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Surface Roughness and Material Removal Rate Optimization of Uncoated Carbide Inserts in Dry Hard Turning of EN-31 Steel

KEYWORDS: Uncoated, Cemented Carbide, Dry Turning, Material Removal Rate, Surface Roughness.

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ABSTRACT *Cutting tools, are very much useful for improving their performance in high-speed machining such as Dry turning. However problem of quality and economical production occurs for developing cutting tools to use for high-speed machining of very hard materials. In the present study, experiments of dry turning of EN31 Steel were conducted to evaluate the performance of uncoated tool materials for the cutting of this material. A L9 orthogonal Array and ANOVA are applied to study the performance of machining parameters. Tool material to be used is cemented carbide. Optimum parameters has been also found for improved Surface roughness and high material removal rate during the machining of EN31.*

Introduction

The challenge of the mass production firms is focused mainly on the achievement of high quality in terms of work piece dimensional accuracy, high production rates and high material removal rate. Cutting tool is one of the main important factor on which all this depends and for this a lot of efforts has been made by the manufacturing industries to increase the quality of the product and decrease the cost of machining. A number of cutting tools has been developed over the past few ages. In today's world cemented carbide tool is widely used for the hard and dry turning.These tools were introduced in the 1930s. Because of their high hot hardness and wear resistance, these are the most important tool materials. The main disadvantage of cemented carbides is having low toughness. These tools are produced by powder metallurgy technique, sintering grains of tungsten carbide (WC) in cobalt (Co) matrix (which provides toughness). Other carbides which are used in the mixture are titanium carbide (TiC) and/or tantalum carbide (TaC) in addition to WC.

Experimental details

Work piece Materials, cutting tools and CNC machine

The work materials used for the research work were En31 steel round bar. It contains C 0.90-1.20%, Mn 0.25-0.75%, Si 0.15-0.35%, Cr 1.20-1.60%, S 0.025%, P-0.03%. The dimensions of the EN31 Steel procured are 40 mm in diameter and 60 mm in length and these were machined under dry condition. The CNC machine used for the machining was HMT STALLION 100HS.

The Cutting tools used for the experiment were commercially available and the geometry of uncoated carbide insert is CNMG 120408 EN-M50 CTP125.

Surface Roughness (Ra) was measured using a Mitutoyo Surface Roughness Tester and material removal rate was measured by measuring the weight work piece after each cut.

The important process parameters were cutting speed, depth of cut and feed rate.

Table 1:Machining Parameters used in the experiment

Factors	Level		
	1	2	3
Spindle Speed (rpm)	1500	1750	2000
Feed Rate (mm/rev)	0.10	0.15	0.20
Depth of Cut (mm)	0.5	1.0	1.5

The graphs and tables were produced by using design of experiments and analysis has been performed by using Minitab software 16.

The Taguchi Method and DOE for the Experimentation

The Taguchi method of designing the experiments provides an easy and simple approach to the optimization of parameters and for performance quality and cost. Taguchi approach has been used for obtaining the design of experiments. In manufacturing industries it is an excellent approach for quality control.

In this method results are studied to achieve any of the following objectives.

- To estimate the contribution of individual factors.
- To estimate the response under the optimum conditions.
- To establish the best of the optimum condition for the process or a product.

Depending upon the type of responses, these S/N ratios are used:

- Higher the better

MSDHB=Mean Square Deviation for higher the better re-

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sponse

- Lower the better

MSDHB=Mean Square Deviation for lower the better response

Results and Analysis
Surface Roughness

Sr. No.	Spindle Speed (rpm)	Feed Rate (mm/rev)	Depth of Cut (mm)	R_a (µm) (Uncoated)
1.	1500	0.10	0.5	0.527
2.	1500	0.15	1.0	1.198
3.	1500	0.20	1.5	1.622
4.	1750	0.10	1.0	1.144
5.	1750	0.15	1.5	1.142
6.	1750	0.20	0.5	0.933
7.	2000	0.10	1.5	1.442
8.	2000	0.15	0.5	1.559
9.	2000	0.20	1.0	1.550

Table 2: Experimental data for Surface Roughness

With the Taguchi analysis following data has been obtained:

Table 3: Response Table for S/N Ratios (Smaller is better) for UC

Level	Spindle Speed (rpm)	Feed Rate (mm/rev)	Depth of Cut (mm)
1.	-0.06879	0.40532	0.76974
2.	-0.57316	-2.19313	-2.18143
3.	-3.61429	-2.46843	-2.84455
Delta	3.54550	2.87375	3.61429
Rank	2	3	1

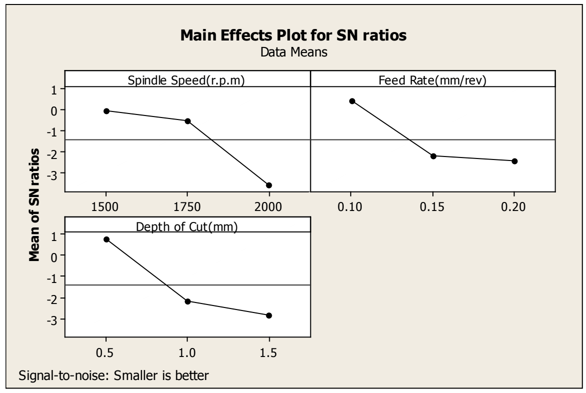
Table 4: Analysis of Variance for Ra (µm) (Uncoated), using Adjusted SS for Tests

Source	DF	SEQ SS	Adj. SS	Adj. MS	F	P
Spindle Speed (rpm)	2	0.3600	0.3600	0.1800	1.69	0.371
Feed rate (mm/rev)	2	0.1827	0.1827	0.0913	0.86	0.538
Depth of Cut (mm)	2	0.2522	0.2522	0.1261	1.19	0.457
Error	2	0.2127	0.2127	0.1063		
Total	8	1.0076				

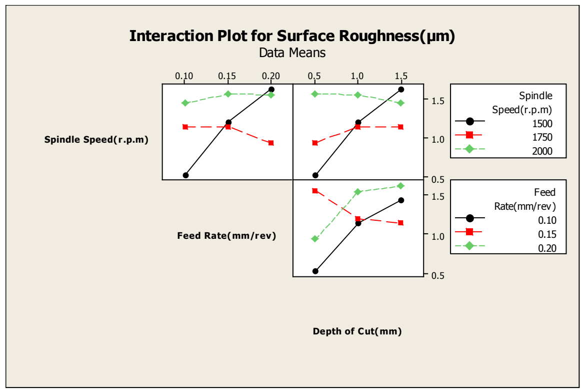
S = 0.326093 R-Sq = 78.89% R-Sq (adj) = 15.57%

Interaction plots show the graphical representation of spindle speed, feed rate and depth of cut versus surface roughness at different parameters. From Table 4.2, it is evident that depth of cuthave a significant effect on the surface roughness. It was seen in graphs that the surface roughness for inserts tool is decreased with the increase in spindle speed.Optimum parameters for minimum surface roughness for uncoated inserts are Spindle speed 1500 rpm, feed rate 0.10 mm/rev and depth of cut 0.5mm.

Graph 1: Main Effects Plot for SN ratios for R_a (UC)



Graph 2: Interaction Plot for SR (UC)



It is evident from the above analysis that the surface roughness varies proportionally to the feed rate and depth of cut and inversely to the spindle speed. The optimum parameters for surface roughness were obtained.

Material Removal Rate (MRR)
Table 4: Experimental Data for Material Removal Rate

Sr. No.	Spindle Speed (rpm)	Feed Rate (mm/rev)	Depth of Cut (mm)	MRR (g/sec) (Uncoated)
1.	1500	0.10	0.5	0.84
2.	1500	0.15	1.0	1.80
3.	1500	0.20	1.5	2.33
4.	1750	0.10	1.0	1.14
5.	1750	0.15	1.5	2.67
6.	1750	0.20	0.5	1.20
7.	2000	0.10	1.5	2.60
8.	2000	0.15	0.5	1.50
9.	2000	0.20	1.0	2.50

The effect of machining parameters on the material removal rate values is shown in the below graph for S/N ratio. MRR is increasing with increase in spindle speed. So the optimum spindle speed 2000 RPM. MRR is proportional to the feed rate. So the optimum feed rate is 0.15 mm/rev. MRR is increasing with increase in depth of cut. So the optimum depth of cut is 1.5 mm. It is evident that depth of cut and spindle speed have maximum effect over the material removal rate.

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Table 5: Response Table for S/N Ratios (Larger is better) for UC

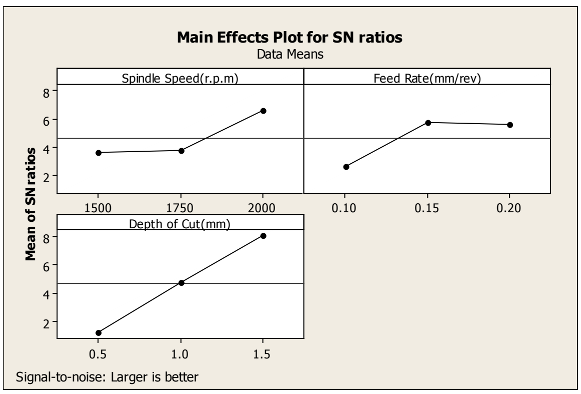
Level	Spindle Speed (rpm)	Feed Rate (mm/rev)	Depth of Cut (mm)
1.	3.646	2.641	1.197
2.	3.751	5.719	4.734
3.	6.593	5.630	8.059
Delta	2.947	3.078	6.862
Rank	3	2	1

Table 6:Analysis of Variance for MRR (g/sec) (UC), using Adjusted SS for Tests

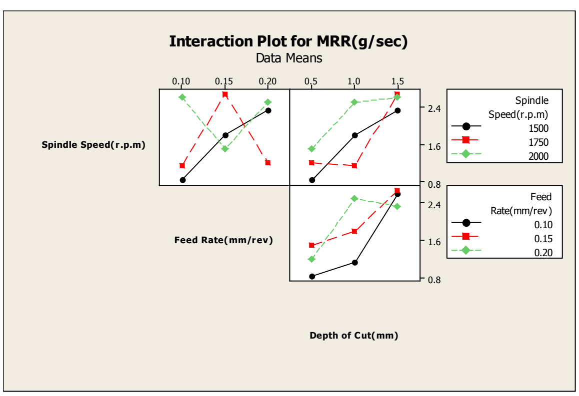
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Spindle Speed (rpm)	2	0.57629	0.57629	0.28814	3.15	0.241
Feed rate (mm/rev)	2	0.44869	0.44869	0.22434	2.45	0.290
Depth of Cut (mm)	2	2.75102	2.75102	1.37551	15.04	0.062
Error	2	0.18296	0.18296	0.09148		
Total	2	3.95896				

S = 0.302453 R-Sq = 95.38% R-Sq(adj) = 81.51%

Graph 3: Main Effects Plot for SN ratios for MRR (UC)



Graph 4: Interaction Plot for MRR (UC)



Conclusions

The following conclusions, based on the experimental results presented and analyzed, are drawn on the effect of spindle speed, feed rate and depth of cut on the performance of uncoated carbide tools when turning EN31 Steel:

- Optimization of the different cutting parameters based on the experimentation.
- Optimum parameters for minimum surface roughness for uncoated inserts are Spindle speed 1500 rpm, feed rate 0.10 mm/rev and depth of cut 0.5mm.
- MRR is increasing with increase in spindle speed. So the optimum spindle speed is 2000 RPM. MRR is proportional to the feed rate. So the optimum feed rate is 0.15 mm/rev. MRR is increasing with increase in depth of cut. So the optimum depth of cut is 1.5 mm.

REFERENCE • Hari Singh & Pardeep Kumar, "Tool wear optimization in turning operation by Taguchi method", Indian Journal of Engineering & Material Science, vol , pp. 19-24, 2004. | • Farhad Kolahan 1, Mohsen Manoochehri, "Application of taguchi method and ANOVA Analysis for simultaneous optimization of machining parameters and tool geometry in turning", World Academy of science, Engg. And Tech., pp. 48-58, 2011. | • Ahmet Hascalik & Ulas Caydas, " Optimization of turning parameters for surface roughness and tool life based on taguchi method", International Journal advanced manufacturing technology, pp. 896-903, 2008. |