THE EFFECT OF COOLING MEDIA AND SPINDLE SPEED ON THE RESULTS OF WORKING OBJECT SURFACE STRENGTH IN THE FINISHING PROCESS USING A CNC PU LATHE

Amir Mashudi
Undergraduate of Mechanical Eng. Education, Faculty of Eng., Universitas Negeri Surabaya
Email: amirmashudi16050524047@mhs.unesa.ac.id
Nur Aini Susanti
Department of Mechanical Eng., Faculty of Eng., Universitas Negeri Surabaya
Email: nursusanti@unesa.ac.id

Abstract

The development of computer technology has experienced rapid progress such as the application of machine tools (lathes, milling machines, grinding machines, welding machines, etc.). The combination of the results of computer technology with mechanics has produced a machine tool called *Computer Numeric Controlled* (CNC). However, there are obstacles in the workpiece cooling process, workpiece roughness caused by wear and tear that is often used and cutting speed, feed rate, and depth of cutting. This research was conducted to test the turning with S45C steel material by giving variations of the coolant dromos cooling media, compressed air, and without treatment (without coolant) and spindle rotation speed of 1400 rpm, 1650 rpm, 1950 rpm. This type of research is included in experimental research. This research was conducted in February-March 2020 at PT Tjokro Putra Perkasa Sidoarjo. This study used three variables, namely the type of cooling variation and the spindle rotational speed (independent variable), the level of hardness of the S45C steel surface in the CNC lathe process (the dependent variable), and all the factors that influence the level of roughness of the CNC turning surface in addition to the cooling variations and spindle speed (control variable). The results of the study it be concluded (1) there is a significant influence between the variation of the cooling media and the spindle rotational speed on the surface roughness results of the S45C workpiece in the finishing process using a CNC PU lathe; (2) the variation of the cooling media affects the surface roughness value; (3) the variation of the lowest roughness value is coolant cooling media with 1950 rpm spindle rotational speed resulting in roughness value 2,771 µm, and the highest variation of roughness value was variation of pressurized air cooling media with spindle rotational speed of 1400 rpm resulting in roughness value 3,313 µm.

Keywords: rotating speed, cooling, CNC, S45C steel.

INTRODUCTION

The era of globalization requires various manufacturing industries to innovate to compete in national and international markets. The time of globalization has made the industry move to improve quality, work speed, security, minimize production costs, and be environmentally friendly. Improving the quality of machine-processed products is always related to the suitability of dimensions and surface roughness values. It makes the surface hardness the standard for product accuracy and quality.

The role of steel in the industry today is very important, especially in the manufacture of automotive components such as gears and shafts. JIS S4C steel is a type of carbon steel with JIS (Japan Industrial Standard) standards and is commonly used by Japanese industries. This JIS S45C steel has a carbon content of around 0.45%. JIS S45C steel is carbon steel which is included in the medium carbon steel S45C shows that the steel contains ± 0.45% of the carbon element in it (Firmansyah, 2014).

The carbon content in steel is between 0.2% and 2.1% of the steel size according to the specified standards. The higher the carbon content of the steel, the higher its hardness (hardness) and tensile strength. However, in other aspects, it can reduce the level of ductility and make steel brittle (Beumer, 1994). Carbon is an alloy of the main element in steel, which can be divided into three parts, namely high, low, and medium carbon steels (Amanto, 1999).

Low carbon steel (low carbon steel) contains carbon between 0.055C to 0.3% C. Steel with a carbon content <0.3% C cannot be hardened because the carbon content is not sufficient to form a martensite structure so that it has properties that are easy to spice and easy to work in the machining process.

Medium carbon steel / medium (medium carbon steel) contains carbon between 0.3% C to 0.6% C. This type of steel can be categorized as harder and stronger when compared to low carbon steels. The carbon content in this type allows the steel to be hardened through an appropriate heat-treatment process.

High carbon steels have a carbon content between 0.6% C - 1.5% C. This type of steel has high hardness. However, if viewed from the tenacity it can be categorized as lower. In contrast to low steel, hardening by heat treatment in carbon is higher and does not produce optimal results. This happens because there are too many martensites that affect steel to become brittle (Amanto, 1999).

The materials in JIS S45C steel are widely used for the manufacture of machine components because of their low price compared to other materials. JIS S45C steel has

similarities with other steels, such as DIN C45W, AISI 1045, ASSAB760, HITACHI NS1045, and THYSSEN 1730. Carbon steel has the same number of carbon, manganese, and selenium elements. However, this steel is produced using different standards from one factory to another (Satyarini, 2013). S45C steel has the following data elements.

Table 1**.** Chemical Element Composition of S45C Steel

No	Chemical elements	Number of contents
1	Carbon (C)	0,45%-0,50%
2	Iron (Fe)	97,74%
3	Mangan (Mn)	0,50%-0,80%
4	Fosfor (P)	0,035%
5	Sulfat (S)	0,035%

Source: (Satyarini, 2013)

One result of a combination of computer technology with mechanics is a machine tool called computer numeric controlled (CNC). CNC is a machine tool that has a computer-based control system and can understand the N and G codes (G code) that govern the machine tool system. In this machine, there is a machine-powered mechanical device that functions to create components/workpieces. CNC operating system parameters can be changed through a program in the appropriate software (Wirawan Sumbodo, 2008: 403).

The CNC operating system uses a computer system with numerical language. This CNC work process uses a computer system with numerical language but still requires mechanics as operators to run CNC machines and also to avoid work process errors.

When compared with conventional machine tools, CNC machines have advantages in the work process including size accuracy (accuracy), precision (precision), work effectiveness, and production capacity. This makes many industries replace conventional machine tools with CNC tools to reduce production costs and pursue more and faster production targets.

There are 2 programs for CNC machines, namely absolute and incremental. Absolute system programming is a G-Code CNC programming system which when determining the location data of the workpiece geometry elements is guided by one reference point without changing, while incremental programming is a G-Code programming system which when determining the location data of the workpiece geometry elements is measured from the point moving reference. There are 2 types of CNC machines, namely TU (TrainingUnit) and PU (Production Unit), in that the work process between TU and PU has the same working principle, but the difference between the two lies in their use in the field. CNC TU is commonly used for basic programming training and this type of machine can only be used for light jobs with relatively soft materials. CNC PU used for mass production is designed for light and heavy work with a variety of different materials according to the specifications of the PU CNC machine.

To get good product quality, roughness as desired, high precision, and efficient workmanship, many conditions must be met, such as cooling media and spindle speed. The coolant has a special function in machining. This function is to extend the chisel time, reduce forces, and smooth the surface of machining products. This fluid is usually used during the machining process with four categories, namely straight oil, soluble oils, synthetic fluids, and semisynthetic fluids (Widarto, 2008: 299-300).

The rotational speed of the workpiece is regulated by the main motion mechanism in the fixed head with levers to adjust the rotating speed. The work spindle on a CNC machine has a function as a rotational speed regulator on a fixed head or a rotational speed regulator for a workpiece that is clamped using a chuck. On a CNC machine, the spindle has an S code as a reference for the spindle turning.

Low turning and large feeding speed using coarse cutting. To get good results it is necessary to cut the finish level or finish with a high rotation and slow feeding. The rotational speed of the workpiece is shown at a rotating point in time units, then the total length (weight/gram of cut) that is cut or cut in 1 minute, for example, n turns, then the total length cut in 1 minute = dxπxn m / minute, length This total is measured in meters per minute and is called the cutting speed (V). So: V = dxπxn m / minute. Since the diameter is expressed in mm, v is divided by 1000 into:

$$V = \frac{\pi.d.n}{1000}\ m/minute \quad (1)$$

So:

$$n = \frac{v.1000}{\pi.d}\ rotations/minute(rpm)$$

Notes:
v= *cutting speed* (*Cs)* in m/minute
d= diameter in mm
n= rotation speed in rotations/minute (rpm)

$$\pi = \frac{22}{7}\ (konstanta\ lingkaran)$$

The standard rules relating to cutting speed in spindle rotational speed are listed in the following table.

Table 2. *Cuting Speed* (Rpm/Menit)

Material	HSS chisel		Carbide chisel	
	Smooth	Rough	Smooth	Rough
Tool Steel	75-100	25-45	185-230	110-140
Low Carbon Steel	70-90	25-40	170-215	90-120
Medium Carbon Steel	60-85	20-40	140-185	75-110

UNESA Universitas Negeri Surabaya

Gray Cast Steel	40-45	25-30	110-140	60-75
Brass	85-110	45-70	185-215	120-150
Aluminum	70-110	30-45	140-215	60-90

Source: (Wirawan Sumbodo, 2008: 348)

With the spindle rotational speed formula and the cutting speed table of the S 45 C material, which is medium carbon steel using an HCS carbide chisel, the spindle rotational speed variations (140, 155, 185) are obtained as follows using formula (1) which produces 1400 rpm 1650 rpm, and 1950 rpm.

Surface roughness is the threshold separating solid objects from their surroundings. When viewed through a smaller scale based on configuration, the surface can be categorized in the geometric characteristics by the type of micro geometric group. Macrogeometry includes holes, sides, shaft surfaces, and elements that include size, position, and shape geometry (Taufiq Rochim, 2001: 52).

The surface characteristics of the material are a major factor in designing machine or tool components. There are many aspects to the surface characteristics which can be described clearly, for example, those related to wear, friction, lubrication resistance, adhesion, etc. The surface configurations are generally not as neat as the ones we have seen. If we look at the material surface profile from the cross-section of the object, it will show the irregularity of the material. The irregularity of the configuration of material when viewed from its profile, is described into various levels. The first level is a micro geometric irregularity, namely the entire surface that forms (form error). The second level, also called a wave, is a periodic irregularity with a wavelength greater than the amplitude. The third level is called a groove. The fourth level is called a flaw. Between the groove and the flaw is known as roughness (Taufiq Rochim, 2001: 54).

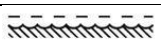
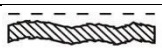
Level	Measurable profile; form of measurement results	Term	Examples of possible causes
1		Roughness of shape	Error guiding areas of machine tools and workpieces, workpiece clamping position errors.
2		Waviness	Error in tool shape, error in tool centering, vibration in the machining process.
3		Groovesi	Traces / cutting marks (chisel tip shape, feeding motion).
4		Flekes	The process of forming a snarl, deformation due to the sand-emitting process, the formation of modules in the electroplating process.
5.			Irregular combination from level 1 to 4.

Table 3**.** Surface Profiles

Source: Taufik Rochim, 2001: 55

The figure on the surface roughness symbol is the value of the arithmetic surface roughness (Ra). The maximum quantity (Ra) tested is written with a triangle symbol. The unit used is under the length unit in the technical drawing (metric or inch). If the minimum roughness figure Ra is required it can be written below the maximum roughness number. The roughness score Ra has been grouped into 12 roughness classes as shown in the table below.

Table 4**.** Roughness Value

Roughness (µm)	Roughness level	Sample length (mm)
50 25	N12 N11	8
12.5 6.3	N10 N9	2.5
3.2 1.6 0.8 0.4	N8 N7 N6 N5	0.8
0.2 0.1 0.05	N4 N3 N2	0.25
0.025	N1	0.08

Source: (Taufiq Rochim, 2001: 62)

The roughness number (ISO number) serves to minimize the roughness of the interpretation of the unit price of violence. Specifically, roughness can be written with an ISO roughness value or number. The size of the measurement sample length can be adjusted to the roughness number on the surface (Taufiq Rochim, 2001: 55-63)

Table 5. ISO 1302 table

Roughness value		*Roughness grade numbers (given in the previous edition of ISO 1302)*
µm	µin	
50	2000	N12
25	1000	N11
12.5	500	N10
6.3	250	N9
2.3	125	N8
1.6	63	N7

UNESA Universitas Negeri Surabaya

0.8	32	N6
0.4	16	N5
0.2	8	N4
0.1	4	N3
0.05	2	N2
0.025	1	N1

Source: (Taufiq Rochhim, 2001: 55-63)

In an equilateral triangle with one end attached to the surface. In this triangle, some numbers and symbols have several meanings which are shown in the image below:

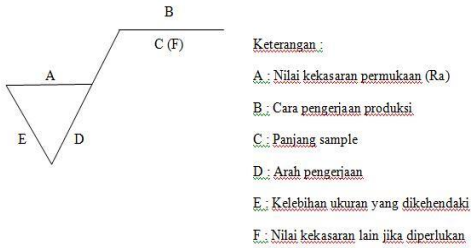


Figure 1. Roughness symbol

CNC machines have advantages in several ways compared to conventional machines but there are several obstacles in the work process of CNC machines. This advantage lies in the cooling process of the workpiece. However, this process has the constraints of differences in the roughness of the workpiece due to wear of the cutting tool, cutting speed, infeed rate, and cutting depth. To minimize workpiece defects due to wear and tear of frequently used cutting tools, the researcher will conduct a study entitled "The Effect of Cooling Media Variation and Spindle Rotation Speed on the Result of Workpiece Surface Roughness in the Finishing Process Using a PU CNC Lathe".

This study has several similarities and differences with previous relevant studies. First, research relevant to this research was conducted by Ardhi Budi Ramadhani and Muchamad Arif Irfa'i (2015) entitled "Analysis of Spindle Rotation Speed, Type of Chisel, and Surface Depth Variation Against Roughness and Flatness of 6061 Aluminum Surface on TU-3A CNC Machines with Absolut G01 Program. " Second, relevant research has been conducted by Rendi Alfianto and Diah Wulandari (2018) with the title "Experimental Study of Spindle Spinning Speed and Cutting Depth on Chisel Vibration and Roughness Level in the Shaft Turning Process Using a Lathe." Third, Yohanws Tri Joko Wibowo (2015) "Analysis of Surface Roughness Levels from Mill Slot Process Results on Machined Steel SCM 440.". The research equation to be carried out by Yohanes Tri Joko Wibowo is in the level of surface roughness of the results, while the difference lies in the use of variations of the coolant and the objects used. Fourth, relevant research has been conducted by Rao, Nagerwara, and Srihari (2013) on "Influence of cutting Force and Surface Finish In Turning Operation". This study shows that the optimum roughness is 3.96 µm (Ra) at a feed rate of 0.05mm / rev, cutting speed of 50 m / min, and a depth of 0.5 mm. Fifth, research conducted by Deny Firdiawan and Yunus on the study of "Cutting Depth, Spindle Rotation Speed, and Chisel Cut Angle Against Surface Roughness of Conventional Composite Materials". This research resulted in the smallest arithmetic mean surface roughness (Ra), which was 5.59 µm which resulted from the parameters into the cut 0.1 mm spindle speed of 800 Rpm, and the cutting angle was 78. Sixth, the relevant research was conducted by Indra Lesmono and Yunus (2013) concerning "The Effect of Chisel Type, Spindle Speed and Surface Depth on the Roughness and Surface Hardness of St 42 Steel in Conventional Lathe Processes". Seventh, the relevant research was conducted by Tri Adi Prasetya on "The Effect of Feeding Motion and Cooling Media on Metal Surface Roughness Resulting from Turning Metal Surface of Hq 760 Steel Material". In this study, the results of the surface roughness of the workpiece without cooling media were 7,880 µm and 6,004 µm using SAE oil cooling media. So it can be concluded that the cooling medium has a roughness of 23.8% of the surface roughness of the Hq760 steel. Eighth, relevant research has been carried out by Henu Tri Wicaksono (2017) regarding "The Effect of Cooling Media Variation and Spindle Speed on the Surface Roughness of 6061 Aluminum Workpiece in the Finishing Process Using a Fanuc Series 01 Mate-Tc PU CNC Lathe".

To avoid discussion deviation, the following is a limitation on the scope of research.

- The research process used a CNC LC-11 TNL 120 AL with Fanuc control.
- Material using S45C steel.
- HCS carbide chisel (high cut steel) 0.8 mm radius.
- The research process uses ISO standards for machining parameters with different spindle rotational speeds.
- The work process on a Fanuc CNC lathe uses the flat lathe method with an absolute program with a cutting depth of 1.5 mm with a finish of 0.2 mm.
- The effect of the quality of the research results is controlled through the finishing process with a variety of coolants (coolant, compressed air, without coolant) and the spindle rotating speed (1400 rpm, 1650 rpm, 1950 rpm) refers to the standard rules relating to cutting speed in the spindle rotating speed listed in the table according to previous research.

UNESA Universitas Negeri Surabaya

- The test uses the same material with a different cooling version and spindle speed according to the large variety of coolant and spindle rotating speed with all materials and cutting tools in new conditions.

Based on these descriptions, this study aims to determine (1) the effect and how much variation of coolant with spindle rotating speed of 1400 rpm, 1650 rpm, 1950 rpm on the surface roughness of the workpiece in the Fanuc CNC flat turning finishing process; (2) the influence and how much variation of the compressed air cooler with a spindle rotating speed of 1400 rpm, 1650 rpm, 1950 rpm on the surface roughness of the workpiece in the Fanuc CNC flat turning finishing process; and (3) the influence and how big the variation of coolant without coolant with spindle rotating speed of 1400 rpm, 1650 rpm, 1950 rpm on the surface roughness of the workpiece in the flat turning process CNC Fanuc.

METHODS

This type of research is experimental research. This experimental research is a research method used to find the effect of certain treatments on other aspects under specified conditions (Sugiyono (2011: 72). This research was conducted from February 2020 to March 2020 at PT. Tjokro Putra Perkasa Sidoarjo. Work of objects Tjokro Putra Perkasa Sidoarjo test and surface roughness testing and image taking were carried out at PT. Tjokro Putra Perkasa Sidoarjo. This research has independent variables in the form of cooling type and spindle rotational speed, dependent variations in the form of S45C steel surface roughness in the CNC lathe process, and control variables covering all factors that can affect the hardness of the CNC turning surface other than cooling variation and spindle speed (the type of material, cutting step, the sharpness of the tool, thickness of feeding, and operator).

The instrument used in this study used the Mitutoyo Digital Vernier Caliper (Sorong term), the Mitutoyo type MT0000044, and the Mitutoyo Roughness Tester type SJ-310 cut of length: 0.08, 0.25, 0.8, 2.5, 8 mm, data output via RS232C Interface / SPC output. , USB Digimatic. In this study, the material used is S45C steel because this material is widely used in the manufacture of shafts. The size of the workpiece is 95mm long, 25.4mm in diameter. S45C steel is low carbon steel that has a carbon content of less than 0.3% and more than 99%.

In this research, an experiment and a literature study of CNC turning specimens were carried out with a variety of cooling media with different spindle rotational speeds to have the accuracy as the basis of this background science. The procedure used in this study is described as follows.

- Prepare materials and equipment (workpiece with S45C steel 30mm in diameter and 90mm in length, CNC lathes, inset chisels, surface roughness measuring instruments).
- Preparing a program with a variety of spindle rotation with a predetermined rpm and a variety of cooling media that has been prepared.
- The first operation, with a variation of the spindle rotation speed of 1400 rpm with coolant cooling media.
- The second operation, with variations in the spindle rotation speed of 1650 rpm with pressurized air-cooling media.
- The third operation, with variations in the spindle rotation speed of 1950 rpm with cooling media without treatment.
- Workpieces are cleaned.
- Testing the roughness of the workpiece that has been machined using a roughness tester.

All data obtained were then analyzed data (Sugiyono, 2011: 335).

Table 6. S45C Steel Surface Roughness Testing

Spindle speed (rpm)	Cooling medium variations	Test object	Surface Roughness Measurement Results µm			
			T1	T2	T3	Mean
1400 rpm	Coolant	1				
	Compressed air	2				
	Without treatment	3				
1650 rpm	Coolant	4				
	Compressed air	5				
	Without treatment	6				
1950 rpm	Coolant	7				
	Compressed air	8				
	Without treatment	9				

Note: T1 measurement point 1
T2 measurement point 2
T3 measurement point 3

UNESA Universitas Negeri Surabaya

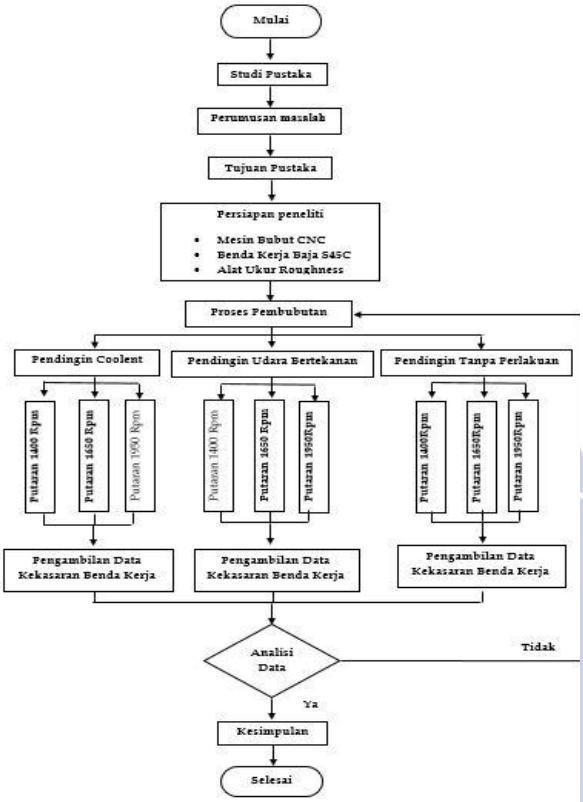


Figure 2. Research procedure

RESULTS AND DISCUCCIONS

The results of research on "The Effect of Cooling Media and Spindle Rotation Speed on the Surface Roughness of the Workpiece in the Finishing Process Using a PU CNC Lathe" obtained data in the form of numbers. The data includes the surface roughness test of the S45C steel workpiece from the influence of different cooling media variations and spindle rotational speeds.

Surface roughness testing produces data in the form of numbers (values) of mean surface roughness (Ra) and values of wave height (Ry). The data is obtained from the Surface Roughness Tester with the Mitutoyo brand SJ-310 on the surface resulting from the flat turning process using a CNC PU lathe. This measurement is carried out after the workpiece has been turned flat with a variety of cooling media including: a.) Coolant, b.) Compressed air c.) Without treatment and three spindle rotational speeds, namely 1400rpm, 1650rpm, and 1950rpm. I use the rotating speed according to the standard table of tool strength.

Workpiece work is done by flat turning 85 mm with a diameter of 20 mm, then taking 3 points for roughness testing. The first test (point 1) is carried out on the upper side, the second (point 2) is tested on the side, namely the object is rotated by 1/3 part for the second test, the third (point 3) is tested at the bottom of 1/3 turn. The results of these are then taken the average to get the roughness value.

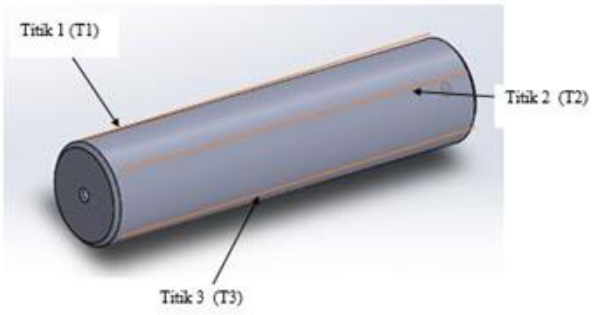


Figure 3. Roughness Test Point

The results of the S 45 C workpiece surface roughness test in this study can be seen in the following table.

Table 7. Surface Roughness Measurement Results

Spindle speed (Rpm)	VM cooler	Test Object	Surface Roughness Measurement Results µm			
			T1	T2	T3	Mean
1400 Rpm	Coolant	1	Ra 3,389 Ry 11,315	Ra 2,849 Ry 11,241	Ra 2,990 Ry 11,059	Ra 3,076 Ry11,205
	Compressed air	2	Ra 3,423 Ry 12,991	Ra 3,451 Ry 13,346	Ra 3,067 Ry 13,998	Ra 3,313 Ry 13,445
	Without treatment	3	Ra 2,578 Ry 12,753	Ra 2,890 Ry 11,625	Ra 3,087 Ry 12,978	Ra 2,851 Ry 12, 452
1650 Rpm	Coolant	4	Ra 3,305 Ry 12,532	Ra 3,556 Ry 12,209	Ra 2,505 Ry 8,883	Ra 3,122 Ry 11,208
	Compressed air	5	Ra 2,483 Ry 11,326	Ra 3,005 Ry 11,356	Ra 2,989 Ry 11,651	Ra 2,825 Ry 11,434
	Without treatment	6	Ra 2,884 Ry 11,139	Ra 3,465 Ry 11,596	Ra 3,459 Ry 11,769	Ra 3,269 Ry 11,511
1950 Rpm	Coolant	7	Ra 2,215 Ry 9,291	Ra 2,852 Ry 11,592	Ra 3,247 Ry 12,296	Ra 2,771 Ry 11,059
	Compressed air	8	Ra 3,435 Ry 13,166	Ra 2,913 Ry 12,136	Ra 2,772 Ry 12,965	Ra 3,04 Ry 12, 755
	Without treatment	9	Ra 3,289 Ry 13,323	Ra 3,368 Ry 13,179	Ra 3,075 Ry 12,597	Ra 3,244 Ry 13,033

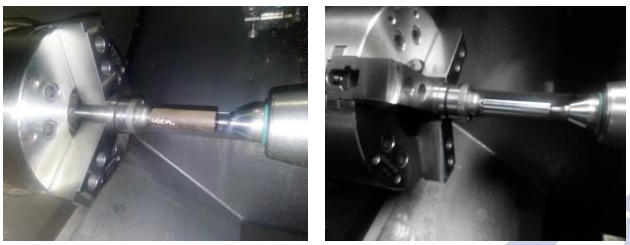
The turning process uses a PU CNC machine using the S 45 C workpiece material. First, cut the workpiece using an amada saw cutting machine with a length of 90 mm. Then, feshing was carried out or stolen from the right and left with a length of 85 mm so that each side now has a flat surface so that the material does not roll too badly. Then do the right and left more center aiming for the dripping process (pegging on a CNC lathe). Furthermore, to distinguish media variations and spindle rotational speed, the matrix is applied to mark the numbers by using a laser to mark the numbers 1-9 according to the test table.



(1) (2)

Figure 3. Material Preparation (1) and Marking (2)

After that, it is turned on a PU CNC lathe using the dripping center method. Dripping center, namely in the fixed head position (Headstock), install the shook drill center (dripping center) and press the flashlight towards the fixed head to clamp or press the workpiece. For this turning process using a dripping center so that the lathe can be completely flat while turning the workpiece.



(1) (2)

Figure 4.Driping Center Process Before (1) and After Turning (2)

After that, do the programming on the CNC machine to carry out work orders on the machine, namely the absolute program with an infeed of 1.5 mm using a 0.8 mm radius chisel.



Figure 5. Absolute Program

The turning process uses various speeds, namely a.) 1400rpm b.) 1650 c.) 1950 and uses a cooling variation a.) Coolant b.) Compressed air c.) Without treatment, the lathe is 85 mm long with a cut depth of 1.5 mm with cutting (cutting) finishing 0.2 mm. After the turning process is complete, the surface roughness of the workpiece is measured using a surface roughness tester with 3 test points for each workpiece.

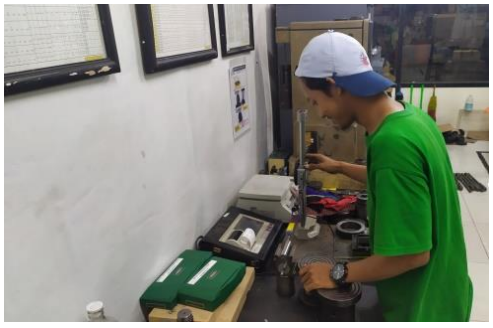


Figure 6. Testing Pictures

Based on the data from the turning results that have been carried out, namely, the roughness test on the surface of the S 45 C workpiece that has been flat-turned with a PU CNC lathe with 3 types of cooling variations and different spindle rotating speeds, the following graph can be made.

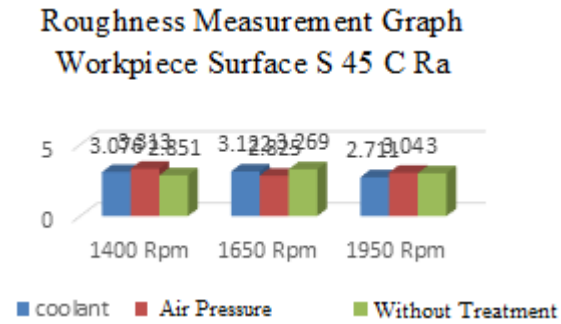


Figure 7. Roughness Measurement Graph Workpiece Surface S 45 C Ra

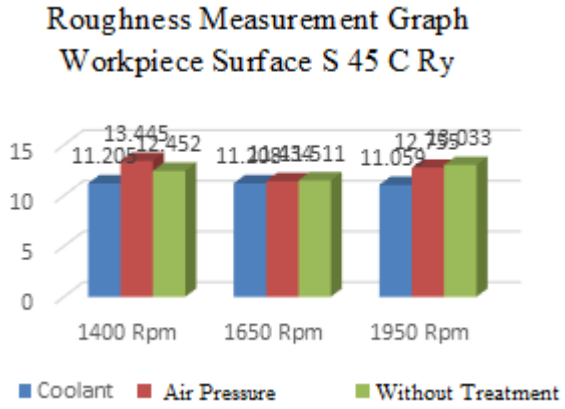


Figure 8. Roughness Measurement Graph Workpiece Surface S 45 C Ry

Based on the results of the hardness test carried out, it appears that the variation of the cooling medium and the spindle rotating speed both influence the surface hardness of the workpiece S 45 C. The cooling medium and spindle rotating speed have a significant effect on the level of surface roughness. The picture above shows that the roughness level produced by each cooler and the spindle rotating speed towards the finishing.

- Variation of coolant media using a spindle rotating speed of 1400 rpm, 1650 rpm, 1950 rpm is 3.076 µm: 3.122 µm: 2.771 µm.
- Variation of pressurized air cooling media using spindle rotating speed of 1400 rpm, 1650 rpm, 1950 rpm is 3,313 µm: 2,825 µm: 3.04 µm.
- Variation of cooling media without treatment using a spindle rotation of 1400 rpm, 1650 rpm, 1950 rpm is 2.851 µm: 3.269 µm: 3.244 µm.

Based on the roughness level, the coolant media is the most optimal medium by producing the lowest level of

workpiece surface roughness at 1950 rpm spindle rotation with a roughness value of 2.771 µm. The highest roughness value was obtained in the pressurized air cooler variation with a spindle rotating speed of 1400 rpm with a roughness value of 3,313 µm.

ACKNOWLEDGEMENT

The author would like to thank Dr. Soeryanto, M.Pd. as the Head of the Department of Mechanical Engineering at the State University of Surabaya, Dr. Soeryanto, M.Pd. as Head of the Mechanical Engineering Education Undergraduate Study Program in the Department of Mechanical Engineering, State University of Surabaya, Nur Aini Susanti, S.Pd, M.Pd. as the supervisor, as well as the Production Division of PT Tjokro Putra Perkasa Sidoarjo, East Java, which has provided a place for research.

CLOSING

Conclusions

Based on the results of the research "The Effect of Cooling Media Variation and Spindle Rotation Speed on the Workpiece Surface Roughness Results in the Finishing Process Using a PU Lathe," it can be concluded as follows:.

- There is a significant influence between the variation of cooling media and spindle rotational speed on the surface roughness results of the workpiece S 45 C in the finishing process using a PU CNC lathe, this shows the roughness test results in this study.
- The variation of the cooling medium on the surface roughness due to the different roughness values for each variation is different.
- The variation with the lowest roughness value is the coolant medium with a spindle rotating speed of 1950 rpm to produce a roughness value of 2.771 µm, and the variation with the highest roughness value is the variation of pressurized air-cooling media with a spindle rotating speed of 1400 rpm resulting in a roughness value of 3,313 µm. So, the lowest roughness value is produced by the coolant variation with high rotational speed.

Suggestions

Suggestions that can be given regarding the results and conclusions of this study are:

- Research on this PU lathe CNC can be used as an initial process for other researchers who are interested in conducting relevant studies.
- The need to calibrate measuring instruments and machines so that they are still precise and the size fits well.
- To produce accuracy in the study, the next researcher can perform a roughness test with varying control variables during CNC PU turning, such as the ratio of coolant to water.
- Suggestions for further research are that it is necessary to research the effect of hardness on the workpiece after turning it with various medical variations and it is necessary to vary the chisel angle (Radius on CNC PU chisels).
- For the knowledge of the person who turned it for the first time to know the factors that can affect the quality of the surface of the workpiece when turning it.

REFERENCES

Alfianto, Rendi dan Diah Wulandari. 2018. "Studi Eksperimen Kecepatan Putar Spindle dan Kedalaman Potong Terhadap Getaran Pahat dan Tingkat Kekerasan pada Proses Pembuatan Poros Menggunakan Mesin Bubut." *Jurnal Teknik Mesin, 6*(2): 61—68.

Fidiawan, Deny dan Yunus. 2014. Pengaruh Kedalaman Potong, Kecepatan Putar Spindel, Sudut Potong Pahat Terhadap Kekasaran Permukaan Hasil Bubut Konvensional Bahan Komposit, JTM, Volume 3, UNESA.

Lesmono, Indra dan Yunus. 2013. Pengaruh Jenis Pahat, Kecepatan Spindel, dan Kedalaman Pemakanan Terhadap Tingkat Kekasaran dan kekerasan Permukaan Baja ST.42 Pada Proses Bubut Konvensional. JTM. Volume 01 No 03, 2013 : 48-55

Prasetya, T.A., 2010, Pengaruh Gerak Pemakanan Dan Media Pendingin Terhadap Kekasaran Permukaan Logam Hasil Pembubutan Pada Material Baja HQ 760, Skripsi, Universitas Sebelas Maret

Ramadhani, Ardhi Budi dan Muchamad Arif Irfa'i. 2015. "Analisis Kecepatan Putar Spindle, Jenis Pahat dan Variasi Kedalaman Pemakanan Terhadap Kekasaran dan Kerataan Permukaan Alumunium 6061 pada Mesin CNC TU-3A dengan Program Absolut G01." *Jurnal Teknik Mesin, 1*(01): 118—125.

Rao, C. J, Nageswara dan Srihari. 2013. Influence Of Cutting Parameters On Cutting Force And Surface Finish In Turning Operation. Procedia Engineering, 64: 1405-1415.

Rochim, T. 2001. *Spesifikasi Geometris Metrologi Industri & Kontrol Kualitas*. Bandung: ITB Bandung

Setyorini Y., 2013. Pengaruh Media Pendingin pada Heat Treatment Terhadap Struktur Mikro dan Sifat Mekanik Friction Wedge AISI 1340, Jurnal Teknik Material dan Metalurgi Institut Teknologi Sepuluh November (ITS), Surabaya

Sugiyono. 2011. Metode Penelitian Kuantitatif, Kualitatif, dan R&D. Bandung: Penerbit Alfabeta

Sumbodo, W. 2008. *Teknik Produksi Mesin Industri*. Jakarta: Direktorat Pembinaan Sekolah Menengah Kejuruan Standar ISO 1302: 2002.

Tim Ft.Unesa.2016 Panduan Penulisan Skripsi Program S1 Surabaya: Jurusan Pendidikan Teknik Mesin Fakultas Teknik Universitas Negeri Surabaya.

Wayudi, 2011. Studi Metode Pendinginan Terhadap Kualitas Hasil *End Milling*. Tugas Akhir UMS.

Wibowo, A. Pengaruh Variasi Kecepatan Putar Spindel dan Bahan Pahat Terhadap Kehalusan Permukaan Baja EMS 45 Pada Mesin CNC TU 2A dengan Progam Absolute. Jurnal Teknik Mesin. (online) (digilib.uns.ac.id), diakses tanggal 13 Desember 2019.

Wibowo, Yohanes Tri Joko. 2015. "Analisis Tingkat Kekasaran Permukaan Hasil Proses Mill Slot pada Baja Permesinan SCM 440." Seminar Nasional Mesin dan Teknologi Kejuruan di Universitas Negeri Jakarta, Jakarta pada Mei 2015.

Wicaksono, Henu Tri. 2017 "Pengaruh Variasi Media Pendingin dan Kecepatan Putar Spindel Terhadap Hasil Kekasaran Permukaan Benda Kerja Pada Proses Finishing Menggunakan Mesin Bubut CNC Fanuc Series 01 Mate-Tc".

Widarto. 2008a. *Teknik Pemesinan Jilid 1*. Jakarta: Direktorat Pembinaan Sekolah Menengah Kejuruan

Widarto. 2008b. *Teknik Pemesinan Jilid 2*. Jakarta: Direktorat Pembinaan Sekolah Menengah Kejuruan

UNESA
Universitas Negeri Surabaya