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ANALYSIS OF SURFACE ROUGHNESS OF POLYTETRAFLUOROETHYLENE (PTFE) MATERIAL IN THE TURNING PROCESS

Celina Ramadhani [1,a], Sobron Yamin Lubis [2,b], Erwin Siahaan [3,c]

[1,2,3]Mechanical Engineering Study Programme Faculty of Engineering - Tarumanagara University

[a]celina.515200027@stu.untar.ac.id, [b]sobronl@ft.untar.ac.id, [c]erwins@ft.untar.ac.id

Abstrak.
Proses pembubutan merupakan proses penghilanngan sebagian material benda kerja dengan menggunakan pahat bubut. Seringkali hasil pembubutan tersebut menimbulkan goresan yang menyebabkan kekasaran permukaan. Kekasaran permukaan tersebut merupakan salah satu indikator dalam menentukan kwalitas hasil proses. Jika nilainya semakin kecil maka kekasaran permukaan benda kerja yang dihasilkan adalah baik, demikian pula sebaliknya. Pada pembubutan bahan politetrafluoroetilena (PTFE) adalah penting untuk menghasilan kekasaran permukaan yang nilainya kecil dan memiliki dimensi sesuai dengan design. Untuk melakukan pembentukan profil benda kerja PTFE dengan menggunakan mesin bubut. Sangatlah sulit untuk menentukan suatu kombinasi parameter pemotongan yang sesuai guna menghasilkan kondisi permukaan yang baik. Berdasarkan hal tersebut maka penelitian ini dilakukan. Proses eksperimen dilakukan dengan menggunakan mesin bubut konvensional model C6132A, mata pahat yang digunakan adalah karbida sisipan TCMT16T304. Benda kerja PTFE memiliki dimensi diameter 120mm, spesimen 485 mm. Parameter pemotongan yang divariasikan terdiri dari kecepatan pemotongan, putaran spindle 210, 260, 360 r/min, hantaran pemotongan 0,1, 0.3 dan 0.5 mm, dan kedalaman pemotongan 0.2 mm. Hasil proses pembubutan dilakukan pengukuran kekasaran permukaan dengan menggunakan alat surface rougness test. Dan pengukuran dimensi spesimen dilakukan dengan menggunakan jangka sorong. Hasil pengukuran kekasaran permukaan diperoleh Nilai Kekasaran Permukaan (Ra) pada dimensi diameter dalam tertinggi yaitu 4,420 µm dengan variasi parameter pemotongan kecepatan potong 138,474 m/min dan pemakanan 0,5 mm/rev. Sedangkan Nilai Kekasaran Permukaan (Ra) pada dimensi diameter dalam terendah yaitu 3,132 µm dengan variasi parameter pemotongan kecepatan potong 237,384 m/min dan pemakanan 0,1 mm/rev. Semakin tinggi kecepatan potong dan semakin rendah pemakanan maka menghasilkan nilai kekasaran permukaan yang kecil, dan begitu juga sebaliknya semakin rendah kecepatan potong dan semakin tinggi pemakanan maka menghasilkan nilai kekasaran permukaan yang besar.

Kata Kunci: Kekasasaran permukaan, *politetrafluoroetilena (PTFE)*, parameter pemesinan

Abstract.
The turning process is a process of partial removal of workpiece material using a lathe tool. Often the turning results cause scratches that cause surface roughness. Surface roughness is one indicator in determining the quality of the process results. If the value is getting smaller then the surface roughness of the workpiece produced is good, and vice versa. In turning polytetrafluoroethylene (PTFE) material it is important to produce a surface roughness that is small in value and has dimensions by the design. To perform profile forming of PTFE workpieces using a lathe. It is very difficult to determine an appropriate combination of cutting parameters to produce good surface conditions. Based on this, this research was conducted. The experimental process was carried out using a conventional lathe model C6132A. the cutting tool used is TCMT16T304 inserted carbide. The PTFE workpiece has

dimensions of 120mm diameter and 485 mm length. The varied cutting parameters consist of cutting speed, spindle rotation 210, 260, 360 r/min, cutting delivery 0.1, 0.3, and 0.5 mm, and depth of cut 0.2 mm. The results of the turning process are measured surface roughness using a surface roughness test tool. The measurement of specimen dimensions is carried out using a caliper. The results of surface roughness measurements obtained Surface Roughness Value (Ra) in the highest inner diameter dimension is 4.420 µm with cutting parameter variations cutting speed 138.474 m/min and 0.5 mm/rev. The Surface Roughness Value (Ra) in the lowest inner diameter dimension is 3.132 µm with the cutting parameter variation of cutting speed 237.384 m/min and 0.1 mm/rev. The higher the cutting speed and the lower the feed, the smaller the surface roughness value, and vice versa, the lower the cutting speed and the higher the feed, the greater the surface roughness value.

Keywords: *Surface roughness, polytetrafluoroethylene (PTFE), machining parameters*

INTRODUCTION

Evolving technology has become a new demand for the manufacturing industry to produce quality products with efficient production time and low cost. The machining process is a production process by removing some unnecessary parts to form a product with a good surface shape and size(El Hofy, 2014). Lathes are one of the most frequently used machine tools. A lathe is used to reduce objects by the process of prenatal objects that are rotating (Atmantawarna, 2013). In the turning process, the desired result is to match the planned dimensions and a good surface roughness value.

Some of the factors that affect surface roughness using the turning process include depth of cut, feed speed, engine speed, workpiece material, cutting tool profile, cutting edge, machine conditions, cooling, and operator. Meanwhile, to improve the quality of surface roughness, the finishing process is continued. Machining parameters in the turning process include cutting speed, depth of cut, and feed rate. In application, these three parameters have a considerable influence on the surface roughness of the machining process results. The workpiece produced by the cutting process has a certain quality when known from the dimensional accuracy, shape accuracy, and surface roughness of the workpiece. One of the factors that affect the accuracy of the workpiece is the accuracy of the lathe used in the workpiece-cutting process (Indrawan, A., Aziz, et al., 2020).

A hydraulic cylinder is one component of heavy equipment that functions to lift a workload with a hydraulic mechanism using pressurized fluid. Hydraulic cylinder inner part components such as o-ring seals are often damaged as a result of high operational work. This component is made of polytetrafluoroethylene (PTFE) which is a polymer material. Polymers or known as plastics by most people are non-metallic materials consisting of molecules that include a series of one or more than one monomer unit. Polymers have distinctive properties compared to other materials, namely polymers are much lighter, corrosion resistant, strong enough, cheap, and easily formed into complex shapes. (sobron, 2014) The manufacturing process can be done using machine tools (turning). Of course, the manufacturing process requires good results on surface roughness. In the turning process, there are cutting parameters that affect the resulting surface conditions. Based on this, this research was conducted to determine the effect of variations in cutting parameters when turning polytetrafluoroethylene (PTFE) material on surface roughness. In this study, the analysis of the cutting process experiment using the parameters of spindle speed and feed speed in the turning process was carried out. This is very important because it can help provide a more accurate understanding of how these parameters affect the results of cutting, and from the information obtained manufacturers and engineers can maximize the parameters used to be able to achieve more efficient and quality cutting results.

RESEARCH METHODS

This research was conducted experimentally using a lathe. The combination of cutting parameters was carried out as follows:

Table 1 Variation of Cutting Parameters

Cutting Parameters	Variable
Spindle rotation (r/min)	210, 260, 360
Cutting feed (mm/rev)	0.1, 0.3, 0.5
Depth of cut (mm)	0.2

To determine the cutting speed in the turning process, it can be done in the following equation:

$$v = \frac{\pi.d.n}{1000}\,. \qquad (1)$$

Table 2 Cutting speed calculation

Spindle rotation (r/min)	Cutting Speed (m/min)
210	138,474
260	171,444
360	237,384

Material

The workpiece material used is polytetrafluoroethylene (PTFE) with a diameter of 120mm, length of 485 mm. The test specimen will be subjected to a turning process with dimensions of 100 mm diameter by 10 mm thick. As shown in Figure 1.

Figure 1 Polytetrafluoroethylene (PTFE) workpiece material

Equipment

The equipment used is:

1. Model C6132A, lathe, used for the turning process on the workpiece.

Figure 2. Lathe

2. The cutting tool used is TCMT16T304 inserted carbide cutting tool as shown in Figure 3.

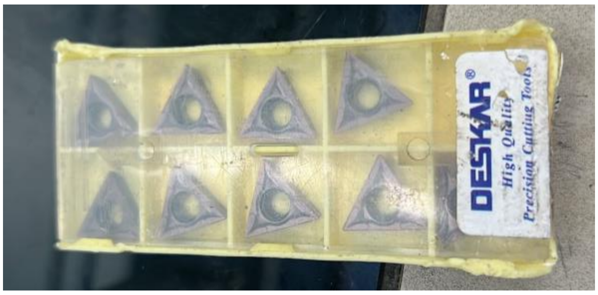

Figure 3. TCMT16T304 Inserted Carbide Cutting Tool.

3. Measurement of the surface roughness of the turned workpiece was carried out using a Mitutoyo surface test tool.

Figure 4 Surface Test Mitutoyo

PROCEDURE EXPERIMENT

In this study, the polytetrafluoroethylene (PTFE) workpiece was turned according to the planned design drawing. Cutting was carried out using a TCMT16T304 Inserted carbide cutting tool. The turning process was carried out by varying the cutting parameters as presented in Table 1.

The turning process is carried out transversely using a depth of cut of 0.2 mm. The turning process was carried out on a Polytetrafluoroethylene (PTFE) workpiece with an outer diameter of 120 mm. This research focuses on the surface roughness of Polytetrafluoroethylene (PTFE) test specimens by turning using the feeding speed and spindle rotation in the finishing process. The test specimens were 9 pieces and did not focus on the profile of the test specimens.

After turning the test specimen, the roughness of the surface of the Polytetrafluoroethylene (PTFE) material will be measured using the Mitutoyo Surface tester. In this process, the measurement of the surface roughness value is carried out by adjusting the position of the surface tester on the test specimen. The Mitutoyo surface tester uses a probe or stylus that moves back and forth over the surface of the test specimen to measure the roughness on the surface of the test specimen. This probe or stylus follows the shape of the surface of the test specimen which converts the back-and-forth movement into an electrical signal recorded by the tool, the signal is processed to obtain the (Ra) value.

For each time the turning process is completed at one combination of cutting parameters, the measurement of the surface roughness of the workpiece and the measurement of the dimensions of the workpiece is carried out. The values obtained are then entered into a table and a graph is made to further analyze the surface roughness and dimensional accuracy of the workpiece resulting from the turning process.

RESULTS AND DISCUSSION

After measuring the surface roughness of the workpiece, the surface roughness values are presented in Table 2 and Table 3.

Table 3 Surface Roughness Values of Test Specimens Inner Diameter

Spes.	spindle rotation (rpm)	feed mm/rev	a (mm)	Surface Roughness of each Point (Ra)			Average (Ra)
				P_1	P_2	P_3	
1	210	0.1	0.2	3.115	3.432	2.902	3.150
2		0.3	0.2	3.969	4.160	4.471	4.200
3		0.5	0.2	4.415	4.916	3.941	4.424
4	260	0.1	0.2	3.320	3.826	3.675	3.607
5		0.3	0.2	4.280	4.141	4.359	4.260
6		0.5	0.2	4.348	4.362	4.386	4.365
7	360	0.1	0.2	3.039	3.393	2.964	3.132
8		0.3	0.2	3.415	3.614	3.537	3.522
9		0.5	0.2	3.909	4.300	4.014	4.074

Table 4 Surface Roughness Values of Test Specimens Outer Diameter

Spes.	spindle rotation (rpm)	feed mm/rev	a (mm)	Surface Roughness of each Point (Ra)			Average (Ra)
				P_1	P_2	P_3	
1	210	0.1	0.2	4.861	4.625	4.587	4.691
2		0.3	0.2	4.227	4.520	4.167	4.305
3		0.5	0.2	4.653	4.696	4.416	4.588
4	260	0.1	0.2	4.180	4.012	4.145	4.112
5		0.3	0.2	3.884	3.876	3.920	3.893
6		0.5	0.2	4.251	3.897	3.255	3.801
7	360	0.1	0.2	3.134	3.427	3.033	3.198
8		0.3	0.2	3.262	3.422	3.394	3.359
9		0.5	0.2	3.134	4.002	3.736	3.624

From the results of surface roughness testing on the workpiece, the data is then displayed in graphical form for as presented in Figure 5, Figure 6, Figure 7 and Figure 8.

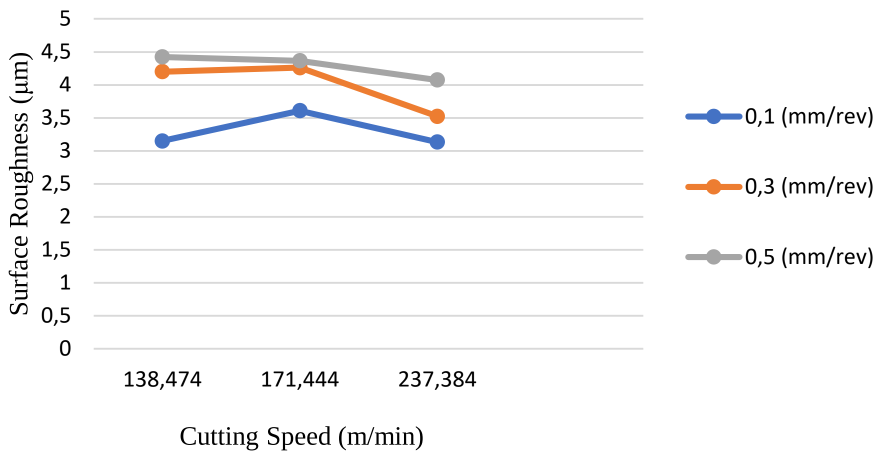

Figure 5 Graph of the Effect of Cutting Speed on Surface Roughness at Inside Diameter

Based on Figure 5, it can be seen that the lowest surface roughness value on the inner diameter is obtained at a cutting speed of 237.384 m/min at 3.132 µm and the highest surface roughness value at a cutting speed of 138.474 m/min at 4.424 µm.

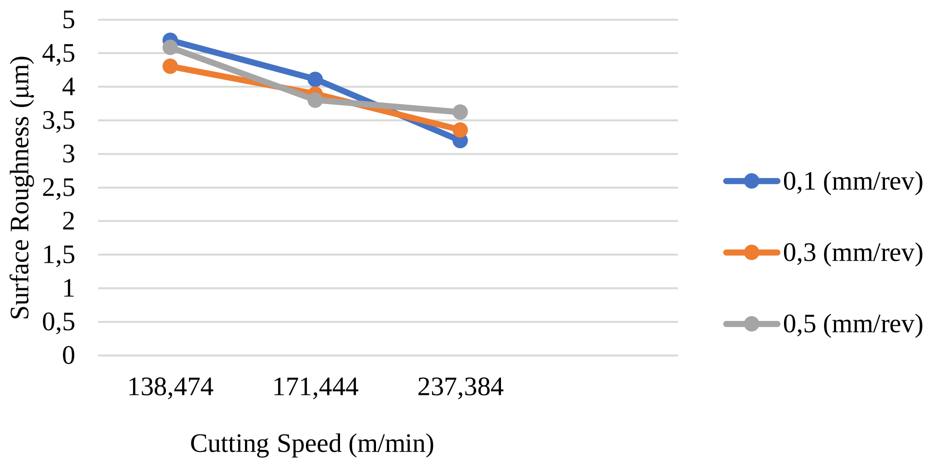

Figure 6 Graph of the Effect of Cutting Speed on Surface Roughness at Outside Diameter

In Figure 6, it is known that the lowest surface roughness value on the outer diameter is obtained at a cutting speed of 237.384 m/min at 3.198 µm and the highest surface roughness value at a cutting speed of 138.474 m/min at 4.691 µm.

Based on Figures 5 and 6, it can be seen that the trend graph shows that the increase in cutting speed influences the decrease in the surface roughness value of the resulting workpiece. This happens because the best workpiece surface roughness is obtained with the highest cutting speed, due to the high cutting speed, the tool moves faster to make cuts, so that the workpiece is often cut causing the surface to become smoother. With the increasing cutting speed, the pile of grit at the end of the tool will be released along with the flow of grit. With the loss of the pile of grit on the tip of the tool, the surface of the workpiece produced will be better because the surface roughness will only be caused by the traces of the tool's feeding motion.

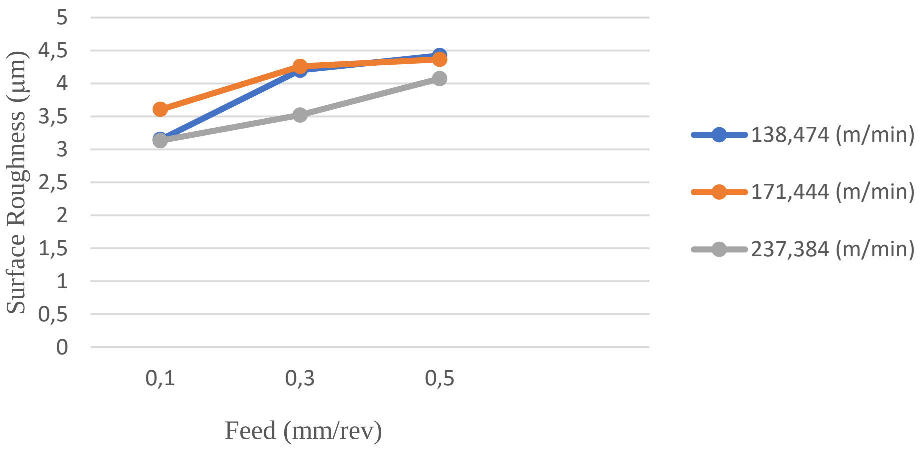

Figure 7 Graph of the Effect of Feeding on Surface Roughness at Inside Diameter

Based on Figure 7, it can be seen that the highest surface roughness value on the inner diameter is obtained at 0.3 mm/rev of 4.424 µm and the lowest surface roughness value at 0.1 mm/rev of 3.132 µm.

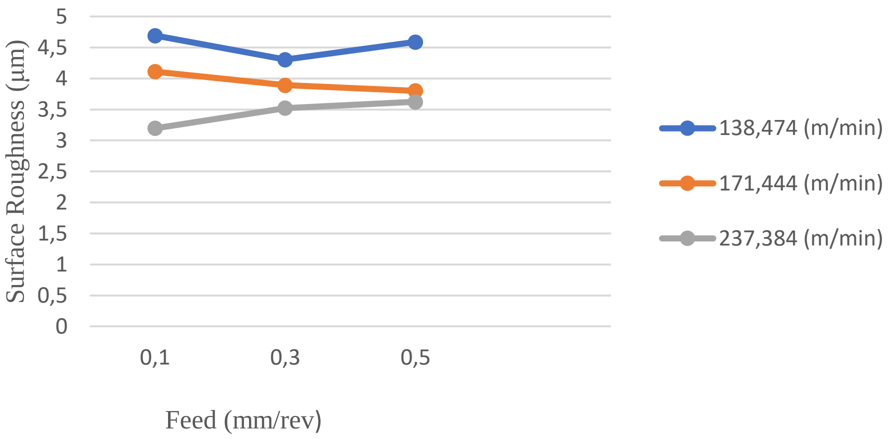

Figure 8 Graph of the Effect of Feeding on Surface Roughness at Outside Diameter

In Figure 4.4 it is known that the highest surface roughness value on the outer diameter is obtained at 0.1 mm/rev Feeding of 4.691 µm and the lowest surface roughness value at 0.1 mm/rev Feeding of 3.198 µm. The difference in feed rate value affects the roughness value produced by the PTFE surface (Ra).

Based on Figure 7 and Figure 8, it can be seen that increasing the feed affects increasing the surface roughness value. The smoothest workpiece surface roughness or has the smallest (Ra) value obtained with a small feed. This is because the small feed makes the tool blade load when cutting smaller so that the tool blade does not vibrate too much. Changes in the feed in the turning process will cause changes in the surface roughness of the resulting product. The roughness of the product that occurs is caused by the vibrations that arise on the machine when the machine is operating. The higher the feed will make the vibration between the knife and the workpiece greater, this will make the surface of the workpiece rougher. The incision process carried out by the knife is getting bigger, and the power required will also increase. A small depth of feed also produces a small-sized scour. If the depth of feed is large, it makes the tool blade load when cutting is also large, so the knife has a vibration. With a large depth of feed, it also produces large-sized grit as well.

The results of the interaction between cutting speed and feed on the surface roughness of the workpiece obtained the higher the cutting speed and the lower the feed, the smaller the surface roughness value, and vice versa the lower the cutting speed and the higher the depth of feed, the greater the surface roughness value.

CONCLUSIONS

After conducting experiments and analyses, the following conclusions can be made:

1. The highest surface roughness value (Ra) in the inner diameter dimension is 4.420 µm with a cutting parameter variation of 138.474 m/min cutting speed and 0.5 mm/rev feeding. The Surface Roughness Value (Ra) at the lowest inner diameter dimension is 3.132 µm with the cutting parameter variation of cutting speed 237.384 m/min and 0.1 mm/rev.
2. The highest surface roughness value (Ra) on the outer diameter dimension is 4.691 µm with a cutting parameter variation of 138.474 m/min cutting speed and 0.1 mm/rev feeding. The Surface Roughness Value (Ra) at the lowest outside diameter dimension is 3.198 µm with the cutting parameter variation of cutting speed 237.384 m/min and 0.1 mm/rev.
3. The results of the study of the effect of variations in cutting speed with the feed on the surface roughness of the workpiece, obtained that the higher the cutting speed and the lower the feed, the smaller the surface roughness value, and vice versa the lower the cutting speed and the higher the feed, the greater the surface roughness value.

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