International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** III **Month of publication:** March 2017

DOI:

www.ijraset.com
IC Value: 45.98

Volume 5 Issue III, March 2017
ISSN: 2321-9653

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Taguchi Approach for Experimental Investigation to Minimize Surface Roughness for Turning EN 24 Steel

Prashant D. Kamble[1], Dr. Atul C. Waghmare[2], Dr. R.D. Askhedkar[3], Shilpa B. Sahare[4]

[1,4]*Department of Mechanical Engineering, YCCE, Wanadongri, Nagpur, MS, India*

[2]*Department of Mechanical Engineering, Umrer college of Engineering, Umrer Dist. Nagpur, MS, India*

[3]*Department of Mechanical Engineering, KDK college of Engineering, Nagpur, MS, India*

Abstract: *The main aim of this paper is to optimize the material removal rate (MRR) in turning process. Taguchi methodology is used as an optimization tool to optimize the turning process. The input parameters for turning process are Cutting Environment, feed rate, nose radius, depth of cut and tool type. The response variable is Surface Roughness. Consideration of noise factor (uncontrollable factor) makes the design robust. Hence machine tool condition in terms of spindle vibration is taken. Cutting speed is kept constant (210 m/min). The results of ANOVA indicate that feed rate is the most significant machining parameters followed by nose radius, cutting environment, depth of cut and tool type. Based on the main effect plot of S/N ratio, the optimal machining parameters are the cutting environment at level 3 (A_3 = MQL), nose radius at level 3 (B_3= 1.2 mm), feed rate at level3 (C_3=0.35 mm/rev), depth of cut at level 2 (D_2 = 1.0 mm), and tool type at level 1 (E_1= Uncoated or $A_3B_3C_3D_2E_1$ in short. Surface roughness is optimized up to 0.98 um. Conformity test revealed that the predicted and experimental values of Surface roughness are within the range given by confidence interval.*

***Keywords*: Turning process, Surface roughness, Taguchi, noise factor, ANOVA, Optimization**

I. INTRODUCTION

Now a day, demand of customers regarding quality of product and its production rate is increasing. To stand in the market with strong root manufactures have to fulfill this demand within the time. This can be achieved by the optimization of the process. Manufacturing process often involves optimization of machining parameters in order to improve product quality as well as to enhance productivity. In metal cutting process, especially turning, milling process, besides the basic cutting process parameters viz. cutting speed, feed rate, depth of cut, tool geometry, environment of cutting and the type of tool plays an important role to decide the performance of quality characteristics.

Wuyi Chen [1] (2000), in this paper the majority of Ra data collected during the tests are summarized by using histograms. The graphs are able to show the variations of surface roughness with the changing work piece hardness. When finish cutting of hardened steel is considered, the radial thrust force (Fy) became the largest among the three cutting force components and is the most sensitive to the changes of cutting edge chamfer, tool nose radius and flank wear. S.M. Darwish [2] (2000), Karin Kandananond *et al* [10] (2009), Ilhan Asiltürk *et al* [19] (2011), These paper stated the effect of cutting speed, feed rate and depth of cut on minimization of surface roughness during turning of super met 718 Nickel super alloy, ferritic stainless steel AISI 12L14, AISI 4140 respectively. C.R. Liu, *et al* [3] (2000), in this paper a thermo-elastic-viscoplastic model using explicit finite element code abacus is developed to investigate the effect of sequential cuts and tool chip friction on residual stresses in a machined layer. The affected layer from the first cut slightly changes the chip thickness, cutting forces, residual strain and temperature of the machined layer, but significantly affects the residual stress distribution produced by the second cut. M.H. El-Axir [4] (2002), this paper introduces a more comprehensive experimental model which has the capability of predicting residual stress profile. The main advantage of this model over the existing models is that it provides the effect of machining parameters on maximum residual stress and determines both the location and depth of this maximum residual stress. Hari Singh *et al* [5] (2003), Araştırma Makalesi *et al* [7] (2006), Nilrudra Mandal *et al* [18] (2011), these paper stated the effect of cutting speed, feed rate, depth of cut on flank wear, crater wear, tool wear during turning of EN24 steel, AISI 304 Austenite stainless steel, AISI 4340 steel respectively. Hari Singh *et al* [6] (2005), in this paper, a design of experiment based approach is adopted to obtain the optimal setting of turning process parameter that may yield optimum tool wear. The predicted optimal values of flank wear width crater wear depth of coated carbide tool while

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

machining the EN 24 steel are 0.172mm and 0.244 microns respectively. S.R. Carvalho *et al* [7] (2006) in this paper the thermal model is obtained by a numerical solution of the transient three-dimensional heat diffusion equation that considers both the tool and the tool holder assembly. Several cutting tests using cemented carbide tools were performed in order to check the model and to verify the influence of the cutting parameters on the temperature field. G. H. Senussi *et al* [8] (2007), Ashish Yadav *et al* [25] (2012), These papers stated the effect of cutting speed, feed rate, depth of cut on hardness during turning of 304 Austenite stainless steel, EN8 respectively.

II. TAGUCHI PHILOSOPHY

Among the available methods, Taguchi design is one of the most powerful DOE methods for analyzing of experiments. It is widely recognized in many fields particularly in the development of new products and processes in quality control. The salient features of the method are as follows:

It is a simple, efficient and systematic method to optimize product/process to improve the performance or reduce the cost.

It helps arrive at the best parameters for the optimal conditions with the least number of analytical investigations.

It is a scientifically disciplined mechanism for evaluating and implementing improvements in products, processes, materials, equipments and facilities.

It includes the noise factor and makes the design robust.

Therefore, the Taguchi method has great potential in the area of low cost experimentation. Thus it becomes an attractive and widely accepted tool to researchers.

Quality characteristic is the object of interest of a product or a process. It is called as a functional characteristic. Generally, the quality characteristic has a target.

There are three types of targets:

A. Lower The Better (LB)

It is a non-negative measurable characteristic that has an ideal state or target of zero.

$$S/N = -10\log\left(\left(\frac{1}{n}\right)\sum y^2\right) \qquad (1)$$

B. Nominal The Best (NB)

It is a measurable characteristic with a specific user defined target value.

$$S/N = -10\log\left(\frac{\hat{y}}{s^2}y\right) \qquad (2)$$

C. Larger The Better (LB)

It is a non-negative measurable characteristic that has an ideal state or target of infinity.

$$S/N = -10\log\left(\left(\frac{1}{n}\right)\sum \frac{1}{y^2}\right) \qquad (3)$$

III. EXPERIMENTATION

The experiment was performed on CNC SPINNER15 lathe machine as shown in fig 1. Test pieces of size 50mm×80mm were cut from EN 24 steel bar. The five input variables used in this study are cutting environment, Nose radius, Feed rate, Depth of cut and tool type and spindle vibration was taken as a noise factor. Cutting speed was kept constant.

Volume 5 Issue III, March 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

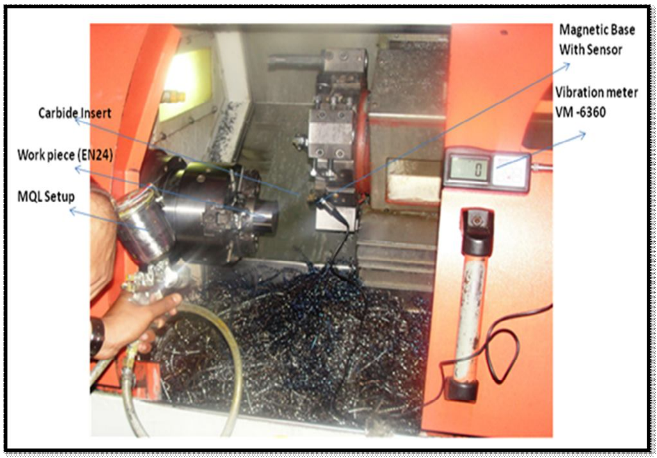

Fig 1 Experimental Setup

Fig 2 CNC Lathe SPINNER 15

TABLE 1PROCESS PARAMETERS AND THEIR LEVELS

Process Parameters	Code	Level-1	Level-2	Level-3
Cutting Environment	A	Dry	Wet	MQL
Nose radius (mm)	B	0.4	0.8	1.2
Feed rate (m/rev)	C	0.15	0.25	0.35
Dept of cut (mm)	D	0.5	1	1.5
Tool type	E	Uncoated	PVD	CVD
Spindle vibration (m/s^2)	N	1.7	4.3	6.9

A. Measurement of Surface Roughness

The surface roughness is measured by MITECH MDT310 Portable Surface Roughness Tester at three different levels of spindle vibration. Roughness measurements on the work pieces have been repeated three times and average of three measurements of surface roughness parameter values has been recorded as shown in figure 6.6. The instrument is a portable, self-contained instrument for the measurement of surface texture. The measurement results are displayed on an LCD screen. The instrument is powered by rechargeable battery.

Fig 3 Surface roughness Measurement

Volume 5 Issue III, March 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

TABLE 2 EXPERIMENTAL DATA FOR SURFACE ROUGHNESS AT THREE LEVELS OF SPINDLE VIBRATION

Run	SR_NF1	SR_NF2	SR_NF3	Avg_SR
1	7.40	7.44	10.07	8.30
2	5.79	5.81	7.04	6.21
3	4.51	4.53	5.49	4.84
4	6.27	6.30	8.53	7.03
5	4.83	4.85	5.87	5.18
6	2.93	2.94	3.56	3.14
7	4.96	4.99	5.43	5.13
8	3.52	3.54	4.47	3.84
9	2.07	2.08	2.52	2.23
10	6.67	6.70	8.11	7.16
11	5.23	5.25	6.35	5.61
12	3.78	3.80	4.60	4.06
13	5.50	5.52	5.43	5.48
14	4.21	4.23	4.47	4.30
15	2.31	2.32	2.81	2.48
16	4.35	4.37	5.29	4.67
17	2.90	2.92	3.53	3.12
18	1.46	1.47	1.77	1.57
19	6.20	6.23	5.43	5.96
20	4.61	4.63	4.47	4.57
21	3.16	3.18	3.85	3.40
22	5.04	5.07	6.13	5.41
23	3.60	3.61	4.37	3.86
24	1.70	1.70	2.06	1.82
25	3.73	3.75	5.43	4.31
26	2.13	2.14	4.47	2.91
27	0.96	0.97	1.16	1.03

IV. DATA ANALYSIS

Taguchi method is used for single objective optimization. The S/N (signal-to-noise) ratio is used by Taguchi approach to analyse experimental data because the S/N ratio represents both the average (mean) and variation (scatter) of the experimental results. In single objective optimization, Taguchi method provides the individual optimal setting for each output parameters. The experiments are conducted as per Taguchi method and experimental data is collected for surface roughness. Surface roughness is measured for each level of spindle vibration and average value is taken as the final value shown in table 2. Minitab17 software is used for data analysis as it provides an effortless method to create, edit and update graphs. Also it provides a dynamic link between a graph and its worksheet that helps in updating the graph automatically whenever the data is changed. Its appearance and easy to use enhancements further add to its advantages.

Data analysis has been carried out by Taguchi method as shown below.

Selection of equation for Signal-to-Noise ratio (S/N ratio) according to the objective of optimization. As the objective is to minimize the surface roughness, therefore lower the better (LB) equation (1) of S/N ratio has been selected.

Computation of S/N ratio for each run. Surface roughness with S/N ratio is listed in Table 3.

Calculation for response table for mean S/N ratio at each level of surface roughness to identify the rank of level (Table 4).

Selection of optimal setting from mean S/N ratio (fig 4).

Computation of ANOVA to find the significance and contribution of each parameter on the surface roughness (Table 5).

Volume 5 Issue III, March 2017
ISSN: 2321-9653

Calculation of predicted value of surface roughness by predicted additive model.

Verification of predictive model by confirmatory test.

TABLE 3 SURFACE ROUGHNESS AND SIGNAL TO NOISE RATIO

Run	Avg_SR	SR_SN
1	8.30	-18.3834
2	6.21	-15.8636
3	4.84	-13.7044
4	7.03	-16.9452
5	5.18	-14.2887
6	3.14	-9.9410
7	5.13	-14.1991
8	3.84	-11.6875
9	2.23	-6.9513
10	7.16	-17.0969
11	5.61	-14.9780
12	4.06	-12.1633
13	5.48	-14.7814
14	4.30	-12.6739
15	2.48	-7.8905
16	4.67	-13.3826
17	3.12	-9.8784
18	1.57	-3.8945
19	5.96	-15.4989
20	4.57	-13.1956
21	3.40	-10.6198
22	5.41	-14.6686
23	3.86	-11.7326
24	1.82	-5.2012
25	4.31	-12.6813
26	2.91	-9.2782
27	1.03	-0.2554

A. Mean S/N Ratio for Surface Roughness

The mean S/N ratio for each input parameter at levels 1, 2, and 3 is calculated by averaging the S/N ratios at respective level and is shown in Table 4. The delta is calculated by taking the difference of maximum and minimum value of mean S/N ratio. The rank of input parameter is decided by the delta. Higher value of delta, higher is the rank of input parameter. The rank of the parameter shows that which parameter is most effective. The mean S/N Ratio is used to find out optimal level for each parameter and rank of the parameter. Fig.7.1 illustrates the main effect plot for S/N of surface roughness.

TABLE 4 RESPONSE TABLE FOR S/ N RATIOS (SMALLER THE BETTER) OF SURFACE ROUGHNESS

Level	Cutting environment	Nose radius	Feed rate	Depth of cut	Tool type
1	-13.552	-14.612	-15.293	-11.651	-11.197
2	-11.860	-12.014	-12.620	-11.282	-11.926
3	-10.348	-9.134	-7.847	-12.827	-12.636
Delta	3.204	5.477	7.446	1.546	1.439
Rank	*3*	*2*	*1*	*4*	*5*

Volume 5 Issue III, March 2017
ISSN: 2321-9653

B. Analysis of Variance (ANOVA)

TABLE 5 ANOVA FOR SIGNAL TO NOISE RATIO OF SURFACE ROUGHNESS

Process parameters	Degree of freedom	Sum of square	Mean sum of square	F	P	% Contribution
Cutting environment(A)	2	46.233	23.116	39.15	0.002	09.84
Nose radius (B)	2	135.121	67.560	114.42	0.000	28.77
Feed rate (C)	2	256.119	128.059	216.88	0.000	**54.54**
Depth of cut (D)	2	11.731	5.865	9.93	0.028	02.50
Tool type (E)	2	9.319	4.660	7.89	0.041	01.98
*A * B*	4	0.634	0.159	0.27	0.885	00.14
*A * C*	4	6.381	1.595	2.70	0.719	01.36
*A * D*	4	1.726	0.432	0.73	0.616	00.37
Residual Error	4	2.362	0.590			
Total	*26*	*469.626*				

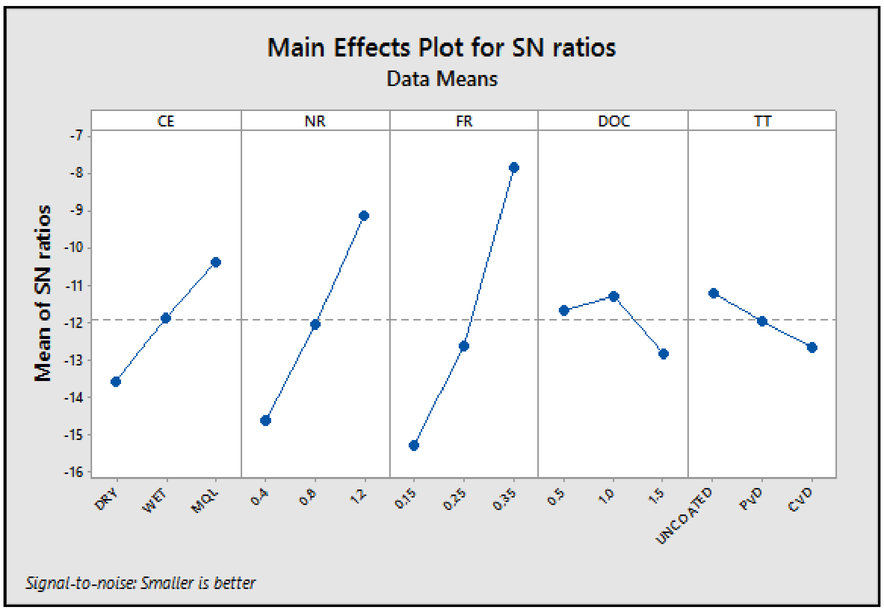

Fig. 4 Main effect plot for S/N

C. Prediction of Surface Roughness at Optimal Setting $A_3B_3C_3D_2E_1$

Optimal value of output parameter can be predicted by additive model

$$\mu_{pred} = \bar{Y} + \sum(\bar{Y}_i - \bar{Y})$$

□*SR* □□*YSR* □□(A3 □□*YSR*) □□(B3□□*YSR*) □□(C3 □□*YSR*) □□(D2 □□*YSR*) □□(E1 □□*YSR*)

□*SR* = 4.36+(3.70-4.36)+(3.20- 4.36)+(2.73- 4.36)+(4.35-4.36)+(4.40- 4.36)

= 0.947um

Error variance Ve =0.0706 (from Table 7.2)

Therefore, CI= +- 0.2718

The 95% confidence interval of the population is: [µSR − CI] < µSR < [µSR + CI]

0.675< 0.947< 1.219

TABLE 6 CONFIRMATORY EXPERIMENT FOR SURFACE ROUGHNESS (UM)

Surface Roughness (um)			
Sample	NF_1 1.7 m/s^2	NF_2 4.3 m/s^2	NF_3 6.9 m/s^2
1	0.906	0.919	1.094
2	0.908	0.913	1.149
3	0.906	0.916	1.070
Average	0.907	0.916	1.104
Total Average	**0.98**		

V. RESULTS

The results of ANOVA indicate that feed rate is the most significant machining parameters followed by nose radius, cutting environment, depth of cut and tool type. Based on the main effect plot of S/N ratio, the optimal machining parameters are the cutting environment at level 3 (A_3 = MQL), nose radius at level 3 (B_3= 1.2 mm), feed rate at level3 (C_3=0.35 mm/rev), depth of cut at level 2 (D_2 = 1.0 mm), and tool type at level 1 (E_1= Uncoated or $A_3B_3C_3D_2E_1$ in short.

TABLE 7 VALUES OF PROCESS PARAMETERS AT OPTIMUM LEVEL

Process Parameters	Code	level1	level2	level3
Cutting Environment	A	DRY	WET	MQL
Nose radius(mm)	B	0.4	0.8	1.2
Feed rate (mm/rev)	C	0.15	0.25	0.35
Dept of cut (mm)	D	0.5	1	1.5
Tool type	E	Uncoated	PVD	CVD

VI. CONCLUSION

The Taguchi method is successfully applied in this study to find optimal setting for turning EN 24 steel. The results are discussed as follows:

The single-objective problem is solved with the application of Taguchi Analysis.

Quality characteristic Surface roughness is optimized to 0.98 um.

Optimal parameter setting for turning EN 24 is ($A_3B_3C_3D_2E_1$) i.e. cutting environment=MQL, nose radius=1.2 mm, feed rate =0.35 mm/rev, depth of cut = 1.0 mm, and uncoated cutting tool.

Conformity test shows that the predicted and experimental values of surface roughness are within the range given by confidence interval.

REFERENCES

[1]. Wuyi Chen, "Cutting forces and surface finish when machining medium hardness steel using CBN tools", International Journal of Machine Tools &Manufacture, Elsevier, 2000, pp. 455-466

[2]. S.M. Darwish, "The impact of the tool material and the cutting parameters on surface roughness of supermet 718 nickel super alloy", Journal of Materials Processing Technology, Elsevier, 2000, pp. 10-18.

[3]. C.R. Liu, Y.B. Guo, "Finite element analysis of the effect of sequential cuts and tool chip friction on residual stresses in a machined layer", International Journal of Mechanical Sciences, Elsevier, 2000, pp 1069-1086.

[4]. M.H. El-Axir, "A method of modeling residual stress distribution in turning for different materials", International Journal of Machine Tools & Manufacture, Elsevier, 2002, pp. 1055-1063.

[5]. Hari Singh, Pradeep Kumar, "Tool wear optimization in turning operation by Taguchi Method", Indian Journal of Engineering & Material Sciences, vol 11, 2003, pp 19-24.

[6]. Hari Singh, Pradeep kumar, "Optimizing Cutting Part For Turned Part By Taguchi Parameter Design Approach", Indian Journal of Engineering & Material Sciences, vol 12, 2005, pp.97-103.

[7]. S.R. Carvalho , S.M.M. Lima e Silva , A.R. Machadoa, G. Guimar, "Temperature determination at the chip–tool interface using an inverse thermal model considering the tool and tool holder", Journal of Materials Processing Technology, Elsevier, 2006, pp. 97-104.

Volume 5 Issue III, March 2017
ISSN: 2321-9653