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Surface Roughness Optimization of Multilayer Coated Ceramic Inserts Under Varying Cutting Conditions of EN-353 Steel

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Abstract: Hard coatings and cutting fluids are healthy acknowledged to enhance the performance of cutting tools during the various machining operations, such as machining of MMC and high-speed machining etc. Inappropriately, the growth of cutting tool for high-speed machining of hard and materials which are quite difficult for cutting has continue problem for excellence and budget of production. The present work studies the performance of multilayer coated ceramic inserts or tools under the varying cutting conditions of EN-353 Steel. The present work studies the performance of multilayer coated ceramic and carbide inserts or tools under the varying cutting conditions of EN- 353 Steel. A comparison between the performance of all the coated inserts has been made using cutting parameters (speed, feed and doc) by using the Surface roughness A L9 orthogonal Array and ANOVA are applied to study the performance of machining parameters. Optimum parameters have been also found for improved Surface roughness during the machining of EN353.

Keywords: Multilayer coated, Ceramic Inserts Cutting conditions, Surface Roughness.

I. INTRODUCTION

In the modern civilization, to meet the increasing demand, overall production and productivity the major force on the industry is to developing a new and good quality tool material. The purpose of developing a new cutting tool material has following advantages like lead time reduces, manufacturing cost has been reduced, difficult and hard materials are easily machined, improve surface roughness and material removal rates (MRR) increases. In various types of machining process, the important parameter which needs to be control or reduce are cutting temperature and cutting force because these parameters directly effects the life of tool thus effected the tool cost. Metal working fluids are essential coolants and lubricants used in material removal and deformation processes to improve manufacturing productivity by increasing process throughout and tool life [1]. The process of using cutting fluids during the machining process has influential effect in reduction of temperature and lubrication of both the tool and the work piece, which ultimately tends to enhance the life of tool. Where as in case of machining processes where high production takes place, the high cutting region temperature causes failure of the cutting tools and dimensional deviation and subsequently the surface integrity damages of the product [2]. Conventional cutting fluids flop to transfuse the tool-chip interface and consequently fail to strip the heat generation in the cutting zone [3]. Also, cutting fluids tends to increase the overall machining cost. A no. of researchers also reported the fact that machining costs are quite high due to the use of cutting fluids during the machining processes which have considerably of higher cost than that of the cutting tools used for the machining [4]. An estimate of the total cost has been made by some researchers which suggests that almost 16% of the total manufacturing costs are consist of cutting fluid costs and when it comes to the cut or machine the materials which are very hard to machine and they reach up to 20-30 percent [5,6]. The changes in laws against environmental pollution, together with the increased awareness regarding the environmental impact of industrial activities, are obliging companies to upsurge the maintainable performance of different types of products and processes. Many chemical additives are pollutant for the environment, as well as hazardous substances for workers' health. [7, 8]. In addition, the costs which are related to the cutting fluid supply and their dumping are not negligible when they are compared with the overall production costs. Therefore, policies are converging to the decline of various cutting fluid use are indeed required [9]. This type of problems related to the cutting fluids can be overcome by the use of the cryogenic cooling or by the use of cryogenic coolants. The cryogenic treatment is compared with that of the heat treatment processes. The main objective of using cryogenic coolants during machining processes is to improve wear resistance properties of the tool and to enhance the dimensional stability. On the other hand, cutting temperatures generated during the process are also reduced and it leads to stronger and harder workpiece material, enhancing the cutting force. Experiments also show that use cryogenics as coolant tends to enhance the tool life significantly compared to the dry cutting. It is also found out that cryogenic machining lessens the surface roughness and the tensile residual stress of the machined surfaces [10, 11, 12]..

II. EXPERIMENTAL DETAILS

Work piece Materials, cutting tools and CNC machine

The work materials used for the research work were EN353 steel round bar. It contains C 0.171%, Mn 0.56%, Si 0.3%, Cr-0.953%, Mo 0.16%, Ni 0.989%. The dimensions of the EN353 Steel procured are 40 mm in diameter and 60 mm in length and these were machined under varying cutting conditions Cutting tools materials used for the experiment were Multilayer coated Ceramic inserts. The geometry of coated ceramic inserts was TNMG 160404 FX105. These different inserts were coated with TiN and TiAlN and then these are used for machining the material. The CNC machine used for the machining was HMT STALLION 100HS under the dry and wet conditions. The controller of the CNC turning Centre was Siemens. The Spindle Speed used was 1000, 1500 and 2000 rpm having the feed rate of 0.20, 0.30 and 0.40 mm/rev and depth of cut was 0.8, 1.3 and 1.8 mm respectively. The cutting conditions tested are listed in Table 1. The Surface roughness of the surface was measured by using the Mitutoyo Roughness Testing Machine. L9 taguchi orthogonal array has been used and the graphs and tables were produced by using doe and analysis has been done by the use of Minitab software 16.The important process parameters were cutting speed, depth of cut and feed rate.

Table 1: Machining Parameters used in the experiment

S.No.	**Factors**		
	1	2	3
Speed(r.p.m)	1000	1500	2000
Feed Rate(mm/rev)	0.8	1.3	1.8
Doc (mm)	0.20	0.30	0.40

III. 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 [8]**.**

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 most favorable conditions.
- To establish the best of the optimum condition for the process or a product [9].

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

- Higher the better

MSDHB=Mean Square Deviation for superior the better response

- Lower the better

MSDHB=Mean Square Deviation for lower the better response [10].

IV. RESULTS AND ANALYSIS

4.1 Surface Roughness.

The CNC machine used for the machining was HMT STALLION 100HS under the dry and wet conditions. The controller of the CNC turning Centre was Siemens. EN-24 steel is used as a specimen for conducting the different tests. The roughness of the surface was measured by Mitutoyo Roughness Testing Machine. It was measured by using the surface tester roughness in Ra (µm). Measurements are usually made along a straight line, running at right angle on the surface.

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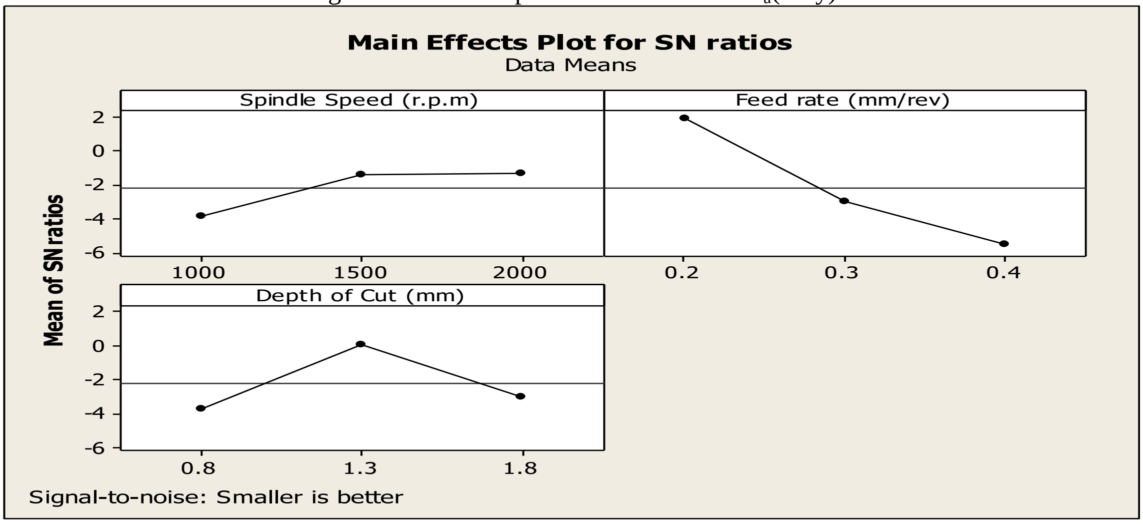
Table 2: Experimental data for Surface Roughness

S.NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/rev)	DEPTH OF CUT (mm)	(CERMETI NSERTS) Ra (µm)	(CARBIDE INSERTS) Ra (µm)
1	1000	0.20	0.8	0.96	0.83
2	1000	0.30	1.3	1.48	1.28
3	1000	0.40	1.8	2.67	1.82
4	1500	0.20	1.3	0.60	0.65
5	1500	0.30	1.8	1.17	1.23
6	1500	0.40	0.8	2.31	1.77
7	2000	0.20	1.8	0.90	0.47
8	2000	0.30	0.8	1.60	1.20
9	2000	0.40	1.3	1.09	2.30

4.1.1Effect of Speed, Feed and DOC on Roughness for Coated Ceramic inserts during dry turning

The effects of various types of input parameters on the surface roughness are given below in fig. 1 for SN ratios

Fig 1. Main effects plot of SN Ratios for R_a(Dry)



Optimum parameters for minimum surface roughness for multilayer coated ceramic inserts during dry turning are speed 2000 rpm, doc 1.3 mm and feed 0.20 mm/rev.
From Table 3, it has been found that feed is the factor which affects the roughness more effectively than the other factors.

Table 3: Value of Response for SN Ratios for Ceramic Inserts (Dry Turning)

Level	Spindle Speed(rpm)	Feed Rate(mm/rev)	Depth of Cut(mm)
1.	-3.86029	1.90223	-3.66669
2.	-1.39966	-2.95045	0.09440
3.	-1.30526	-5.51700	-2.99293
Delta	2.55503	7.41923	3.76109
Rank	3	1	2

4.1.2 Effect of Speed, Feed and DOC on Roughness for Coated Ceramic inserts (Wet Turning)

The effect of various factors on the surface roughness values is given in fig. 2 for SN ratios. Optimum parameters for minimum surface roughness during wet turning are speed 2000 rpm,doc 1.8 mm. and feed 0.20 mm/rev..

Fig 2. Main Effects Plot of SN Ratios for Ra
(Wet Turning)

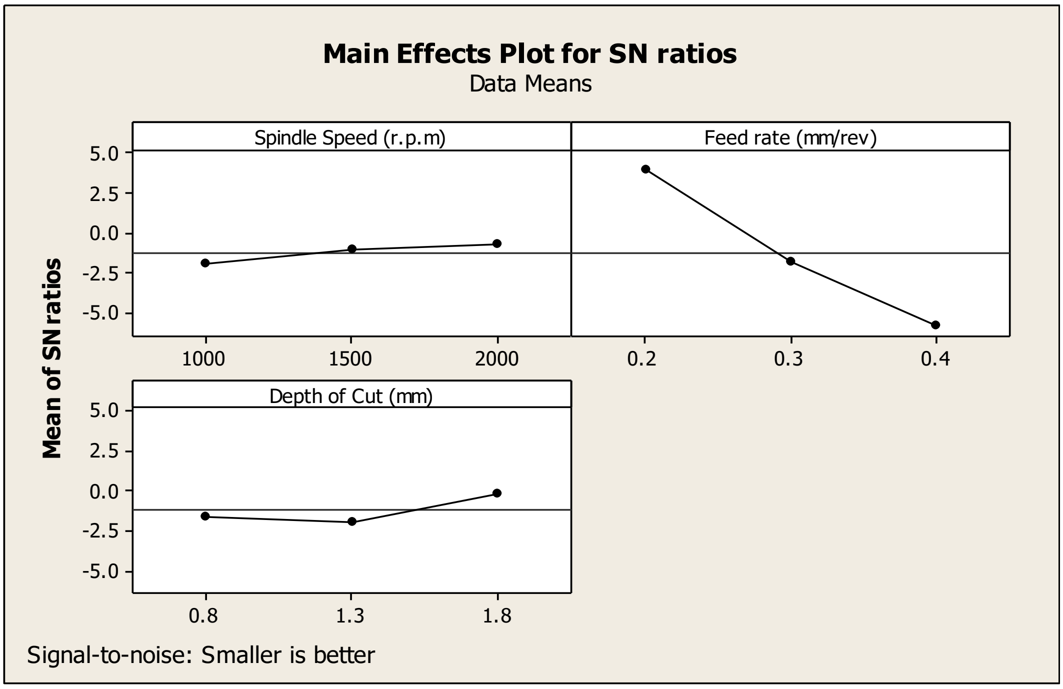


Table 4: Value of Response for SN Ratios for Ceramic Inserts (Wet Turning)

Level	Spindle Speed(rpm)	Feed Rate(mm/rev)	Depth of Cut(mm)
1.	-1.9091	3.9727	-1.6416
2.	-1.0053	-1.8420	-1.8790
3.	-0.7534	-5.7985	-0.1472
Delta	1.1557	9.7712	1.7318
Rank	3	1	2

From Table 4, it has been found that feed is the factor which affects the roughness more effectively than the other factors.

V. CONCLUSION

From the analysis of the results in the turning process using the conceptual (S/N) ratio approach, ANOVA and Taguchi optimization method, following conclusions has been made from the present study. The following conclusions, based on the experimental results presented and analyzed, are drawn on the effect of spindle speed, feedrate and depth of cut on the performance of ceramic tools when turning EN353 Steel under varying cutting conditions. Optimization of the different cutting parameters based on the experimentation. Feed and doc are the substantial aspects which distresses the Ra. Optimum parameters for minimum surface roughness are Speed 2000 rpm, doc 1.8 mm and feed 0.20 mm/rev in case of Multilayer Coated Ceramic inserts during Wet Turning.

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