OPTIMIZATION MACHINING PARAMETERS IN A TURNING OPERATION OF STEELS TO MINIMIZE SURFACE ROUGHNESS AND TEMPERATURE

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Abstract - ***The present work concerned an experimental study of turning on Steel grade of EN8, Mild steel and OHNS by a Tungsten and cemented coated carbide insert tool. The primary objective of the ensuing study was to use the Taguchi Methodology in order to determine the effect of machining parameters viz. cutting speed, feed, and depth of cut, On the Temperature, Hardness and Surface roughness of the machined material. The objective was to find the optimum machining parameters so as to minimize the surface roughness and Temperature for the work materials in the chosen domain of the experiment. Temperature was measured using a digital thermometer; Surface Roughness was measured using a Mitutoyo surface tester and hardness with the help of a Brinell hardness tester. The data was compiled into MINITAB 18 for analysis. Taguchi and Analysis of Variance (ANOVA) were used to investigate the significance of these parameters on the response variables with the machining parameters as the independent variables, with the help of a MINITAB. Results showed that cutting speed is the most significant factor affecting the surface roughness and hardness, closely followed by feed and depth of cut, while the only significant factor affects the temperature was found to be the depth of cut.***

Key Words: Surface roughness, ANOVA and Taguchi method.

1. INTRODUCTION

The turning operation is a basic metal machining operation that is used widely in industries dealing with metal cutting [1]. The selection of machining parameters for a turning operation is a very important task in order to accomplish high performance [2]. By high performance, we mean good machinability, better surface finish, lesser rate of tool wear, hardness, lower temperature, higher material removal rate, faster rate of production etc. The surface finish of a product is usually measured in terms of a parameter known as surface roughness. It is considered as an index of product quality [3]. Better surface finish can bring about improved strength properties such as resistance to corrosion, resistance to temperature, and higher fatigue life of the machined surface [4, 5].

In addition to strength properties, surface finish can affect the behaviour of machined parts too, as in friction, light reflective properties, heat transmission, ability of distributing and holding a lubricant etc. [6, 7]. Surface finish also affects production costs [3]. For the aforesaid reasons, the minimization of the surface roughness is essential which in turn can be achieved by optimizing some of the cutting parameters.

2. LITERATURE REVIEW

The ensuing chapter covers published work of researchers pertaining to the turning process in order to optimize parameters. Specifically, theory and information relating to the experiment and the turning process is presented. The scope of the review also extends to various optimization techniques that are used to obtain optimal solution mainly focusing on the Taguchi's Method.

3. WORK MATERIALS

3.1EN8 CARBON STEEL:

EN8 is an unalloyed medium carbon steel grade with reasonable tensile strength. EN8 is widely used for applications which require better properties than mild steel but does not justify the costs of an alloy steel.EN8 can be flame or induction hardened to produce a good surface hardness with moderate wear resistance.EN8 is available from stock in bar and can be cut to your requirements. We also offer flame cut plates cut to your required sizes and normalised.

3.2 MILD STEEL:

Mild steel (iron containing a small percentage of carbon, strong and tough but not readily tempered), also known as plain-carbon steel and low-carbon steel, is now the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications. Mild steel contains approximately 0.05–0.25% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form; surface hardness can be increased through carburizing. Low-carbon steels contain less carbon than other steels and are easier to cold-form, making them easier to handle.

3.3 OHNS (OIL HARDENIND AND NON- SHRIKING STEEL):

The material used for this work is OHNS steel. OHNS steel is a general purpose tool steel that is typically used in application where alloy steel cannot provide sufficient hardness, strength and wear resistance. OHNS steel is a non shrinking steel. This term refers to steels which show little change in volume from the annealed state when hardened and temperature at low temperature. Such steels are required for master tools, gauges and dies which must not change size when hardened after machining in the annealed condition.

4. PROBLEM IDENTIFICATION

The identification of turning problem for OHNS Steel rods which cannot be tackled using conventional technique because of following problems occurs in turning process. High surface roughness. Difficult to achieve Close tolerance Machining distortion. Poor Chip Breaking. Need more cutting pressure for machining. Need high hardness cutting tool for machining.

5. TOOL MATERIALS

5.1 CEMENTED CARBIDE TOOL:

Cemented carbide is a hard material used extensively as cutting tool material as well as other industrial application. Most of the time carbide cutting tool leave a better surface finish. Carbide tool withstand high temperature.

Fig-1: Cemented Carbide Tool Insert

5.2 TUNGSTEN CARBIDE:

Tungsten carbide is a chemical compound containing equal parts of tungsten and carbon atoms. It most basic form of tungsten carbide is a fine grey powder, it can be pressed and formed into shapes through a process called sintering for use in industrial machinery, cutting tool, abrasives , other tools and instruments, and jewellery.

Fig-2: Tungsten Carbide Tool Insert

6. Turning Process:

Turning process is a form of machining a material removal process which is used to create rational parts by cutting away unwanted materials. Turning process requires a turning machine or lathe, work piece and cutting tool. The cutter is typically a single point cutting tool that is also secured in the machine although some operations make use of multipoint cutting tool.

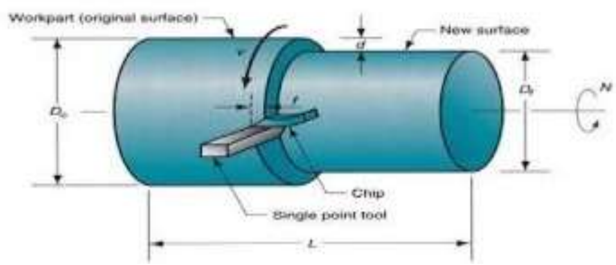


Fig-3: Turning Operation

7. METHODOLOGY

There are two types of methods:

- Taguchi Analysis
- ANOVA (Analysis of Variance)

8. TOOL WORK COMBINATION OF CEMENTED CARBIDE AND TUNGSTEN CARBIDE

Table 1: Tool work combinations

Work piece	Tool-work combination of Cemented carbide (CC)	Tool-work combination of Tungsten carbide (TC)
EN8	EN8-CC	EN8-TC
Mild steel	MS-CC	MS-TC
OHNS	OHNS-CC	OHNS-TC

8.1 TAGUCHI ANALYSIS:

The Taguchi analysis was used to study the significance and effect of the cutting parameters on the response variables of the various Tool work combinations for Table Temperature (^{0}C), Hardness (BHN) and Surface Roughness (RA).

8.2 ANOVA (ANALYSIS OF VARIANCE):

The analysis of variance (ANOVA) was used to study the significance and effect of the cutting parameters on the response variables of the various Tool work combinations for Table i.e. Temperature (^{0}C), Hardness (BHN) and Surface Roughness (RA).

Table 2: Factors and levels for the Response Surface

CODE	PARAMETER	LEVEL 1	LEVEL 2	LEVEL 3
A	CUTTING SPEED(RPM)	475	310	200
B	FEED(mm/rev)	0.7	0.75	0.8
C	DEPTH OF CUT(mm)	1	1.5	2

9. RESULT AND DISCUSSION

The Taguchi method uses a special design of orthogonal array (OA) in order to study the entire parameter space with a small number of experiments. The full factorial design could require 3 x 3 = 27 experimental runs, which would make the effort and experimental cost prohibitive and unrealistic. However, the experimental design of an OA can be of nine experiments.

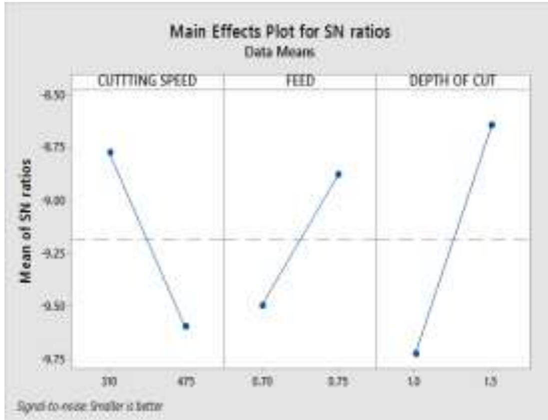
Table 3: orthogonal Array Columns of L9 (3^4) array: 1 2 3

Taguchi Array	L9(3^3)
Factors:	3
Runs:	9

10. TAGUCHI ANALYSIS: RA (EN8-TC) VS CUTTING SPEED, FEED, DEPTH OF CUT

Table 4: Response Table Signal to Noise Ratios

Level	CUTTTING SPEED	FEED	DEPTH OF CUT
1	-8.776	-9.496	-9.728
2	-9.597	-8.877	-8.644
Delta	0.822	0.619	1.084
Rank	2	3	1

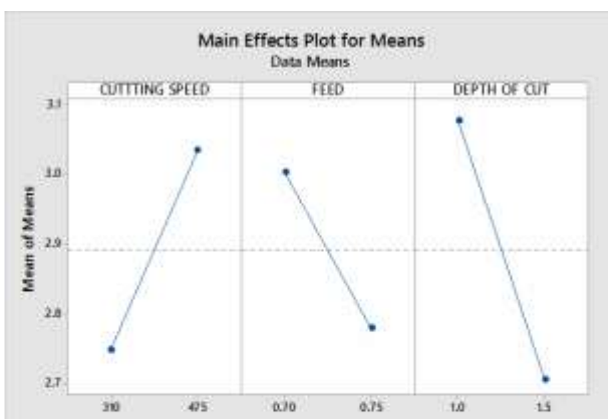


In the main effects plots, if the point is near the average horizontal line has less significant effect and the one which has highest inclination will have most significant effect on the responses. Therefore depth of cut is having the most significant effect on surface roughness.

One-way ANOVA: RA (EN8-TC) versus CUTTING SPEED:

Table 5: Response Table for Means

Level	CUTTTING SPEED	FEED	DEPTH OF CUT
1	2.748	3.002	3.075
2	3.034	2.779	2.705
Delta	0.286	0.223	0.370
Rank	2	3	1



In the main effects plots, if the point is near the average horizontal line has less significant effect and the one which has highest inclination will have most significant effect on the responses. Therefore depth of cut is having the most significant effect on surface roughness.

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
CUTTTING SPEED	1	0.08180	30.47%	0.08180	0.08180	0.88	0.448
Error	2	0.18663	69.53%	0.18663	0.09331		
Total	3	0.26843	100.00%				

One-way ANOVA: RA (EN8-TC) versus FEED:

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
FEED	1	0.04973	18.53%	0.04973	0.04973	0.45	0.570
Error	2	0.21870	81.47%	0.21870	0.10935		
Total	3	0.26843	100.00%				

One-way ANOVA: RA (EN8- TC) versus DEPTH OF CUT:

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
DEPTH OF CUT	1	0.1369	51.00%	0.1369	0.13690	2.08	0.286
Error	2	0.1315	49.00%	0.1315	0.06576		
Total	3	0.2684	100.00%				

Results of analysis of variance indicate that feed is the most significant machining parameter followed by depth of cut affecting the surface roughness.

11. CONCLUSION

Taguchi method was successfully applied in optimizing the temperature, hardness and surface roughness for the chosen best tool-work combination and for the selected domain of the input machining parameters. So the best tool-work combination is EN8-TC. ANOVA analysis was carried out and it is observed that cutting speed is the most significant factor affecting the hardness and surface roughness, closely followed by Feed and depth of cut, while the only significant factor affecting the temperature was found to be the depth of cut. The optimum running condition was found to be at V c (475 rpm), f (0.75 mm/rev) and d (1.5 mm).

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