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Optimization of Turning Process Parameters for Their Effect on En 8 Material Work piece Hardness by Using Taguchi Parametric Optimization Method

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Abstract: A common method to manufacture parts to a specific dimension involves the removal of excess material by machining operation with the help of cutting tool. Turning process is the one of the methods to remove material from cylindrical and non-cylindrical parts. In this work the relation between change in hardness caused on the material surface due the turning operation with respect to different machining parameters like spindle speed, feed and depth of cut have been investigated. Taguchi method has been used to plan the experiments and EN 8 metal selected as a work piece and coated carbide tool as a tool material in this work and hardness after turning has been measured on Rockwell scale. The obtained experimental data has been analyzed using signal to noise and. The main effects have been calculated and percentage contribution of various process parameters affecting hardness also determined.

Key words: Turing, Taguchi, EN 8 Rockwell Scale, S/N ratio, Regression

1. Introduction

Machining is the most wide spread metal machining process in mechanical manufacturing industry. The goal of changing the geometry of raw material in order to form mechanical parts can be met by putting material together. Conventional machining is the one of the most important material method. Machining is a part of the manufacturing all most all metals products. In order to perform cutting operations, different machining tools such as lathes, drilling machine, horizontal and vertical milling machines etc. are utilizing.

Out of this machining process, turning still remains most important operation used to shape metal, because in turning the condition of operation are most varied. Increasing productivity and reducing manufacturing cost has always been the primary object of successful business. In turning, higher values of cutting parameter offered opportunities for increasing productivity but it also involves greater risk of deterioration in surface quality and tool life. Turning operation is very important material removal process in modern industry. The study on the influence of hardness during machining has been going back to change.

From the previous studied, it is evident that although researchers have tried to investigated the relation of surface roughness with different process parameters of different machining operations like drilling, milling etc. but there is a gap in determining of the exact affect of speed, feed and depth of cut on hardness of work piece in turning operation. Therefore this aspect has been selected in this research paper.

2. Taguchi Method

Taguchi method is a powerful tool for the design of high quality systems. It provides simple, efficient and systematic approach to optimize design for performance, quality and cost. Taguchi method is efficient method for designing process that operates consistently and optimally over a variety of conditions. Taguchi approach to design the of experiments easy to adopt and apply for users with limited knowledge of statics, hence gained wide popularity in the engineering and scientific community. The desired cutting parameters determined by handbook. Cutting parameter are reflected on surface roughness, surface texture and dimensional deviation on turned product. Taguchi method is especially suitable for industrial use but can also be used for scientific research.

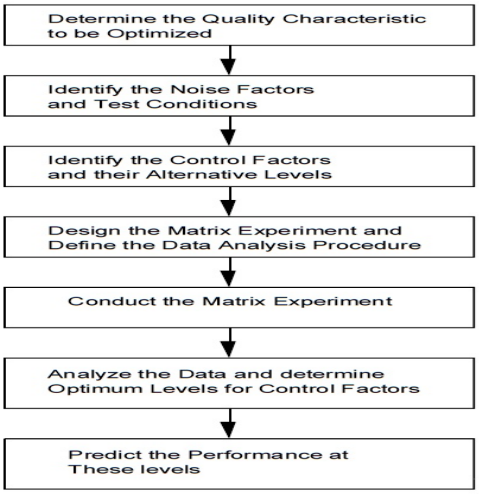

Figure 2.1 steps in Taguchi method

3. Experimental Setup and Cutting Conditions

3.1 Work piece material

The work piece material selected for investigation is EN 8 steel. En 8 finds wide varieties of application not only for forging, casting, axel shaft, crank shaft and connecting rods but also used for low cost die material in tool and die making industries. This steel can be hardened and tempered to provide a greater strength and wear resistance in comparison in low carbon steels. The work piece used for experiment is round bar with 40 mm diameter and 260 mm length.

Table3.1. Chemical composition of work piece material

Elements	C	Mn	Si	S	P
Weight %	0.36	0.66	0.27	0.016	0.020

3.2 Machining Process

The cutting tests were performed on medium duty conventional lathe machine and coated carbide tool. The experiments were conducted as per the orthogonal array and hardness for various combinations of parameters was measured using Rockwell hardness tester.

3.3 Plan of Experiment

The experiment was planned using Taguchi's orthogonal array in the design of experiments, which help in reducing the number of experiments. The L_9 orthogonal array. The cutting parameter identified were spindle speed, feed rate and depth of cut. The controls parameter and their level indicated in table.

Table 3.2. Factors and their level for EN 8

Level	**Spindle speed (rpm) Ss**	**Feed rate (mm/rev) F**	**DOC (mm) D**
1	950	0.15	0.80
2	1450	0.30	1.0
3	1950	0.45	1.2

Table.3.3 orthogonal L9 array of taguchi

Experiment	P1	P2	P3
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

Table3.4 consulate design of parameters and response

Experiment	Combination of input factors	Output (Hardness) Response
1	$S_1F_1D_1$	24
2	$S_1F_2D_2$	30
3	$S_1F_3D_3$	28
4	$S_2F_1D_2$	27
5	$S_2F_2D_3$	25
6	$S_2F_3D_1$	25
7	$S_3F_1D_3$	26
8	$S_3F_2D_1$	26
9	$S_3F_3D_2$	32

4 Analysis of the signal to noise (S/N) ratio

In the Taguchi approach, the term signal represents the desired value (mean) for the output characteristics and term noise represents the undesirable value (standard deviation) for the output characteristics. Therefore, S/N ratio is the ratio of mean to the standard deviation. Taguchi uses the S/N ratio to measure the quality characteristics deriving from desired value

.The S/N ratio is defined as given equation.

Higher the better

It is when the occurrences of some undesirable product characteristics is to be maximized. It is given by

$$S/N = -10 \times \log_{10}\left(\sum(1/y_i^2)/N\right)$$

All the three levels of every factor are equally represented in the twenty seven experiments. S/N ratio and hardness for each parameter at each level. Hardness for each of the parameter at each level is calculated. These also called as main effects.

Table 4.1. Summary sheet of S/n ratio

Experiment No.	S/N ratio
1	27.60
2	29.54
3	28.94
4	28.62
5	27.95
6	27.95
7	28.29
8	28.29
9	30.88

Table 4.2. Average S/N ratio at each level

Symbol	Process Parameter	S/N value of Hardness (dB)		
		Low	Medium	High
Ss	Spindle speed	28.69	28.17	**28.89**
F	Feed Rate	28.17	28.59	**28.99**
D	Depth of cut	27.94	**29.42**	28.39

Table 4.3.Average Hardness for each parameter at three levels

Symbol	Process Parameter	Hardness (HRC)		
		Low	Medium	High
Ss	Spindle speed	27.33	25.66	**28**
F	Feed Rate	25.66	27	**28.33**
D	Depth of cut	25	**29.66**	26.33

The optimum level for a factor is the level that gives the highest value of parameter in each level in the experimental region denoted by bold letter. The estimated main effects can be used for this purpose.

5. Main effects

Main effects plots for the experiments have been given below.

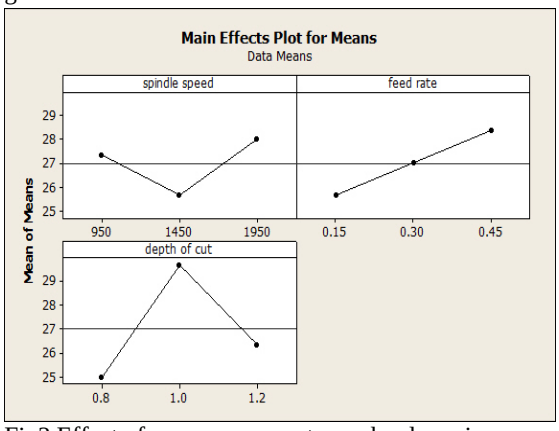

Fig2.Effect of process parameter on hardness in EN 8

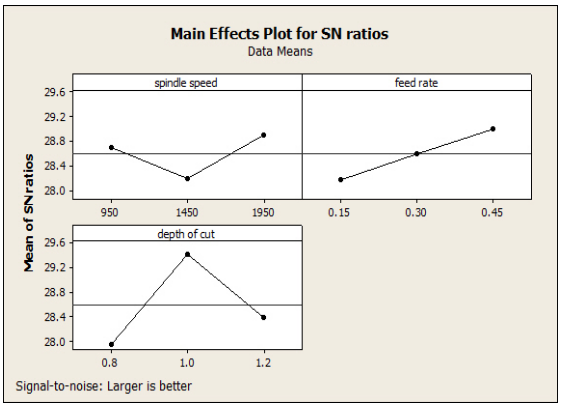

Fig.3. Main effect for S/N ratio value of hardness

Levels	Prediction (Taguchi Method)	Prediction (Regression Modeling)	Actual Experimental Value
Level	$Ss_3 + F_3 + D_2$	$Ss_3 + F_3 + D_2$	$Ss_3 + F_3 + D_2$
Hardness (HRC)	31.99	28.28	32

From main effects plots of EN 8, it is observed that there is decreased in hardness as the speed is increased but when speed is further increased hardness goes increased. The hardness increases when feed rate is changed from 0.15 mm/rev to 0.3 mm/rev and 0.3 to 0.45mm/rev, similarly when depth of cut is increased from 0.8mm to 1.0 hardness increases, but as the depth of cut is further increased to 1.2 mm hardness decrease considerably.

5.1 Conformation of experiment

While considering three factors the experiments were conducted and result is that the combination of Higher Spindle speed (Ss3), higher Feed rate ((F3) and Medium Depth of cut (D2), then the Hardness is maximum.

Hardness (HRC)	S/N ratio (dB)
32	30.10

6. Mathematical regression Modelling

For the combination of parameters setting hardness value for EN 8 is tabulated. Empirical formula has fined out by using regression modeling.

Modeling of parameters

To generalize the results, the Modeling of input parameters (Spindle Speed, Feed rate, Depth of cut) and output parameter (Hardness) is done using REGRESSION MODELLING and MATLAB Software R2011b.

$$\mathbf{H = 25.950(Spindle\ speed)^{0.0203} * (Feed\ rate)^{0.0845} * (Depth\ of\ cut)^{0.1500}}$$

The developed models are able to predict the hardness for any set of parameters within the range of experiments conducted for En 8 metal.

6.1 Compression of result

Table 6.1. Comparison of results

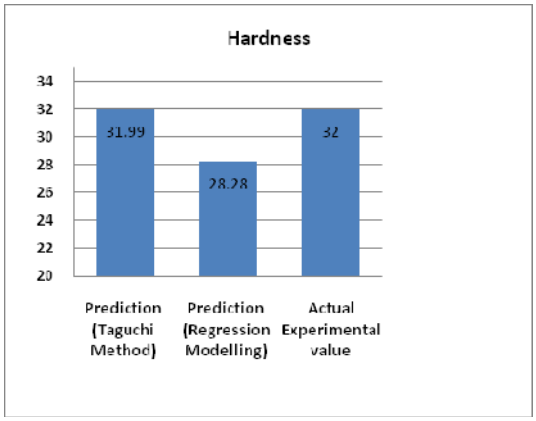

Figure 6.1. comparison chart of results

6.2 Summary

In the present work, the relationship between hardness and various process parameters namely spindle speed, feed rate and depth of cut has been developed.

Taguchi method has been adopted for the design of experiments and the results have been analyzed by maximize S/N ratio.

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