International Journal of Mechanical Engineering and Robotics Research

ISSN 2278 – 0149 www.ijmerr.com
Vol. 3, No. 4, October 2014

Research Paper

OPTIMIZATION OF TURNING PARAMETERS OF EN-8 STEEL CYLINDRICAL RODS USING TAGUCHI METHODOLOGY

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Surface roughness is an important factor for ensuring the dimension geometry is within the permitted tolerance. The ideal surface roughness is determined by optimal turning parameter of EN-8 steel cylindrical rods. EN-8 steel finding many applications such as shaft, axle, gears and Fasteners due to their high hardness, strength to weight ratio. Optimum machining parameters of turning operations are greatly influenced with concern along with manufacturing environment. In this experimental work turning parameters on EN-8 steel with different parameters such as cutting speed, feed and depth of cut are greatly influenced by response parameters. The experimental design was formed based on Taguchi's Technique. An orthogonal array and Analysis of Variance (ANOVA) are employed to investigate the Turning conditions and machining was done using coated tool insert.

Keywords: EN-8, Turning parameters, Taguchi DOE, S/N ratio, ANOVA

INTRODUCTION

Turning is one of the most basic machining processes which work is rotated while a single point cutting tool is moved parallel to the axis of rotation. In turning process parameters such as cutting speed, feed and depth of cut, number of passes as well as use of cutting fluids will impact the production cost and machine qualities like surface roughness and material removal rate. Proper selection of cutting parameters can obtain a minimum cost, maximum material removal rate, longer tool life and better surface roughness. Matsumara *et al.* (2004) performed turning operation and study the machinability of steel and give key note to determination of optimal cutting conditions for surface finish obtained in turning using design of experiments for carbide coated tool. Sutter (2005) gives analyzing the chip formation and chip geometrics during high speed machining for orthogonal cutting conditions and obvious that achievements of

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proper surface finish of the manufactured parts are desirable and essential in some applications. Ghosh Amitabh *et al.* (2006) have discussed the surface finish in machining and have indicated that the resultant roughness produced by a machining operation is the combined effect of two independent quantities namely ideal roughness and natural roughness. According to them, ideal roughness is a result of the geometry of the tool and the feed. Vikram Kumar and Ramamoorthy (2007) have dealt with Performance of coated tools during hard turning under minimum fluid application. Further Sarma and Dixit (2007) have compared the dry and air-cooled turning of grey cast iron with mixed oxide ceramic tool. Gokkaya Hasan and Nalbant Muammer (2007) have studied The effects of cutting tool geometry and processing parameters on the surface roughness of AISI 1030 steel. However, Isik, Yahya et al (2008) have investigated the machinability of tool steels in turning operations (Singh and Rao, 2007) Tamilmani (2007) has shown that the depth of cut had contributed 15% in providing lower surface finish. Aslantas, Ucan, Goek et al (2007) also report the possibility of finish turning of steel with CNB inserts under high speeds. Ersan Aslam *et al.* (2007) has shown that the optimized machining parameters while machining A1S1 140 steel with ceramic tool and shown that cutting speed, feed rake and depth of cut inter actions have significant influence on surface roughness. Paulo Davin (2008) express a note on the determination of optimal cutting conditions for surface finish obtained in turning using design of experiments for carbide coated tool turning. Design Of Experiment (DOE) is a structured, organized method used to determine the relationship between the different input factors (Xs) and the outputs (Ys) of a process. Design of experiment involves designing a set of experiments, in which all relevant factors are varied systematically. When the results of these experiments are analyzed, they help to identify the factors that most influence the results, interactions and synergies between factors, and optimal conditions. Experimental design is a strategy to gather knowledge based on the analysis. This study excludes and fixes less influencing tool wear and many others factors as they were discussed in details the researchers and got optimized earlier. Hence the contributions by the researchers are considered as best suited and kept at constant and referred as least influencing factors for simultaneous optimization.

EXPERIMENTAL DETAILS

EN-8 Steel Rods

In this experimental work the En-8 steel rods having the dimensions of Diameters 22 mm x 100 mm length are used.

No of experiments conducted : 9

Diameter of Specimen : 22 mm

Length of the specimen : 100 mm

Figure 1: Schaublin CNC Lathe

Table 1: Chemical Composition of EN-8 Steel

C	Si	Mn	S	P
0.44	0.40	1.0	0.05	0.05

Table 2: Mechanical Properties of EN8 Steel

Max. Stress	Yield Stress	Proof Stress	Elongation	Impact Strength	Hardness Value
850 N/mm^2	465 N/mm^2	450 N/mm^2	16%	28j	255 Brinell

Figure 2: EN-8 Steel Rods (Before Turning)

Figure 3: EN-8 Steel Rods (After Turning)

Figure 4: Surface Roughness Tester

METHODOLOGY

- State the problem
- State the objectives of experiments
- Select the factors that may influence the selected quality characteristics
- Identify quality and noise factors
- Select levels for the factors
- Select appropriate orthogonal array
- Select interactions that may influence the selected quality characteristics
- Conduct the tests described by trails in orthogonal array
- Analyze and interpret results of the experimental trails
- Conduct confirmation experiment

Taguchi Design of Experiments

Taguchi method is a powerful tool in quality Optimization makes use of a special design of Orthogonal Array (OA) to examine Number of experiments used to design the orthogonal array for 3 factors and 3 levels of turning parameters.

Minimum experiments

$= [(L\text{-}1) \times p] + 1$

$= [(3\text{-}1) \times 3] + 1 = 7 \approx L9$

Table 3: Design of Experiments

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

Analysis of Variance

In statistics, Analysis of variance (ANOVA) is a collection of statistical models, and their associated procedures, in which the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In its simplest form, ANOVA provides a statistical test of whether or not the means of several groups are all equal, and therefore generalizes t-test to more than two groups. Doing multiple two-sample t-tests would result in an increased chance of committing a type I error. For this reason, ANOVAs are useful in comparing two, three, or more means.

The F-test: The F-test is used for comparisons of the components of the total deviation. For example, in one-way, or single-factor ANOVA, statistical significance is tested for by comparing the F test statistic:

$$F = \frac{\text{Variance between treatments}}{\text{Variance within treatments}}$$

RESULTS AND DISCUSSION

Surface Roughness

After conducting the experiments on turning operations of EN-8 steel rods (diameter 22 and 100 mm length) with different turning parameter and predict the lower surface roughness.

- Spindle speed is a dominating parameter to produce lower Surface roughness in turning process.
- The optimum parameter of turning operation of EN-8 steel plates are 225 m/min of cutting speed, 0.2 mm/rev of Feed and 0.5 mm Depth of cut.
- However EN-8 Steel plate having good machinability characteristic and Produce reasonable surface finish.
- Obtained Good surface integrity and minimum wear occur during turning operation of EN-8 steel rods.
- During turning process all parameters are interact and dependable in turning operation.

The Table 4 represent the optimum parameter of surface roughness of EN-8 steel rods were cutting speed 225 m/Min, feed rate 0.2 mm and depth of cut 0.5 mm in turning operation.

Table 4: Turning Parameters of Surface Roughness

Test No.	Cutting Speed (m/min)	Feed Rate (mm/rev)	Depth of Cut (mm)	Surface Roughness (Microns)
1	175	0.1	0.5	2.45
2	175	0.2	0.8	2.75
3	175	0.3	1	2.45
4	200	0.1	0.8	2.65
5	200	0.2	1	2.85
6	200	0.3	0.5	2.96
7	225	0.1	3	2.15
8	225	0.2	0.5	2.10
9	225	0.3	0.8	2.95

Response Table for Signal to Noise Ratios of surface roughness values (Smaller is better)

The Table 5 represent the cutting speed is a dominating parameter (Rank 1) in surface roughness in EN-8 steel plates in turning process.

The Table 6 shows (from F-test bigger valve) cutting speed is a influencing parameter in

Table 5: S/N Ratio of Surface Roughness

Level	Cutting Speed	Feed Rate	Depth of Cut
1	–8.130	–7.632	–7.885
2	–8.996	–8.109	–7.855
3	–7.497	–8.880	–7.855
Delta	1.499	1.248	1.028
Rank	1	2	3

Figure 5: Main Effect Plot for Surface Roughness

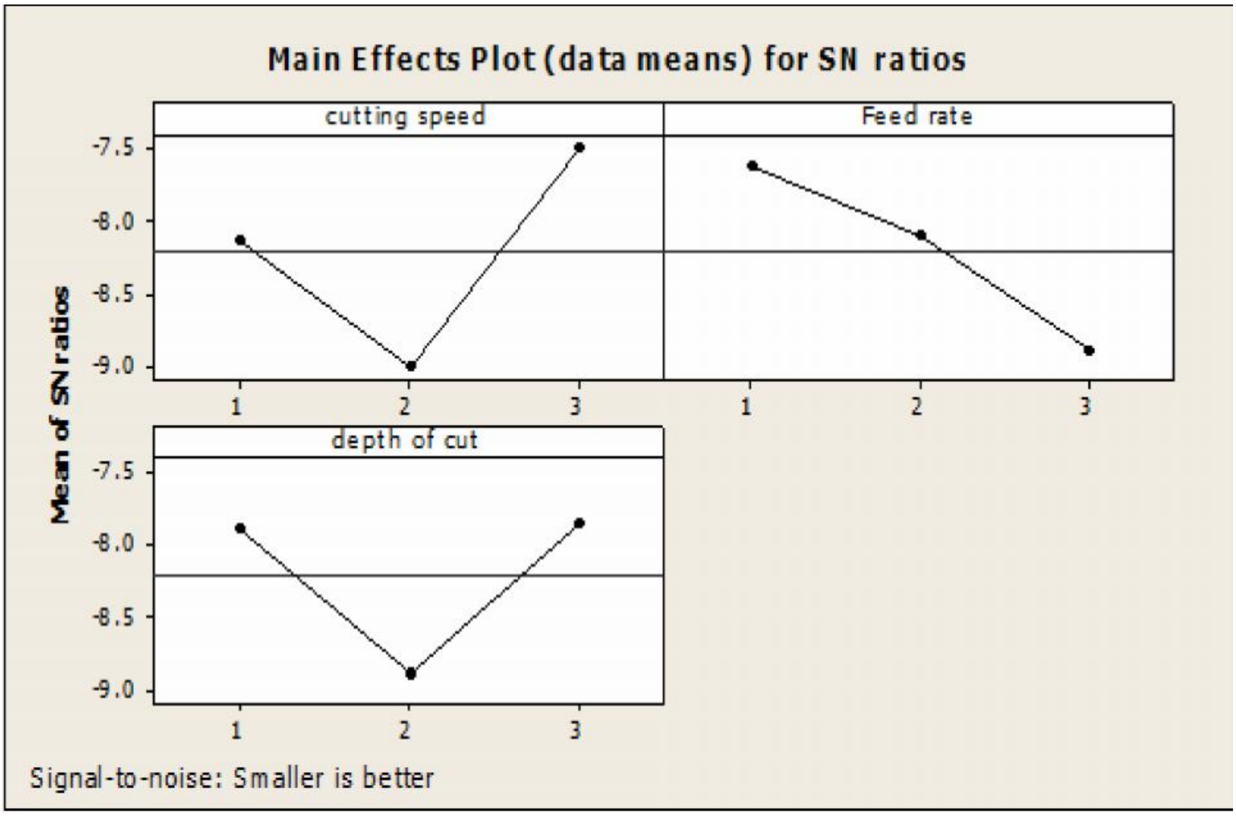

Table 6: Analysis of Variance for Surface Roughness

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Cutting speed	2	0.27102	0.27102	0.13551	1.47	0.404
Feed rate	2	0.21176	0.21176	0.10588	1.15	0.465
Depth of cut	2	0.16669	0.16669	0.08334	0.91	0.525
Error	2	0.18402	0.18402	0.09201		
Total	**8**	**0.83349**				

Figure 6: Interaction Plot for Surface Roughness

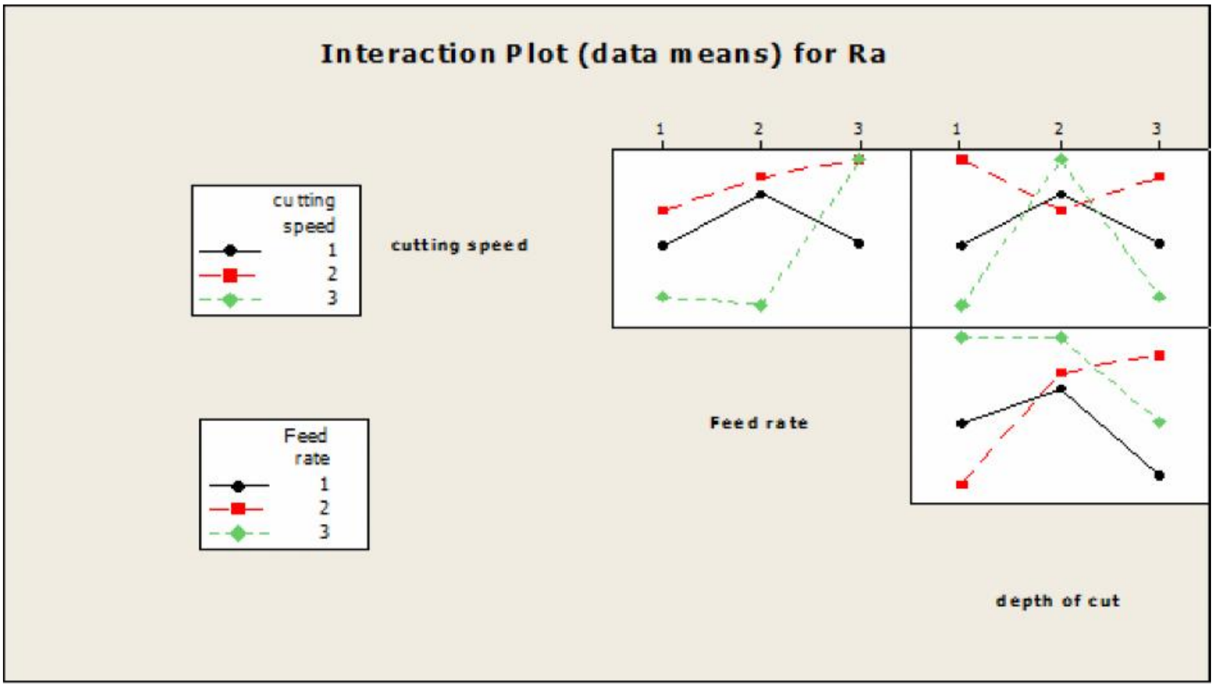

Figure 7: Contour Plot for Surface Roughness

surface roughness of EN-8 steel rods in turning operation process.

The Figure 7 shows contour plot for surface roughness of turning operation, it is a graphical and 3 dimensional representations which indicate the optimum level of cutting speed and feed for lower surface roughness of EN-8 steel cylindrical rods.

CONCLUSION

After conducting the experiments of turning parameters on EN-8 steel rods and optimum parameters of surface roughness is given below:

- Spindle speed is a dominating parameter for achieving lower surface roughness during turning of EN-8 steel rods.
- The optimum parameter achieving lower surface roughness of EN-8 steel rod are 225 m/min of cutting speed, 0.2 mm/rev of Feed and 0.5 mm Depth of cut.
- However EN-8 Steel plate having good machinability characteristic and Produce reasonable surface finish.

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