



Optimization of Surface Roughness in Turning Operation of EN8 using Taguchi Method

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Abstract: The main aim of this paper is to optimise the surface roughness in conventional turning operation using Taguchi Method for the material medium carbon steel EN8. In this work cutting speed, feed rate and depth of cut are taken as performance parameters to achieve better surface roughness. Taguchi Method is used to obtain the main parametric effect on the surface roughness using three levels and factors. L9 orthogonal array is used to design the experiments. Also analysis of variance (ANOVA) was carried out with the significance factor of 95%. After the experimentation, it was found that cutting speed has more influenced on the surface roughness in conventional turning process than feed rate and depth of cut.

Keywords: Taguchi method, Optimisation, Surface roughness, EN8.

I. INTRODUCTION

In today's manufacturing industrial scenario there is requirement of machining process with the high quality at low cost and wastage. To achieve this requirement there is need of optimisation of performance parameters. In the machining process, apart from obtaining the accurate dimensions, achieving a good surface quality and required metal removal rate are importance characteristics. A machining process involves many process parameters which directly or indirectly influence the surface roughness and metal removal rate of the metal. There are several machining processes like turning, grinding, boring, drilling, milling etc. Mostly in the manufacturing industry turning process is mostly used. Surface roughness and metal removal in turning process are depending on various parameters as feed rate, spindle speed, depth of cut. Taguchi Method is one of several methods to achieved optimise process parameters of machining. Taguchi Technique is statistical method to improve performance parameters and widely applicable for engineering, biotechnology, advertisement and marketing. Taguchi transformed the manufacturing process in Japan through cost savings. Taguchi methods identified noise sources, which have the greatest effects on product variability. Taguchi method adopted by successful manufacturers around the globe because of their optimised results in creating superior production processes at much lower costs. The main objective of Taguchi method is to design robust processes with different operating conditions.

EN8 is medium carbon steel which is used in applications where better properties than mild steel are required but where the costs do not justify the purchase of a steel alloy. EN8 can be heat treated to provide a good surface hardness and moderate wear resistance by flame or

induction hardening processes. From the automotive trade to wider general engineering applications, EN8 is popular steel in industry.

II. PROBLEM STATEMENT & OBJECTIVE

Conventional machining offers different types of operations. In turning operation it is difficult to achieve desired surface roughness with undefined performance parameters.

The objective of this work is as follows,

1. To achieve the desired surface roughness by optimizing performance parameters for turning operations.
2. To study effect of parameters on the surface roughness value (Ra).

The scope of the study was limited up to conventional turning process. The material used for study purpose untreated medium carbon steel EN8. The study focuses on to the optimize performance parameter for conventional turning operation with material EN8.

III. METHODOLOGY

The present work deals with the turning of hard material as EN8 on lathe machine. It is an important engineering material employed in manufacturing of components in automotive industries. The experiment deals with machining of medium carbon steel EN8 was carried out with High Speed Steel tool in conventional lathe. The chemical composition of EN8 described in table no. I.



TABLE I CHEMICAL COMPOSITION OF EN8

C	Si	Mn	P	S
0.38	0.15	0.85	0.03	0.03

Solid round bar of EN8 steel with 35mm diameter and 100mm long were used as the work piece. In conventional turning operation surface roughness value is affected by the several parameter such as cutting speed, depth of cut, feed rate, spindle speed, work piece material, tool material, working operating conditions.

Performance parameters as cutting speed, depth of cut and feed rate are the influenced factors on surface roughness value and others are nuisance factors. Turning experiments were carried out at three different cutting speeds (v) which were 200, 300 and 400 rpm and feed rates (f) were 0.2, 0.4, 0.8 mm/rev and depth of cut (d) were 0.2, 0.4 and 0.6 mm for the experimentation and small depth of cut was used for finish turning. The factors and their levels considered in this study are shown in Table II.

TABLE III FACTORS AND LEVELS USED IN EXPERIMENT

Factors	Levels		
	1	2	3
Cutting Speed (rpm)	200	300	400
Feed Rate (mm/rev)	0.2	0.4	0.8
Depth of Cut (mm)	0.2	0.4	0.6

The selection of design parameter factors is the important in the design of experiments. Taguchi method is to optimize the process parameter to achieve best quality performance. It is one of the powerful statistical tools used in the application of design and analysis for experiments adopted to optimize the design parameter and it is an effective approach to produce high-quality products at a relatively low cost. Taguchi analysis is carried out using Minitab 17 statistical software. If the number of process parameter increases, there are number of experiments have to be conducted to get the optimized parameter. To make the task easy, Taguchi method uses design of orthogonal arrays (OA) to study the process parameter with small number of experiments. The present experimental investigation deals with the design of experiment by the Taguchi methodology with a L9 orthogonal array (OA) to determine the importance of the factors or the parameters. Nine experiments with combination of different cutting parameters are randomly conducted.

TABLE IIIII L₉ ORTHOGONAL ARRAY

Sr. No.	Cutting Speed (rpm)	Feed Rate (mm/rev)	Depth of Cut (mm)
1	1	1	1
2	1	2	2
3	1	3	3
4	2	2	2

5	2	3	3
6	2	1	1
7	3	3	3
8	3	1	1
9	3	2	2

The surface roughness (R_a) of the work piece is measured by using Surface Roughness Tester as shown in figure no. 1 at Production Engineering Department in College of Engineering Pune. The instrument was calibrated using a standard calibration block prior to the measurements. The measurement was taken at four locations (90 apart) around the circumference of the work piece.



Figure No. 1 Photography of Measurement of R_a value

IV. 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 $3 \times 3 = 27$ 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 IVV L₉ ORTHOGONAL ARRAY (RESULT OF TAGUCHI ANALYSIS)

Cutting Speed (rpm)	Feed Rate (mm/rev)	Depth of Cut (mm)	R_a (μ m)
200	0.2	0.2	3.97
200	0.4	0.4	4.21
200	0.8	0.6	4.3
300	0.2	0.4	4.25
300	0.4	0.6	4.28
300	0.8	0.2	4.25
400	0.2	0.6	4.3
400	0.4	0.4	4.27
400	0.8	0.2	4.42



Only main effects were considered, whereas interaction effects were assumed to be negligible. In Taguchi method, the experimental results were transformed into S/N ratios to measure the quality characteristics deviating from the desired value. The S/N ratio is the ratio of the mean (signal) to the standard deviation (noise). Regardless of the category of the quality characteristic, a greater S/N ratio corresponded to better quality characteristics. The method of calculating the S/N ratio depends at each run of the experiment on whether the quality characteristic is lower-the-better, higher-the-better, or nominal-the-better.

TABLE V RESPONSE TABLE FOR SIGNAL TO NOISE RATIO

Level	Cutting Speed	Feed Rate	Depth of Cut
1	-12.38	-12.40	-12.38
2	-12.59	-12.57	-12.65
3	-12.73	-12.72	-12.66
Delta	0.35	0.31	0.27
Rank	1	2	3

In the present study, S/N ratio is calculated as the logarithmic transformation of the loss function by using smaller-the-better criterion as minimum values of surface roughness is required. S/N ratio is calculated based on

smaller-the-better criterion for surface roughness is shown in Table V. An influence of each design parameter (speed, feed and depth of cut) on surface roughness is obtained from the response tables of S/N ratio. Taguchi recommends that the larger S/N ratio corresponds to the best quality characteristics, regardless of the category of the performance characteristic. Therefore, the optimal level of process parameter is the level with the highest S/N ratio. So feed rate is having the highest S/N ratio. The response table for mean is shown in Table VI.

TABLE VI RESPONSE TABLE FOR SIGNAL TO NOISE RATIO MEANS

Level	Cutting Speed	Feed Rate	Depth of Cut
1	4.160	4.173	4.163
2	4.260	4.253	4.293
3	4.330	4.323	4.293
Delta	0.170	0.150	0.130
Rank	1	2	3

Results of analysis of variance indicate that feed rate is the most significant machining parameter followed by cutting speed affecting the surface roughness.

TABLE VII ANALYSIS OF VARIANCE FOR SIGNAL TO NOISE RATIO

Level	DF	Seq. SS	Adj. SS	Adj. MS	F	P
Cutting Speed	2	0.18819	0.18819	0.09409	9.98	0.09
Feed Rate	2	0.14539	0.14539	0.07269	7.71	0.11
Depth of cut	2	0.14674	0.14674	0.07337	7.78	0.14
Residual Error	2	0.01885	0.01885	0.00942		
Total	8	0.49917				

The main effect plots for means and for S/N ratios of surface roughness are presented in fig. 1 (a) and fig. 1 (b) respectively.

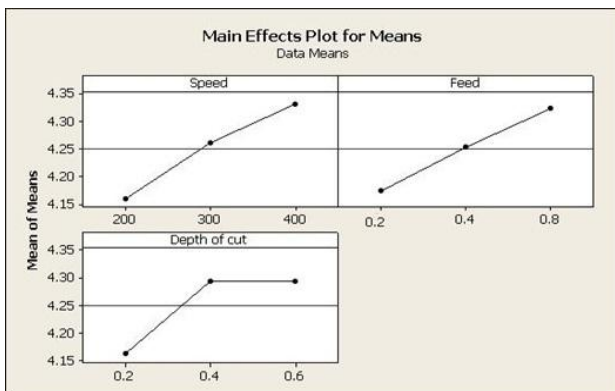


Figure No. 1 (a) Main Effect Plot for means

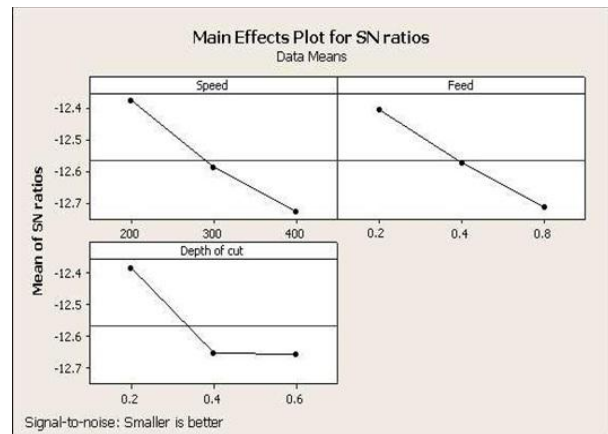


Figure No. 1 (b) Main Effect Plot for SN ratios

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

V. CONCLUSION

- It has been found that cutting speed is found to be the most significant factor & its contribution to surface roughness is greater than feed rate and depth of cut.
- The Surface roughness is mainly affected by feed rate, depth of cut and cutting speed. With the increase in feed rate the surface roughness also increases, as the depth of cut increases the surface roughness first increase and decrease and as the cutting speed increase surface roughness decreases.
- From ANOVA analysis, parameters making significant effect on surface roughness are cutting speed and feed rate.

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