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Optimizing Machining Parameters Using Carbide Insert for Rough Mild Steel Surfaces

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Abstract

In present day world importance of manufacturing plays a vital role in a industrialized nation. Metal cutting process involved in removing material from the workpiece. In this operation are classified based on position of cutting edge of the cutting tool. It can be either orthogonal else oblique cutting. Another important parameter is surface roughness and used as the measure of quality and productivity of machine tool. Serviceability of machine and tool significantly affected by the surface characteristics. In this work,

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various input parameters such as cutting speed and feed rate etc. are used while turning of mild steel with carbide tool. Optimum surface roughness identified using Taguchi method during turning. ANOVA is used to analysis cutting parameters. It was observed that more and more rough surfaces obtained with feed rate increment whereas less rough surface were obtained as cutting speed increases. Surface roughness highly affected by the cutting speed.

Keywords: ANOVA, Taguchi, Metal Cutting, Surface Roughness

INTRODUCTION

It is very difficult to understand tool technology and manufacturing process as it involves the advancement in technology as well as the computerized innovations, which are growing at a very fast rate. In manufacturing, it is very important to select the material so that it should be reliable enough to withstand the design of the product. Quality of the work material influenced by various factors such as cutting conditions, machining process, tool geometry, chip formation, tool material, tool wear and vibrations. Common operating parameters used in the turning process includes cutting speed, feed rate, Depth of cut, and tool noise radius. Range of cutting speed shown in figure 1 as required in workpiece materials.

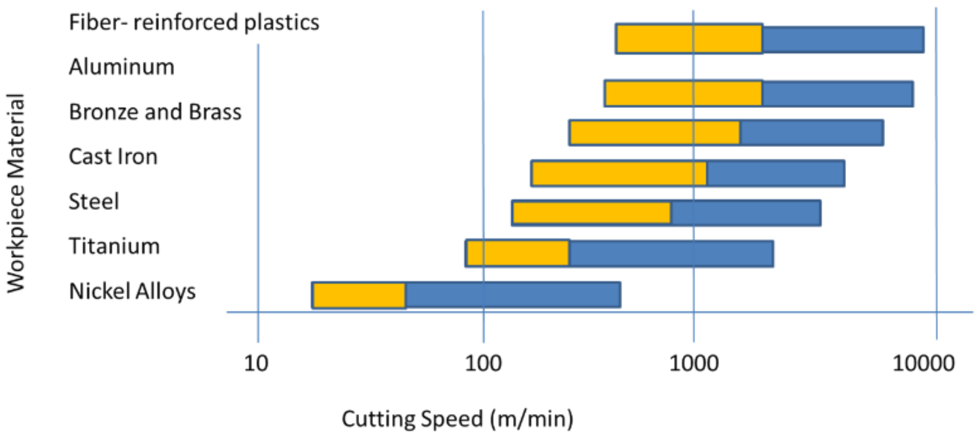

Figure 1. Various materials required range of cutting speed

Ability and properties of carbide tool results in common use of this tool in machining of workpiece material at high temperature and speed.

I.Yu. Konyashin (1995) investigated that the PVD-CVD coated carbide has longer tool life in turning as compared to coated inserts. Jindal et al. (1999) studied that

TiAlN coated tools gave the better performance and higher resistance at higher speeds. T. Kagnaya et al. (2011) in explained that the cutting speed increases, the cutting tool temperature also increases. Ajay Mishra et al. (2012) examine AISI 1045 Steel machined with tool Tungsten carbide tool using Taguchi method and ANOVA. They found that tool flank wear width is reduced by 23.85% when working at selected parameters. S.A. Iqbal et al. (2009) examined the tool chip contact length and found decreasing contact length trend with increasing cutting speed S.A. Iqbal et al. (2007) in his review paper, explained the cutting speed value with the help of finite element model. In this uncoated cemented carbide tool used with various parameters like depth of cut and feed. Sahoo P. (2011) examine surface roughness of AISI 1045 Mild Steel using RSA and GA. Effect of process parameters on surface roughness analyzed using RSM. To obtain better surface quality, Genetic Algorithm was used to find machining parameters**.** Jaharah A.G. et al. (2008) simulated the turning operation, using finite element method. Results reveal that increasing cutting speed while turning, effective stress decrease and cutting temperature also influence on increase cutting speed. Q.Meng et al. (2000) examined the tool life and evaluated optimum cutting conditions for economic criteria such as maximum production rate at minimum cost. Upinder Kumar Yadav et al. (2012) observed that AISI 1045 Steel, surface roughness basically affected by feed rate and cutting speed. A. Das et al. (2015) studied about the turning of alloy steel using Taguchi approach with uncoated carbide tool in dry cutting environment. Surface roughness of the workpiece influenced by feed. Anand S. Shivade et al. (2014) examined the carbide tool and the surface roughness using Taguchi parameter design and ANOVA. Alagarsamy.S.V. et al. (2016) studied about the Al Alloy 7075 optimizing metal removal rate with carbide tool using input parameters cutting speed, depth of cut, feed. Surface roughness mostly affected by cutting speed.

METHODOLOGY AND MATERIAL USED

Traditional approach, change only one variable at a time during experimentation and others are kept constant. Workpiece material used for experimentation was mild steel bars having composition as shown in figure 2. This material has a very large application area in general, such as gears, shafts, and bolts etc. And the properties of the carbide tool used are listed in figure 3. This cemented carbide tool has a good resistance to wear, high hardness and low friction coefficient. By coating the life of the tool improves.

Carbon %	Manganese %	Phosphorus %	Sulphur %	Silicon %
0.16 to 0.18	0.70 to 0.90	0.04 Max.	0.04 Max	0.40 Max.

Figure 2. Chemical composition of Mild Steel

Coefficient of thermal expansion (µm/m°C)	4.7
Density (g/cm³)	15
Poisson's Ratio	0.2
Specific heat (J/kg/°C)	203
Thermal conductivity (W/m°C)	46
Young's Modulus (GPa)	800

Figure 3. Properties of Carbide Tool

By arranging the material for the workpiece as well as tool, preparation of the samples from the bar was done. Turning operation was performed based on the number of test runs to be conducted. After that as per the designed matrix of experiments, they are performed and analysis done after experimentation. Table 1-3 shows various process parameters, levels used for the orthogonal array and matrix of experiments.

Table 1. Process parameters with codes and units

S. No.	Symbol	Process Parameter	Unit
1	A	Cutting Speed	m/min
2	B	Feed Rate	mm/rev
3	C	Depth of Cut	min

Table 2. Parameters, codes, and levels used for the orthogonal array

Parameter	Code	Level1	Level2	Level3
Control Factors				
Cutting Speed (m/min)	A	90	180	270
Feed Rate (mm/rev)	B	0.1	0.2	0.3
Depth of Cut (mm)	C	0.04	0.08	0.12

Table 3. The Basic Taguchi L_9 Orthogonal Array

Run	Control Factors and Levels		
	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

RESULT AND DISCUSSION

After conducting experiments results were arranged in Table 4 showing surface roughness obtained during turning of mild steel. Programming of various input parameters was done in the CNC machine.

Table 4. Results of Surface Roughness for the designed experiments

S. No.	Cutting Speed (m/min)	Feed Rate (mm/rev)	Depth of Cut (mm)	Surface Roughness (micron)
1	90	0.1	0.04	4.16
2	90	0.2	0.08	4.52
3	90	0.3	0.12	5.25
4	180	0.1	0.08	3.65
5	180	0.2	0.12	3.86
6	180	0.3	0.04	3.76
7	270	0.1	0.12	3.19
8	270	0.2	0.04	3.45
9	270	0.3	0.08	3.63

It was observed from the results that considered factors significantly affect the surface roughness during turning. From the analysis of variance (ANOVA) concluded that cutting speed is significant parameter. Feed rate influence is more significant as compared to depth of cut on the surface roughness during turning of mild steel. Response table gives the means for each factor considered for process parameter.

Response Table for Means

Level	A	B	C
1	4.643	3.667	3.790
2	3.757	3.943	3.933
3	3.423	4.213	4.100
Delta	1.220	0.547	0.310
Rank	1	2	3

Response Table for Signal to Noise Ratios
Smaller is better

Level	A	B	C
1	-13.30	-11.23	-11.55
2	-11.49	-11.86	-11.85
3	-10.68	-12.37	-12.07
Delta	2.62	1.13	0.52
Rank	1	2	3

To obtain good surface roughness, the mean and variance should be as small as possible. This graph reveal the optimal level for the ideal cutting parameter. The cutting speed have a strong influence on surface roughness and S/N ratio. Surface roughness has very less effect of feed rate and depth of cut. The optimal set of parameters can be determined from surface roughness and S/N ratio graphs. For surface roughness, the lowest magnitude values are chosen while for S/N ratio the highest magnitude values are chosen. Conformation test concludes the optimized levels for all three parameters. After analysis, it was observed that, for carbide insert, the optimum cutting speed is at level 3 (270 m/min), the optimum feed rate level 1 (0.1 mm/rev) and the optimum depth of cut level 1 (0.04 mm).

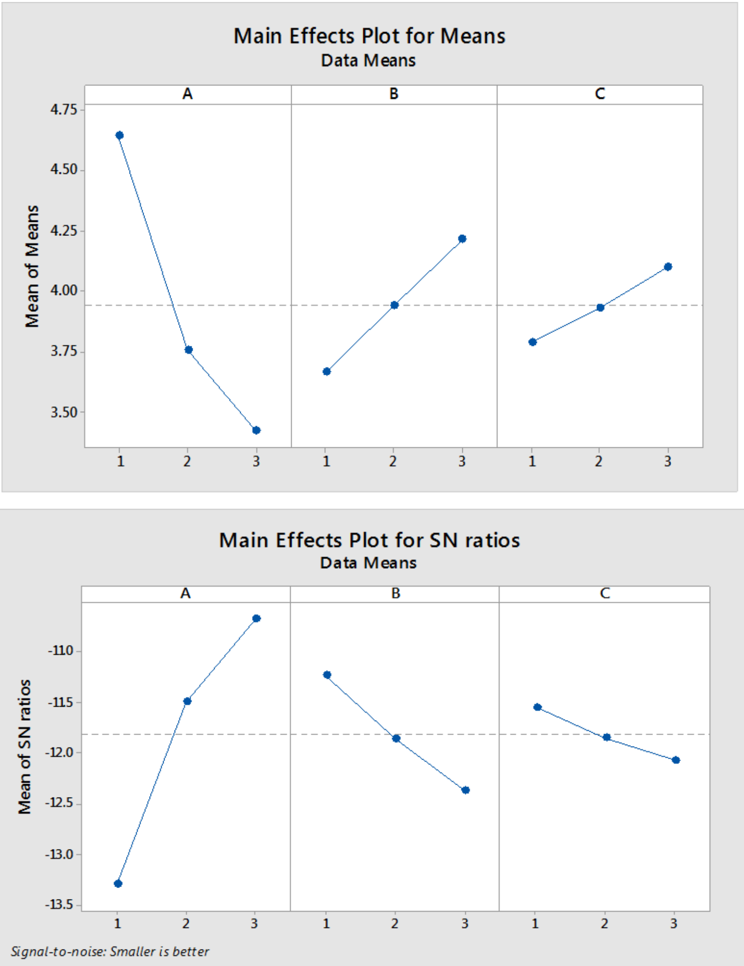

Figure 4. Graphs showing plot for means and S/N ratios

A mathematical software package (MINITAB 17) was used for the computation of the regression analysis.

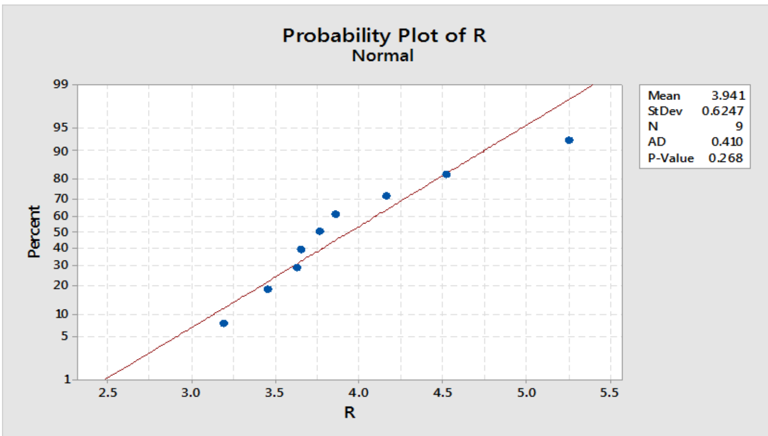

Figure 5. Normal probabaility plot for Surface roughness

Surface roughness predicted at the selected levels for significant parameters during turning mild steel with carbide insert are shown in table 5.

Table 5. Optimum Levels for Carbide Inserts

	Cutting Speed	Feed Rate	Depth of Cut
Optimum level for rough surface of mild steel	270	0.1	0.04

CONCLUSION

With the help of Taguchi techniques optimum surface roughness has been identified during turning of mild steel. Parameters considered were cutting speed, depth of cut and feed rate. Analysis of cutting parameters carried out using ANOVA. Roughness of the surface increased with the increment in feed rate, whereas when cutting speed was increased it decreases. Cutting speed affects heavily the surface roughness followed by depth of cut and feed. The use of carbide insert results in optimum parameters for rough surfaces are given in the table 5, such as cutting speed of 270 m/min, feed rate of 0.1 mm/rev and depth of cut of 0.04 mm.

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