 9 cutting tests to get the roughness value of the machined surface using a surface test tool. Surface roughness data for dry machining with 9 machining tests, the results of which will be compared with surface roughness data for wet machining. To obtain the most optimum cutting conditions, observations and data analysis were carried out by comparing data on dry machining and wet machining. Data treatment in dry machining and wet machining uses a static method with a normal distribution curve.

RESULTS AND DISCUSSION

Machining results from the vertical milling process for dry machining and wet machining with graphical results as follows.

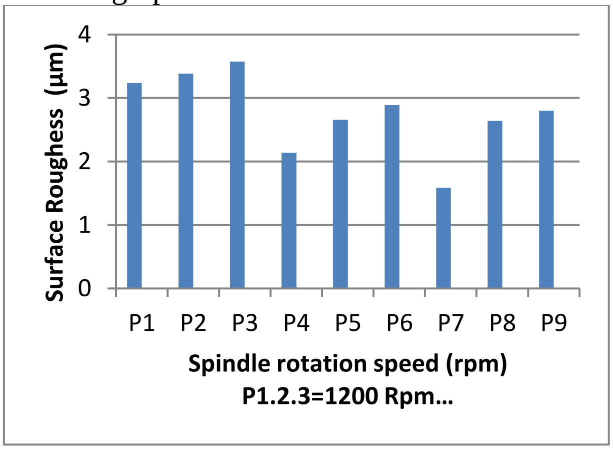

Figure-7. Relationship of machining test results with surface roughness

The machining results of the vertical milling process from AISI 4140 steel metal material in Figure-7 show the curve of wet machining results using a 12 mm 4 flute endmill carbide cutter. Machining tests on type 4140 steel were carried out 9 cutting tests with the independent variables being cutting speed and feed depth. From the 9 specimens tested, a smaller surface roughness level was obtained at a spindle rotation speed of 1600 rpm (P7, P8, P9) for the milling process using cutting fluid (wet milling process).

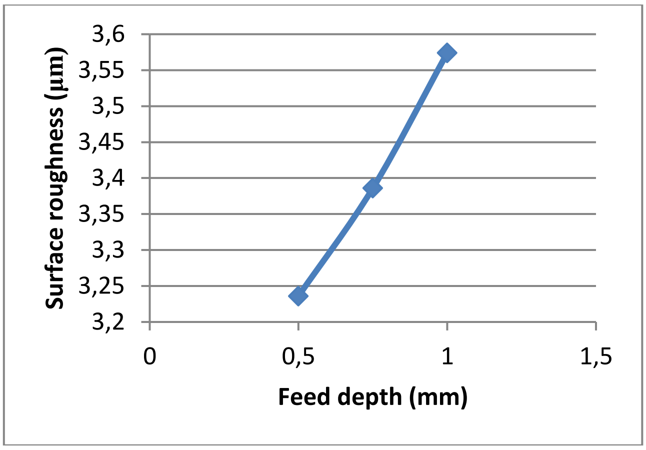

Figure-8. Curve of the relationship between depth of infeed and roughness at n = 1200 rpm.

Surface roughness Ra as a function of burial depth can be seen in figure-8. Figure-8 shows a relatively linear curve, namely RavgPB, as surface roughness data resulting from wet milling machining. With a variation in depth of 0.5 mm; 0.75mm; 1mm obtained surface roughness values RavgPB (wet machining average surface roughness) respectively 3.236 µm, 3.386 µm, 3.574 µm.

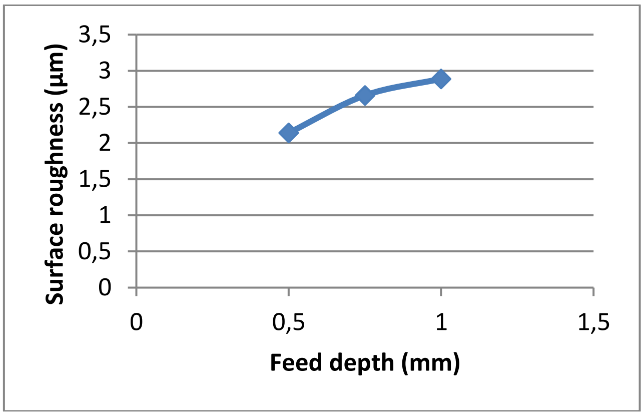

Figure-9. Relationship between depth of ingestion and roughness at n = 1400 rpm.

Figure-9 shows a RavgPB curve which is data for surface roughness resulting from machining using a wet milling process. With a variation in depth of 0.5 mm; 0.75mm; 1mm obtained a surface roughness value of 2.141 µm respectively; 2.659 µm; 2.888 µm. However, the RavgPB curve appears to be relatively linear in the x-y plane.

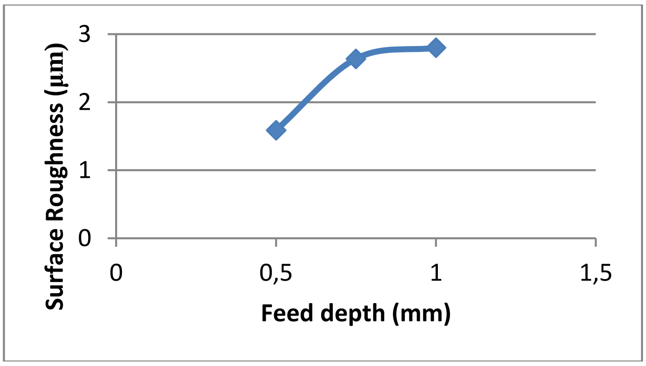

Figure-10. Relationship between feed and roughness at n = 1600 rpm.

Figure-10 shows a RavgPB curve where surface roughness data obtained from wet milling machining is obtained. With a variation in depth of 0.5 mm; 0.75mm; 1mm obtained surface roughness values RavgPB (wet machining average surface roughness) respectively 1.587 µm; 2,639 µm 2,800 µm with a depth of 0.5 mm; 0.75mm ;1mm. After observing the curve, the nature of the curve is not linear.

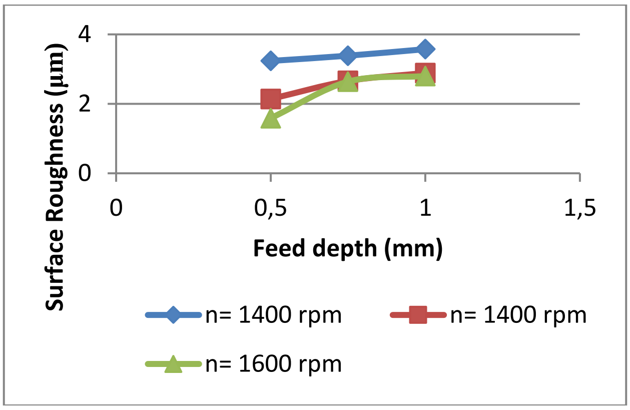

Figure-11. The relationship between depth of right with roughness Ra

Figure -11 shows 3 curves where surface roughness is a function of depth of burial. Machining using the wet milling process, namely the cutting process using cutting fluid, for a spindle rotation speed of 1200 rpm gives a Ra value of 3.236 µm; 3.386 µm 3.574 µm as well as Ra value 2.141 µm; 2.659 µm; 2,888 for 1400 rpm rotation. Meanwhile, for a spindle rotation speed of 1600 rpm, Ra values were obtained, respectively, 1.587 µm; 2,639 µm and 2,800 µm. Obtaining surface roughness values from the three curves above was carried out at a depth of 0.5mm; 0.75mm; 1mm. Observations were made from the three curves for a spindle rotation speed of 1200 rpm; 1400 rpm and 1600 rpm means that testing specimens 7, 8, 9 at a spindle rotation speed of 1600 rpm approaching the x-axis plane means that it provides a better curve because in terms of the Ra value it is smaller than the other 2 curves.

CONCLUSION

1. From figure-7, the wet milling process, which is carried out using cutting fluid, gives a characteristic bar diagram shape where the obtained roughness value Ra in the specimen test is 7,8,9 (1600 rpm) which is smaller (lowest bar diagram) with increasing increase in depth of ingestion 0.5mm; 0.75mm; 1mm.
2. Figure-8 and Figure-9 show a wet machining Ravg curve which is relatively linear in the x-y axis reference plane because each of them has relatively almost the same Ra data. From this figure, the greater the depth of ingestion, the greater the surface roughness obtained.
3. Figure-11 shows 3 curves in the wet milling process, where surface roughness is a function of depth of feed. The data observed from the three curves shows that there is a variation in spindle rotation speed of 1200 rpm; 1400 rpm and 1600 rpm, in fact, testing specimens P7, 8, 9 at a spindle rotation speed of 1600 rpm gave a better curve compared to the other 2 curves because the Ra value obtained was smaller, which was close to the x-y axis plane. So the description of the image above shows that the greater the depth of ingestion, the greater the surface roughness gain value.

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