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Performance of Various Cutting Fluids by Estimating Surface Roughness of Mild Steel in Turning

[1]M. K.Vijaya Prabhu
Assistant Professor
Department of Mechanical Engineering
Surya Engineering College
Erode, India

[2]Dr. P. Ponnusamy
Professor & Head
Department of Mechanical Engineering
Surya Engineering College
Erode, India

[3]J. Senthil Kumar
Assistant Professor
Department of Mechanical Engineering
Surya Engineering College
Erode, India

Abstract

The objective of this thesis work is to calculate the surface roughness of the mild steelwork piece in turning under various eco-friendly cutting fluids as a coolant. The single point cutting tool is used for machining cylindrical shape specimen of mild steel. The sunflower oil, coconut oil, and normal coolant are the cutting fluids used in this operation and also the machining process is done in dry condition (without coolant). A number of tests are performed with different cutting speeds, feed rates and different cutting fluids. Cutting forces and Surface Roughness values are measured from these experiments and these are used for data analysing the cutting process. The High Speed Steel (HSS) tool is used for the experimental work. Viscosities of coolants are also measured before and after machining. Totally twelve experiments are carried out and the results are plotted in the form of graphs. These graphs show the variation of Surface Roughness with respect to the cutting speeds and cutting fluids. By analyzing the graph, the best cutting fluid under various cutting speeds and feeds is found out.

Key words *—Turning, Mild steel, Coconut oil, Sunflower oil, Normal coolant, Cutting forces, Surface roughness.*

1. Introduction

The challenge of modern machining industries is mainly focused on the achievement of high quality, in terms of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact. Mild steel has been used in large quantities for years because of desirable properties as good ductility, good machinability and low cost. During machining, the operators encounter certain difficulties such as premature tool failure and poor surface finish due to high temperature at tool–work piece interface. Due to the fact that, higher tool temperature, the faster the wear, the use of cutting fluids in machining processes has, as its main goal, the reduction of the cutting region temperature, either through lubrication and reduction of friction wear, and through a combination of these functions. In this context, this study becomes necessary to understand the theory behind the performance of various cutting fluids by measuring the surface roughness of the material under various cutting speeds.

2. Turning

Turning is a widely used machining process in which a single point cutting tool removes material from the surface of a rotating cylindrical work piece. The material removed, called chip, slides on the face of tool, known as tool rake face, resulting in high normal and shear stresses and, moreover, to a high coefficient of friction during chip formation. Most of the mechanical energy used to form the chip becomes heat, which generates high temperatures in the cutting region. Due to the fact that, higher the tool temperature, the faster the wear, the use of cutting fluids in machining processes has, as its main goal, the reduction of the cutting region temperature, either through lubrication and reduction of friction wear, and through a combination of these functions.Among all the types of wear, flank wear affects the work piece dimension, as well as quality of surface finish obtained, to a large extent.

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3. Cutting Fluids

Cutting fluid is a type of coolant and lubricant designed specifically for metalworking and machining processes. There are various kinds of cutting fluids, which include oils, oil-water emulsions, pastes, gels, aerosols (mists), and air or other gases. They may be made from petroleum distillates, animal fats, plant oils, water and air, or other raw ingredients. Depending on context and on which type of cutting fluid is being considered, it may be referred to as cutting fluid, cutting oil, cutting compound, coolant, or lubricant.

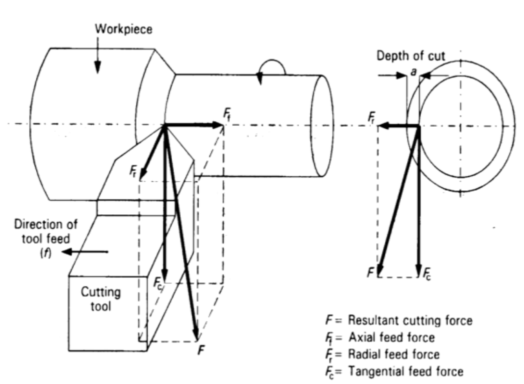
Most metalworking and machining processes can benefit from the use of cutting fluid, depending on work piece material. Common exceptions to this are machining cast iron and brass, which are machined dry.Table1 shows the viscosity of various cutting fluids used in this experiment.

S.No	Temperature (°C)	Viscosity in centipoise		
		Soluble oil	Coconut oil	Sunflower oil
1	30	39.61	37.5	39.61
2	45	17.16	20.3	25.45
3	55	10.55	14.8	19.55
4	70	8.255	9.8	14.2

Table 1. Viscosity of cutting fluids

4. Cutting Force Measurement

There are three cutting forces which are acting on a single point tool and shown in figure1.



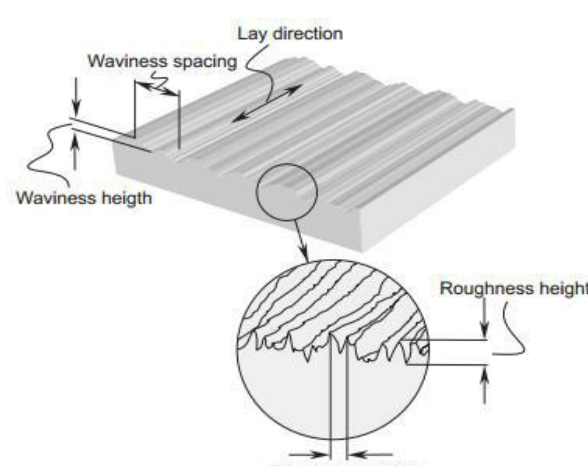
"Figure 1. Cutting forces acting on the tool"

The F_x is the feed force which is acting on the X direction, the F_y is cutting force acting of on Y direction and F_z is the radial force acting on the Z direction. The cutting forces were measured using 3 component dynamometer shown below in Figure 2.

"Figure 2. Lathe Tool Dynamometer"

5. Surface Roughness

The quality of machined surface is characterized by the accuracy of its manufacture with respect to the dimensions specified by the designer. Every machining operation leaves characteristic evidence on the machined surface. This evidence in the form of finely spaced micro irregularities left by the cutting tool. Each type of cutting tool leaves its own individual pattern which therefore can be identified. This pattern is known as surface finish or surface roughness. Surface roughness, often shortened to roughness, is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small the surface is smooth. Roughness is typically considered to be the high frequency, short wavelength component of a measured surface.



"Figure 3. Surface Roughness"

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6. Instrumentation & Experimentation

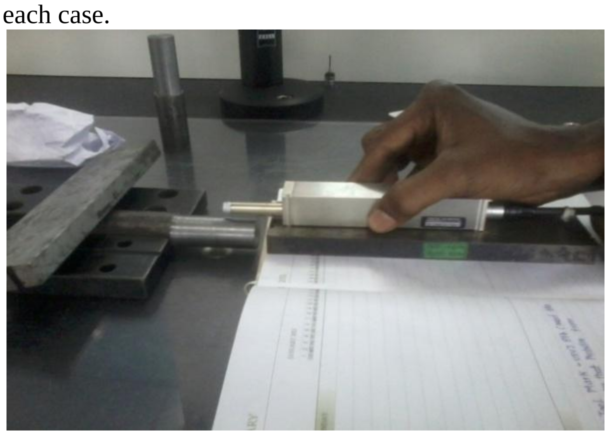
The various instruments used for experimentation are discussed here in this section.

- VeekeY 6’ lathe machine
- Lathe tool dynamometer
- Handy surf surface roughness tester
- Redwood viscometer

A VeekeY 6’ make lathe was used for turning experiment and Figure 4. shows the schematic diagram of the machine and the dynamometer mounted on tool post with the help of a holder specially designed for this experimental work is shown in Figure 4.

“Figure 4. Schematic Diagram of Equipment setup”

Then the actual experiments have been carried out with the different input cutting conditions for different experiments for constant volume of material removal in each case.



“Figure 6. Handy Surf Roughness tester”

The experiments carried out are summarized as:

- Carry out experiment on lathe machine using Mild steel as a work piece and commercial available High speed steel as a tool.
- Machining is done with different sets of Cutting speed, depth of cut, & feed rates.
- Measuring the cutting forces with Lathe dynamometer.
- Measuring the surface roughness by using Hand surf surface roughness tester shown in Figure 6.
- Evaluating the results by plotting graphs.

8. Results and discussions

Here the result for the present problem that is calculating of surface roughness using various environmental friendly cutting fluids in turning operation of Mild steel have been calculated. The number of experiment has been conducted to find out the cutting force ,viscosity and surface roughness of the machined surface of the work piece, made of mild steel, at varying machining parameters which are cutting speed (v), cutting feed (f) and keeping depth of cut (d) constant. Using this data various graphs are plotted. The table 2 shows the investigation table used for experimentation.

Tool material	Work piece material	Condition
High speed steel	Mild steel	Dry condition
		Coconut oil as a coolant
		Sunflower oil as a coolant
		Normal coolant

“Table 2. Investigation table”

The table 3 shows the numerical values of the various machining parameters (cutting speed, feed and the depth of cut), that have been selected for experimentation, for the measurement of cutting forces and surface roughness. The Mild steel work piece material has been used for experimentation and the cutting material used is High Speed Steel.

Cutting speed (rpm)	Cutting feed (mm/min)	Depth of cut (mm)
222	100	0.1
357	150	0.15
570	250	0.2

“Table 3. Machining Parameters”

The table 4, 5 & 6 shows the experimental values of surface roughness, and cutting forces for different speed, feed and depth of cut for the different set of experiments conducted on the High speed steel cutting tool.

S.No	Speed (rpm)	Feed (mm/ min)	Depth of Cut (mm)	Coolants used	Fx (N)	Fy (N)	Fz (N)	Surface Roughness (µm)
1	222	100	0.1	Sun Flower oil	30	220	40	11.5
2				Coconut oil	20	200	30	18.5
3				Normal coolant	33	150	30	13.3
4				Dry condition	41	200	50	22.35

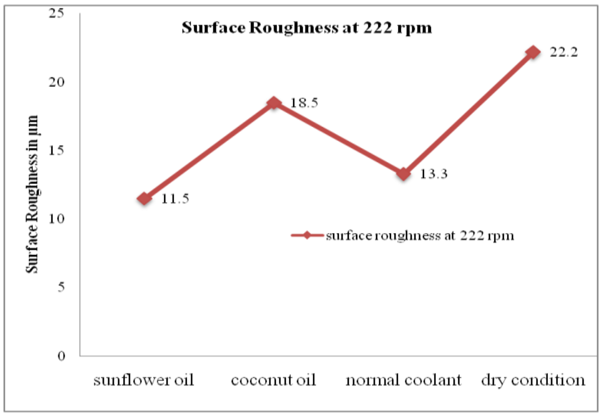
Table 4. Experimental Results at 222 rpm

S.No	Speed (rpm)	Feed (mm/min)	Depth of Cut (mm)	Coolants used	Fx (N)	Fy (N)	Fz (N)	Surface Roughness (µm)
1	357	150	0.15	Sun flower oil	20	270	20	6.1
2				Coconut oil	50	340	60	13.5
3				Normal coolant	40	380	50	11.12
4				Dry condition	80	380	70	27.9

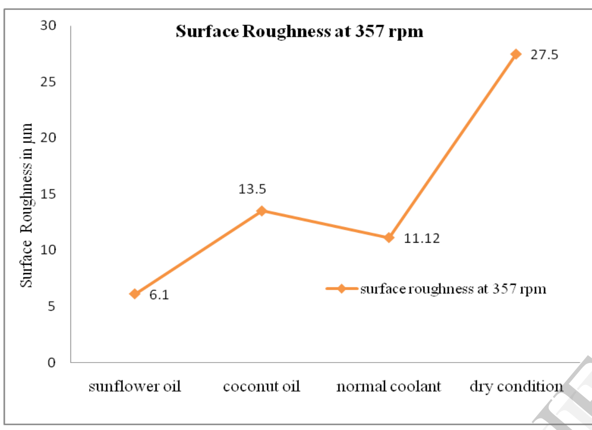
Table 5. Experimental Results at 357 rpm

S.No	Speed (rpm)	Feed (mm/min)	Depth of Cut (mm)	Coolants used	Fx (N)	Fy (N)	Fz (N)	Surface Roughness (µm)
1	570	250	0.2	Sun flower oil	110	410	84	3.66
2				Coconut oil	180	120	60	5.9
3				Normal coolant	80	200	40	3.89
4				Dry condition	170	340	70	10.55

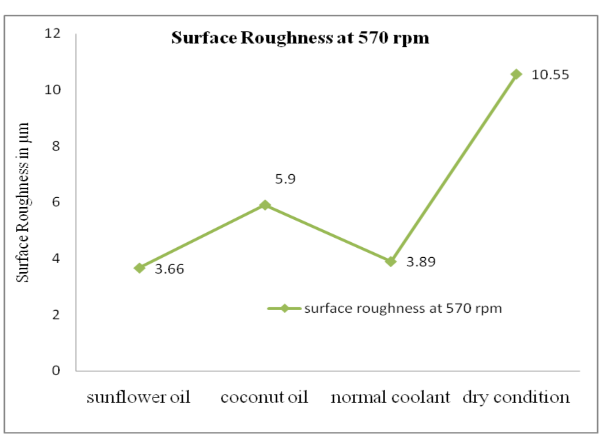
Table 6.Experimental Results at 570 rpm



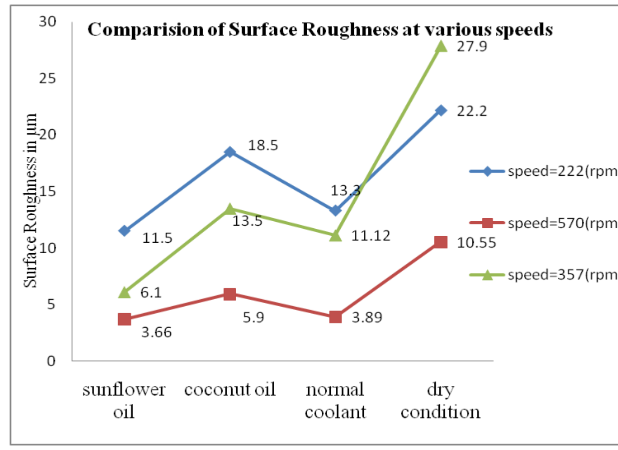
"Figure 1. Surface Roughness at 222 rpm"



"Figure 2. Surface Roughness at 357 rpm"



"Figure 3. Surface Roughness at 570 rpm"



"Figure 4. Surface Roughness at various cutting speeds"

9. Conclusion

Thus it is concluded from the results found out in the previous sections, the cutting forces have significantly less value at the cutting speed of 222 rpm and 357 rpm when compare to the 570 rpm. The radial force F_z was almost equal to F_x and lower than F_y at various cutting speeds. Since Eco-friendly fluids are used, the operator had not found any difficulty while doing machining operation and also while disposing the cutting fluids. From the viscosity graph, it is found that eco friendly cutting fluids are having more viscosity than the conventional cutting fluids the reusability of cutting fluids has been increased and hence reduction in the cost of cutting fluid. The best surface finish is obtained from the sunflower oil with an average surface finish value of 3.66µm at the cutting speed of 570 rpm and 250 mm /min. The surface roughness value of the sunflower oil is very less than the normal coolant in all cutting speeds, feeds and depth of cuts. Therefore the sunflower oil is found to be more efficient than other cutting fluids.

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