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Effect of Cutting Angle and Depth of Cut on Chipping and Workpiece Surface Roughness

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Abstract:- In this era, technological development is very rapid in everyday life and in the industrial sector. Advances in the industrial field have produced many innovations that can help improve the efficiency and quality of the products produced. One of the important cutting processes is the turning process. Lathe is the most common cutting or scraping technique used in the production process. In this study, the problem defined is the effect of cutting angle and depth of cut on the scour produced from the turning process. The limitations of the problem limits used in this study are the workpiece used is VCN 150 with a cylindrical shape, the process of taking data on the thickness of the graver using a manual vernier, and the process of taking data for surface roughness on the workpiece using a mitutuyo surface test. The problem formulation used in this study is how the effect of cutting angle on surface roughness and how the effect of cutting depth on surface roughness on the workpiece. The purpose of this research is to examine analytically about the effect of cutting angle on the resulting grit on cylindrical VCN 150 steel material and examine analytically about the effect of depth of cut on the resulting grit on cylindrical VCN 150 steel material. The benefit of this research is that readers can better know and understand the results of the scour produced from the turning process on VCN 150 steel material. The innovation of this research is that research conducted on scour to determine surface roughness is still little done in Indonesia.

Keywords:- *VCN 150, Chip, Cutting Angle, Depth of Cut, Surface Test Mitutuyo.*

I. INTRODUCTION

Technological advancements in the industrial field have resulted in many innovations that can help in improving the efficiency and quality of manufactured products. In this context, material cutting techniques are a key process in forming various types of products, ranging from electronic components to heavy machinery. The quality and efficiency of the cutting process is influenced by several factors, namely the parameters in the cutting process that can affect the results of the cutting process in order to produce a final product that is in accordance with the specifications and with the desired standards.[1]

One of several important cutting processes is the turning process. lathe is the most commonly used material cutting or scraping technique in the production process. Lathe is the process of cutting a workpiece or material by rotating the workpiece and moving the tool blade towards the rotating workpiece so that the cutting or scraping process occurs. In the turning process, the result of the workpiece is determined by parameter settings such as tool geometry and depth of cut.

The cutting angle is the angle used to determine the cutting direction and the normal line to the surface of the workpiece to be cut, while the depth of cut is how deep the tool cuts the workpiece in the cutting process. From these two parameters can affect the depth of cut, the quality of the surface results, and the life of the cutting tool. [2]

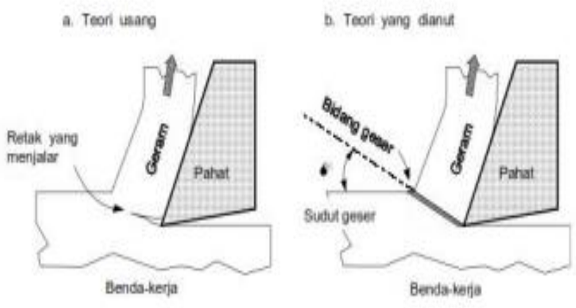

Fig 1. Cutting Angle [3]

In this study, the analysis of cutting process experiments using tool geometry parameters and depth of cut in the turning process 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 achieve more efficient and quality cutting results.

The problem arising in the research "Effect of Cutting Angle and Depth of Cut on Workpiece Surface Roughness" is the effect of cutting angle and depth of cut produced in the turning process on VCN 150 material.

There are also limitations applied in this research, such as: The workpiece used in this machining process is VCN 150 steel with a cylindrical shape, the process of taking data on the thickness and length of the burrs, using a caliper, the cutting angle used is the angle of the tool post on the lathe, and the process of taking surface roughness data on the workpiece using the Mitutoyo surface test.

The research objectives applied in this test are: Analytically examining the effect of cutting angle and depth of cut on surface roughness and the resulting scorch on cylindrical VCN 150 steel material and analytically examining the relationship between scorch and surface roughness produced on VCN 150 steel material.

The benefits obtained from this research are: Providing knowledge of the scour produced in the turning process and providing knowledge about the effect of variations in cutting angle and depth of cut on surface roughness.

This is also related to surface roughness, surface roughness is the size or value of the roughness of a surface or the height of a workpiece surface. The concept of surface roughness can be used to study the flow of heat and electricity in materials, the concept of friction on the surface of material objects, stickiness between two materials, deformation touch areas, and studies of the corrosion properties of workpieces.

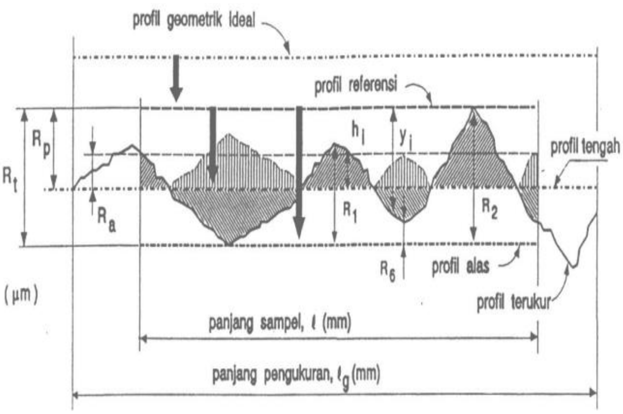

Fig 2. Shape Surface roughness profile [4]

II. MATERIAL AND METHODS

In this study, the method used is experimental research using the turning process using Vc worth 70.65 m/min and f worth 0.1 mm/rev, This steel is a high strength low carbon steel (High strenght low alloy - HSLA Steel) with a class of machine steel (Machinery Steel) with a carbon value of 0.36%-0.43%. VCN 150 steel is a steel with European standard EN 25 or German DIN 34cr. VCN 150 steel is the metal equivalent of ST90, AISI 4340, SNCM439, ASAB 705, Thyssen 6582, DIN 34NiCrMo6, ASSAB 705, Atlas Ultimo 200. This steel is generally used for manufacturing crankshafts, gears, etc. VCN 150 steel has a strength of 255HB Max. In this test, the test specimen will be turned with 9 variations, namely with 3 cutting angles of 100º, 90º, 80º and a depth of cut of 0.2, 0.3, 0.4. After obtaining data from the 9 variations, surface roughness measurements will be made using a surface roughness tester to see the quality of the turning results based on the cutting angle and depth of cut. After obtaining data from the 9 variations, surface roughness measurements will be made using a surface roughness tester to see the quality of the turning results based on the cutting angle and depth of cut. Furthermore, an analysis will be carried out between the surface roughness and the scour produced in the turning process.

The turning process was carried out transversely using a cutting speed (Vc) of 70.65m/min using a conventional lathe. The turning process was carried out on the test specimen by cutting 80mm long using a DNMG 150404-TF tool which was chosen because it has a cutting speed capability in accordance with the catalogbook which is 70.65 mm/min and has a match with VCN 150 material. [5]


Fig 3. Cutting Tools [5]

After turning the test specimen, the roughness on the surface of the VCN 150 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 workpiece. The Mitutoyo surface tester uses a probe or stylus that moves back and forth over the surface of the workpiece to measure the roughness of the workpiece surface. This probe or stylus will follow the shape of the workpiece surface which converts the back and forth movement into an electrical signal that will be recorded by the tool, the signal is processed to get the Ra value.

Table 1 Elemental Composition of VCN 150 Steel Material

NAME		COMPOSITION %
Carbon	C	0.36-0.43
Silicon	Si	0.15-0.35
Mangan	Mn	0.60-0.90
Fosfor	P/S	1.60-2.00
Krom	Cr	0.60-1.00
Molibdenum	Mo	0.15-0.30

Table 2 Mechanical Elements in VCN 150

Mechanical Properties	VCN 150
Tensile Strenght (Mpa)	745
Yield Strengtht(Mpa)	470
Elongation at break (%)	22
Hardness (HB)	217
Elastic Modulus (GPa)	190-210
Bulk Modulus (Gpa)	140
Shear Modulus (Gpa)	80

Table 3 Sifat Fisik VCN 150

Physical Properties	VCN 150
Density (x1000 kg/m^3)	7.85
Melting point (°C)	1427
Thermal Conductivity (@100 °C) (W.m-K)	44.5
Thermal Expansion co-efficient (μm/m°C)	12.3

III. RESULTS AND DISCUSSION

Based on the turning process performed, the following data will be analyzed.

NO	Cut Angle	Cutting Parameter			Surface Roughness
		VC	Feed	Depth of Cut	
		mm/min	mm/rev	mm	µm
1	100°	70.65	0.1	0.2	1.434
2	100°	70.65	0.1	0.3	1.285
3	100°	70.65	0.1	0.4	1.087
4	90°	70.65	0.1	0.2	1.324
5	90°	70.65	0.1	0.3	1.958
6	90°	70.65	0.1	0.4	2.599
7	80°	70.65	0.1	0.2	0.906
8	80°	70.65	0.1	0.3	1.242
9	80°	70.65	0.1	0.4	1.509

Table 4 surface roughness

After the turning process is carried out on the VCN 150 material, the data obtained is as shown in the table 4, from 9 VCN 150 test specimens that have been turned using the Microtara Turnmastr35 machine with a variation of 3 cutting angles and 3 depths of cut and using a DNMG 150404-TF tool which has a suggested cutting speed of 70-180m/min and after the turning process, the surface roughness data is taken on the workpiece using a Mitutoyo surface roughness tester to get the surface roughness number.

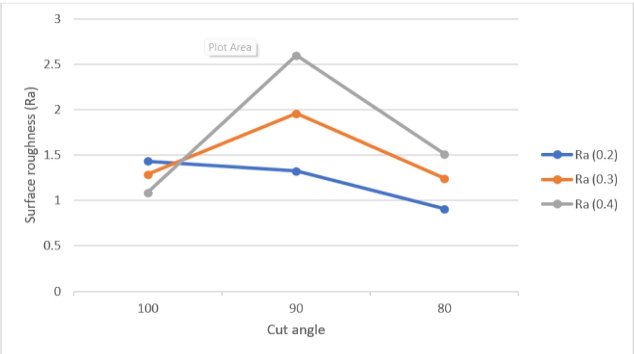

Fig 4. Graph of cutting angle against surface roughness

From the data obtained, 2 depths of cut are 0.3 mm and 0.4 mm and 1 cutting angle is 90° which has a high surface roughness of 1.958 for a depth of cut of 0.3mm and 2.599 for a depth of cut of 0.4 mm.

Based on the research conducted, in the turning process with a predetermined depth of cut and angle of cut, the value of the depth of cut affects the quality of the workpiece surface (Ra), this phenomenon can occur due to contact between the tool and the workpiece as deep as 0.2 mm, 0.3 mm, and 0.4 mm and with an angle of 100°, 90°, and 80° which causes plastic deformation on the surface of the workpiece in contact with the tool. On the surface of the workpiece in contact with the tool, permanent deformation occurs due to the pressure from the tool and high microstructure shifts.

After taking surface roughness data, the next process will be to analyze the surface roughness of the workpiece with the shape of the grit produced during the turning process with predetermined parameters.

Table 5 Chip Characteristics

NO	Cut Angle, VC, Feed, D.O.C	Chip image	Chip Characteristics
1	100°, 70.65, 0.1mm, 0.2mm		Furious Shape: Coil chip Coil length: 0.21mm Width: 0.15mm Thickness: 0.35 mm Diameter: 2.2 mm

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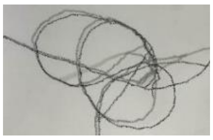
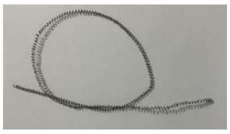
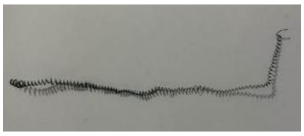
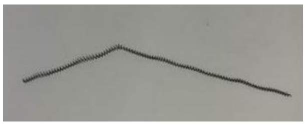
2	100^o, 70.65, 0.1mm, 0.3mm		Furious Shape: Coil Chip Coil Length: 0.36mm Width: 0.55mm Thickness: 0.3mm Diameter: 3.9mm
3	100^o, 70.65, 0.1mm, 0.4mm		Furious Shape: Coil Chip Coil Length: 0.25mm Width: 0.45mm Thickness: 0.25 mm Diameter: 2.55
4	90^o, 70.65, 0.1mm, 0.2mm		Furious Shape: Coil Chip Coil Length: 0.08mm Width: 0.25mm Thickness: 0.2mm Diameter: 1.35 mm
5	90^o, 70.65, 0.1mm, 0.3mm		Furious Shape: Coil Chip Coil Length: 0.20mm Width:0.35mm Thickness:0.1 mm Diameter:1.85 mm
6	90^o, 70.65, 0.1mm, 0.4mm		Furious Shape: Coil Chip Coil Length: 0.15mm Width: 0.35mm Thickness: 0.15 mm Diameter: 1.6 mm
7	80^o, 70.65, 0.1mm, 0.2mm		Furious Shape: Entangled Chip Coil Length: 0.27mm Width: 0.3mm Thickness: 0.05 mm Diameter: 3.45 mm
8	80^o, 70.65, 0.1mm, 0.3mm		Furious Shape: Coil Chip Coil Length: 0.15mm Width: 0.25mm Thickness: 0.15 mm Diameter: 1.35 mm
9	80^o, 70.65, 0.1mm, 0.4mm		Furious Shape: Coil Chip Coil Length: 0.45mm Width: 0.45mm Thickness: 0.3 mm Diameter: 1.6 mm

In this study using the parameters Vc, feed, and d.o.c and with tool geometry, namely the cutting angle. In table 5, the results of the type of grinding from the turning results have the same type of coil chip and there is only 1 result that has a different type of grinding, namely the grinding with a turning parameter of 80o cutting angle, VC 70.65 m/min, feed 0.1mm, and d.o.c 0.2 mm has an entangled coil shape.

From table 5 it can be concluded that the difference between each chip is different in length per coil, width, thickness, and chip diameter. The resulting slurry usually has a spiral shape and has a continuous or non-continuous shape and types of slurry in the form of coil, entangled coil, ribbon coil, short coil, spiral chip, and short coil particle.

Based on the results of the study, it can be analyzed on the trend, in Figure 4 that the smaller the width of the turning result, the result of the surface roughness (Ra) of the workpiece is getting rougher as shown in the diagram above.

Table 6 Ratio of Chip Thickness and Surface Roughness

Cutting Speed (VC) : 70.65 m/min		**Feed (f): 0.1 mm/rev**	
No	**Cut Angle, D.O.C**	**Chip Thickness Ratio (λ_h)**	**Surface Roughness (Ra)**
1	100^o, 0.2mm	1.5	1.434
2	90^o, 0.2mm	2.5	1.324
3	80^o, 0.2mm	3	0.906

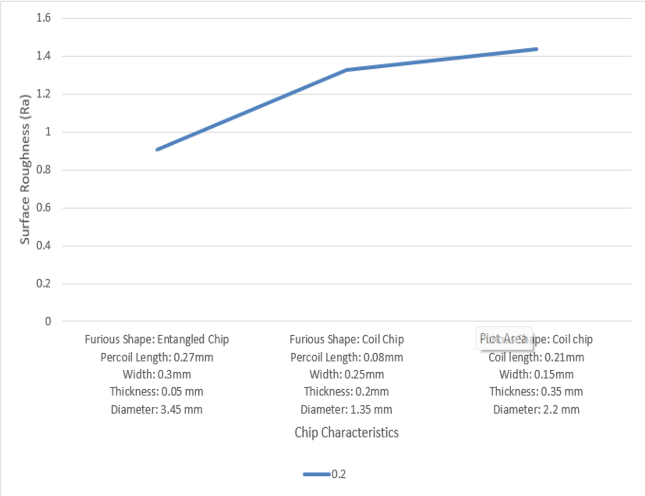


Fig 5. Correlation diagram of grit with surface roughness (Ra)

It can be seen in table 6 in the chip thickness ratio section, on the chip produced in the turning process there is compression on the chip as at a cutting angle of 80° and d.o.c 0.2 mm the chip thickness ratio has a value of 3, a cutting angle of 90° and d.o.c 0.2 mm the chip thickness has a value of 2.5, a cutting angle of 100° and d.o.c 0.2 mm the chip thickness has a value of 1.5. It can be concluded that the smaller the cutting angle, the greater the chip thickness ratio and vice versa, the greater the cutting angle, the smaller the surface roughness value.

It can be concluded in this study that the greater the cutting angle used in the turning process on VCN 150 material using a DNMG 15040-TF tool, the rougher the surface roughness of the workpiece will be caused by changes in the size of the width of the grit with a feed rate that can be referred to as the chip thickness ratio. The reason the chip thickness ratio can affect the surface roughness is because if the chip thickness ratio is low, it can help the chips produced during the turning process to exit the cutting zone, which results in a smoother surface roughness caused by reduced load on the cutting edge and minimizes scratches on the workpiece surface.

IV. CONCLUSION

It can be concluded in this study that the greater the cutting angle used in the turning process, the rougher the surface roughness on the workpiece will be caused by changes in the size of the width of the serration with the feed rate which can be referred to as the chip thickness ratio.

The lowest surface roughness (Ra) value is 0.906 at a cutting angle of 80° and d.o.c 0.2, the highest surface roughness (Ra) value is 2.599 at a cutting angle of 90o and d.o.c 0.4.

The results of the turning process on 9 VCN 150 materials, 8 workpieces have a coil chip shape and 1 workpiece has an entangled chip shape with a continuous type of edge.

In table 6 in the chip thickness ratio section, the chips produced in the turning process occur compression on the chip such as at a cutting angle of 80° and d.o.c 0.2 mm the chip thickness ratio has a value of 3, a cutting angle of 90° and d.o.c 0.2 mm the chip thickness has a value of 2.5, a cutting angle of 100° and d.o.c 0.2 mm the chip thickness has a value of 1.5.

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