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Effect of Process Parameters during Machining of Mild Steel and Titanium

Ramcharan Vuyyala

Department of Mechanical Engineering, Vidya Jyothi Institute of Technology, Hyderabad, India

Abstract: ***The measurement of cutting forces and other parameters in metal cutting is essential to estimate the power requirements to machine performance; work piece and tool material selection, tool life, quality of machined surfaces play a major role in this regard. The parameters selected are speed, feed and depth of cut on a lathe machine. In the experiment the lathe tool dynamometer is used to measure cutting force, feed rate and depth of cut. The dynamometer is connected to the data acquisition system. As the tool comes in contact with the work piece the various forces developed are captured. In this experiment four different materials namely mild steel, annealed mild steel, zirconium coated mild steel and titanium materials are selected. In this study single point cutting tools are employed and then major forces on these materials, hardness and surface roughness of the machined surfaces are evaluated. Graph and numerical formulation is done based on variation of speed and feed.***

Keywords: Lathe Dynamometer, Taguchi Sequence, Thermalspary coating, SAE40

1. Introduction

The term machinability may be taken to imply that there is a property or quality of any given material which can be clearly defined and quantified, thus indicating how easy (or difficult) that mechanical operation can be. In fact, that term is not unambiguous, but the machinability of a material can be assessed by employing criteria such as (i) tool life (ii) cutting forces or power consumption (iii) surface finish and chip morphology. In this project, we study the machinability of the materials Mild steel and Titanium and the materials are studied only to compare the machinability differences between materials. Materials with good machinability require little power to cut, can be cut quickly, easily obtain a good finish, and do not wear the tooling much; such materials are said to be free machining. The factors that typically improve a material's performance often degrade its machinability

2. Experimental Method

2.1 Low Carbon Mild Steel

As we know the Mild steel material is very difficult to machining due to reasons such as having a low thermal conductivity, high built up edge tendency and high corrosive resistance. So study the effect of cutting parameters on cutting force by using the Taguchi method.

2.2 Titanium

Problems in machining titanium originate from three basic sources: high cutting, temperatures, chemical reactions with the tool, and a relatively low modulus of elasticity

2.3 Proposed Methodology

Considering the problem occurring while selecting parameters for machining of Mild steel and Titanium. Here firstly we selected the tool insert for machining of MS and Ti, tool holder MTJNR 2020K 16 . In this L4 OA is selected as per the Taguchi technique for performance of dry turning of Ms and Ti.

2.4. Heat Treatment and Coating

2.4.1Mildsteel Annealed

Annealing is a heat treatment process which alters the microstructure of a material to change its mechanical or electrical properties. Typically, in steels, annealing is used to reduce hardness, increase ductility and help eliminate internal stresses. Annealing is a generic term and may refer to subcritical, intermediate or full annealing in a variety of atmospheres.

Figure 1 Heat Treated Bar

Table 1: Annealing details of Mild Steel

Temperature	450^0C
Time	80 Mins
Type of Cooling	Furnace cooling

2.4.2 Zirconium coated Mildsteel

In this the Mildsteel is taken as the substrate and Zirconium is taken as the coating material. Thermal spraying techniques are coating processes in which melted (or heated) materials are sprayed onto a surface. The "feedstock" (coating precursor) is heated by electrical (plasma or arc) or chemical means (combustion flame).Thermal spraying can provide thick coatings (approx. thickness range is 20 microns to several mm, depending on the process and feedstock), over a large area at high deposition rate as compared to other coating processes such as electroplating, physical and chemical vapor deposition. Coating materials available for thermal spraying include metals, alloys, ceramics, plastics, and composites.

Figure 2: Zirconium coated MS Rod

2.5 Experimental Flowchart

A step by step procedure in this work has been illustrated as shown in Fig.3.All the work pieces after experimentation have been analysed using standard Taugchi method.

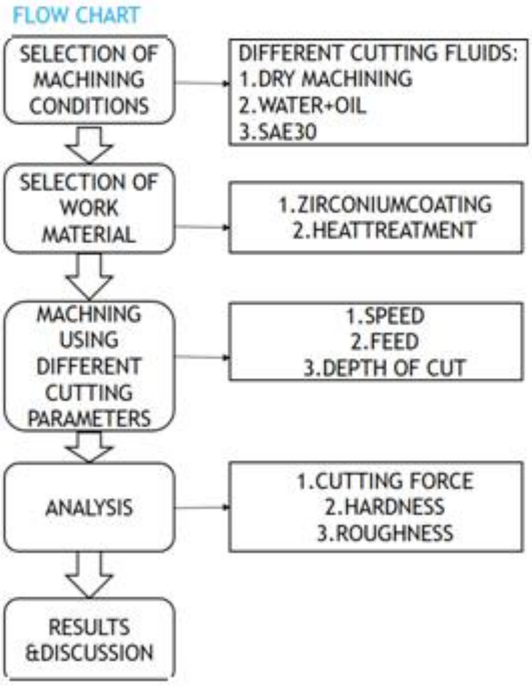


Figure 3: Experimental flowchart

2.6 Parameter Selection

In this experimentation speed, feed and depth of cut parameters are selected at their two levels each and employed for L4 experimentation (Table.2)

Table 2: Taguchi Sequence

S.NO.	SPEED	FEED	DEPTH OF CUT
1	52RPM	0.5MM/REV	1MM
2	52RPM	0.625MM/REV	0.5MM
3	490RPM	0.5MM/REV	0.5MM
4	490RPM	0.625MM/REV	1MM

2.7 Surface roughness

Surface roughness often shortened to roughness, is a component of surface texture. It is quantified by the deviations in the direction of the normal vector 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.(Fig.4)

Figure 4: Taylor Hobson surface roughness tester

2.8 Lathe Tool Dynamometer

A machine-tool dynamometer is a multi-component dynamometer that is used to measure forces during the use of the machine tool. Empirical calculations of these forces can be cross-checked and verified experimentally using these machine tool dynamometers. With advances in technology, machine-tool dynamometers are increasingly used for the accurate measurement of forces and for optimizing the machining process. These multi-component forces are measured as an individual component force in each coordinate, depending on the coordinate system used. The forces during machining are dependent on the depth of cut, feed rate, cutting speed, tool material, and geometry, the material of the workpiece and other factors such as the use of lubrication/cooling during machining.

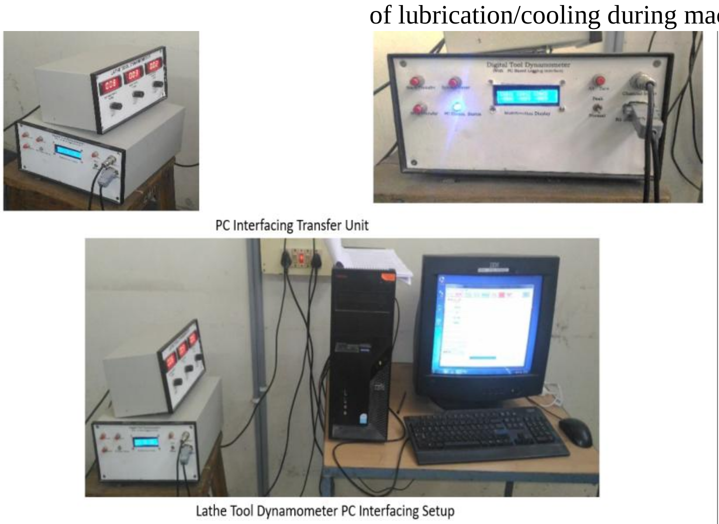


Figure 5: PC Interfacing setup

2.9 Hardness

It is defined as the resistance of a metal to plastic deformation against Indentation, scratching, abrasion of cutting. The hardness of a material by this Rockwell hardness test method is measured by the depth of Penetration of the indenter. The depth of Penetration is inversely proportional to the hardness. Both ball or diamond cone types of indenters are used in this test.

Figure 6: Rockwell Hardness Test

2.10 Coolant used

In this experimentation two different coolants namely water added oil solution and SAE 40 Hydralic oil are used for comparative Evaluation.

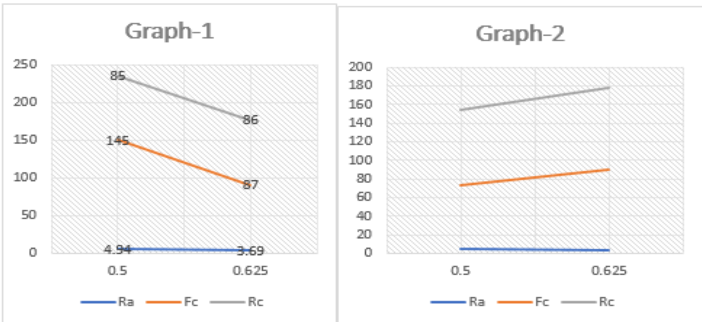
3. Result and Discussion

Sequening in the following Method Given By Taguchi The cutting forces of different rods are acquired in the form of graphs total **48 N0 of Graphs, Surface roughness, Hardness** are studied and analysed here:-

Calculation:

EXPT	SPEED (RPM)	FEED (MM/REV)	DEPTH OF CUT (MM)	SURFACE ROUGHNESS µ	CUTTING FORCE (KGF)	HARDNESS Rc
1	52	0.5	1	4.94	145	85
2	52	0.625	0.5	3.96	87	86
3	490	0.5	1	4.99	68	81.5
4	490	0.625	0.5	3.96	86	88.5

At Speed-52 At Speed-490



✓ With the increase of feed, R_a is reducing while the F_c showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed

Figure 7: Graphical Representaion of RC, FC, RA

3.1 Percentage of contribution by variance of surface Roughness

Table 1: Variation of contribution referring to surface roughness

SPECIMENS	PARAMETERS	DRY	OIL	SAE 30
MS ROD	SPEED	1.87	0.069	10.49
	FEED	97.20	53.451	1.725
	DEPTHOFCUT	0.902	46.48	87.77
ANNEALED MS ROD	SPEED	3.025	18	60.41
	FEED	44.45	32	39.58
	DEPTHOFCUT	52.52	50	0
ZIRCONIUM COATED MSROD	SPEED	65.33	9.09	36.81
	FEED	33.33	9.09	35.25
	DEPTHOFCUT	1.33	81.81	27.92
TITANIUM	SPEED	4.85	0.4	3.67
	FEED	73.9	12.7	88.32
	DEPTHOFCUT	21.164	87.03	8

3.2 Percentage of contribution by variance of Cutting Forces

Table 2: Variation of contribution referring to cutting forces

SPECIMENS	PARAMETERS	DRY	OIL	SAE 30
MS ROD	SPEED	45.20	38.23	6.03
	FEED	11.88	46.13	3.39
	DEPTHOFCUT	42.91	15.63	90.57
ANNEALESD MS ROD	SPEED	0.492	8.90	2.97
	FEED	47.50	91.03	5.707
	DEPTHOFCUT	52.003	0.066	91.315
ZIRCONIUM COATED MSROD	SPEED	41.22	75.78	32.15
	FEED	27.21	21.44	7.45
	DEPTHOFCUT	31.56	2.77	60.38
TITANIUM	SPEED	73.71	0.226	13.25
	FEED	13.14	0.0251	55.85
	DEPTHOFCUT	13.14	99.74	30.88

4. Conclusion

While machining of MS Rod Dry referring to feed, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed. While machining of MS Rod Dry referring to Depth of cut, With the increase of Doc Fc is also increasing while Rc and Ra are going in the reverse trend. Surface Roughness is affected mainly by the feed given during machining and contributes to an extent of 97.2% While speed is affected only 1.87%.The cutting force during machining is caused by speed and depth of cut in the range of 42 to 45% while the feed is affecting the cutting force to an extent of 11.88%. While machining of MS Rod oil as coolant referring to feed, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed. While machining of MS Rod oil as coolant referring to Depth of cut, With the increase of Doc Fc is also increasing while Rc and Ra are going in the reverse trend. Surface roughness is affected mainly by the feed and depth of cut given during the machining and contribution to an extent of 53.41% and 46.48% resp. while speed is affecting only up to 0.009%.The cutting force during machining is caused by speed and feed in the range of 38 to 46% while the depth of cut is affecting the cutting force to an extent of 15.63%.While machining of MS Rod SAE 40 as coolant referring to feed, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed. While machining of MS Rod SAE 40 as coolant referring to Depth of cut, With the increase of Doc Fc is also increasing while Rc and Ra are going in the reverse trend. Surface roughness is affected mainly by the depth of cut given during machining and contributes to an extent of 87.77% while speed is affecting only 10.49%.The cutting force during machining is caused by the depth of cut and is contributed up to 90.357% while speed and feed are in the range of 3 to 6%.While machining of Annealed MS Rod Dry referring to feed, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed. While machining of Annealed MS Rod Dry referring to Depth of cut, With the increase of Doc Fc is also increasing while Rc and Ra are going in the reverse trend. Surface roughness is affected mainly by the feed and depth of cut in the range of 44 to 52% while the speed is affecting the contribution up to 3%. The cutting force during machining is caused by feed and depth of cut in the range of 47 to 52% while the speed is affecting the cutting force to an extent of 0.492%. While machining of Annealed MS Rod oil as coolant referring to feed, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed. While machining of Annealed MS Rod oil as coolant referring to Depth of cut, With the increase of Doc Fc is also increasing while Rc and Ra are going in the reverse trend. Surface roughness is affected mainly by the depth of cut given during the machining and the contribution to an extent of 50% while the feed is affecting up to 32% and speed up to 18%. The cutting force during machining is mainly affected due to the feed and is contributed up to 91.03% while the speed is affecting the cutting force to an extent of 8.90%. While machining of Annealed MS Rod SAE 40 as coolant referring to feed, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed. While machining of Annealed MS Rod SAE 40 as coolant referring to Depth of cut, With the increase of Doc Fc is also increasing while Rc and Ra are going in the reverse trend. Surface roughness is affected by the speed and feed during the machining and the contribution is in the range of 40 to 60%. The cutting force during the machining is mainly affected by the depth of cut where the contribution is 91.35% while the speed and feed are affecting on the cutting forces in the range of 2 to 5%.While machining of zirconium MS Rod Dry referring to feed, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed. While machining of zirconium MS Rod Dry referring to Depth of cut, With the increase of Doc Fc is also increasing while Rc and Ra are going in the reverse trend. Surface roughness is affected mainly by the speed given during machining and the contributes to an extent of 65.33% while the feed and depth of cut are affecting 33.33% and 1.33% resp. The cutting force during machining is caused by speed and depth of cut in the range 361 to 41% while the feed is affecting on the cutting force to an extent of 27.21%.While machining of zirconium MS Rod oil as coolant referring to Feed, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed. While machining of zirconium MS Rod oil as coolant referring to Depth of cut, With the increase of Doc Fc is also increasing while Rc and Ra are going in the reverse trend. Surface roughness is affected mainly by the depth of cut given during machining and contributes to an extent of 81.81% while speed and feed are affecting only 9.09%.The cutting force during machining is caused mainly due to speed and contributes to an extent of 75.78% while feed and depth of cut contribute up to 21.44% and 2.77% resp .While machining of zirconium MS Rod SAE 40 as coolant referring to Feed, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed. While machining of zirconium MS Rod SAE 40 as coolant referring to Depth of cut, With the increase of Doc Fc is also increasing while Rc and Ra are going in the reverse trend. Surface roughness is affected mainly by the speed given during the machining and contributes to an extent of 36.81% while feed and depth of cut are affecting up to 3.25% and 27.62% resp. The cutting force during machining is caused by speed and depth of cut in the range 32 to 60% while the feed is affecting the cutting force to an extent of 7.45%.While machining of Titanium Rod Dry referring to feed, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed. While machining of Titanium Rod Dry referring to Depth of cut, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed. Surface roughness is affected mainly by the feed given during machining and contributes to an extent of 73.9% while speed is affecting only 40.85%, depth of cut contributes about 21.64%. Cutting force is mainly affected by the speed given during the machining and contributes to 73.71%, while feed and depth of cut affect only 13.14% of each. While machining of Titanium Rod oil as coolant referring to Feed, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed.While machining of Titanium Rod oil as coolant referring to Depth of cut, With the increase of Doc Fc is also increasing while Rc and Ra are going in the reverse trend. Surface roughness is affected mainly by the depth of cut given during machining and contributes to an extent of 87% while the feed is affecting only up to 12.7%.The cutting force is mainly affected by the depth of cut during machining which contributes to an extent of 99.74% while speed and feed are almost negligible .While machining of Titanium Rod SAE 40 as coolant referring to Feed, With the increase of feed, Ra is reducing while the Fc showed a reverse trend. The Hardness of the surface is also increasing with the increase in feed.While machining of Titanium Rod SAE 40 as coolant referring to Depth of cut, With the increase of Doc Fc is also increasing while Rc and Ra are going in the reverse trend.Surface roughness is affected mainly by the feed given during machining and contributes to an extent of 88.32% while speed and depth of cut are affecting only up to 3.67% and 8% resp.The cutting force during machining is caused by feed and depth of cut in the range of 30 to 55% while the seed is affecting the cutting force to an extent of 13.25%.

By observing all these we came to know that the parameter

Depth of Cut >Speed>Feed
has high influence during Machining Of Titanium and Mildsteel

5. Future Enhancement

The machining of the materials with multipoint cutting tools employing various mineral oils as cutting fluids can be taken up to measure the responses like Cutting forces, Surface Roughness, Hardness, etc.

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