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Research Article

An Experimental Parametric Study of the Impact of Cutting Factors on Surface Roughness of EN 19 Steel during Turning Operation

VivekJohn[Ȧ*] and Rahul Davis[Ȧ]

[Ȧ]Department of Mechanical Engineering, Shepherd School of Engineering &Technology, Sam Higginbottom Institute f Agriculture, Technology & Sciences, Allahabad, India

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Abstract

The objective of this paper is to analyze and study the impact of the cutting parameters on surface roughness of EN-19 steel as the specimen and with the application of Taguchi Methodology to acquire the required data. In the current paper five different cutting parameters were taken and L-16 orthogonal array was used to get the various combinations of the optimal result from the number of experiments performed. The results were analyzed by using signal to noise ratio and ANOVA method. The Taguchi method has shown that optimal settings of the factors, for producing better surface finish, were spindle speed followed by pressurized coolant jet, rake angle, feed rate and depth of cut. Vibrations of the machining, tool chattering are the factors which contribute to poor surface finish. The results obtained by this method will be useful to other research work for similar type of study and would help the engineers as an eye openers for further research on tool vibrations, cutting forces etc.

Keywords: *Taguchi method, EN-19 Steel, ANOVA, Signal to Noise Ratio*

1. Introduction

The challenge of modern machining industries is mainly focused on the achievement of high quality, in terms of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact (custompartnet.com). Turning is a process in which material removal takes place from the surface of the work piece. It is used to produce parts having different geometry like holes, grooves tapers, threads etc having different dimensions, it also act as a refining feature to those products which were manufactured by various other process (S. Thamizhmanii et al, 2006). Surface roughness is one of the constraints to be considered before machining of the product takes place.

In the present work EN19-steel which is good ductility and resistance to wear (Westyorkssteel, 1975), was chosen as the specimen for turning operation and effect of cutting parameters on surface roughness was studied.

Taguchi method uses a special design of set of orthogonal array in which small number of experiments was done to get the result moreover it influence the quality of products (Diwakar Reddy *et al*, 2011;V, Krishnaiah.G*et al*, 2011).

2. Methodology

In this research work L16 Taguchi orthogonal method has been used in order to study the effect of five different process parameters (spindle speed, pressurized coolant jet, rake angle, feed rate, Depth of cut) on the surface roughness of EN-19 steel in turning operations (Mahapatra S.S. *et al*, 2006)by Carbide P-30 cutting tool and surface roughness was measured in each run in Sparko Engineering Workshop, Allahabad. Therefore for the following research, EN-19 steel with carbon (0.39%), silicon (0.24), Chromium (1%) and Manganese (0.68%) was chosen for specimen material.

Table: 2.1 Details of the Turning Operation

Factors	**Level 1**	**Level2**
Depth of Cut(mm)	0.5	1.0
Feed Rate (mm/rev)	0.16	0.8
Spindle Speed (rpm)	760	1560
Pressurized Coolant Jet (bar)	0.5	1
Rake angles (degrees)	4^0	7^0

From Table 2.3 and 2.4, Optimal Parameters for Turning Operation were A_1, $B_{2,}$ $C_{2,}$ $D_1$and E_2 Signal-to-noise ratio (SN) is utilized to measure the deviation of quality characteristic from the target. In this experiment, the response is the surface roughness which should be maximized, so the desired SNR characteristic is in the category of Larger the better.

Table 2.3 shows the SNR of the surface roughness for each level of the factors. From Table 2.3 the difference of SN ratio between level 1 and 2 indicates that spindle speed contributes the highest effect ($\Delta_{max-min}$=4.48) on the surface roughness followed by pressurized coolant jet

Table 2.2: Results of Experimental Trial Runs for Turning Operation

Expt.	Feed Rate	Spindle	Depth of	Rake Angle	Pressurized	Surface	SN Ratio
1	0.16	780	0.5	4	0.5	44.0	-32.8691
2	0.16	780	0.5	7	1.0	54.9	-34.7914
3	0.16	780	1.0	4	1.0	41.0	-32.2557
4	0.16	780	1.0	7	0.5	133.5	-42.5096
5	0.16	1560	0.5	4	1.0	26.9	-28.5950
6	0.16	1560	0.5	7	0.5	95.2	-39.5727
7	0.16	1560	1.0	4	0.5	87.4	-38.8302
8	0.16	1560	1.0	7	1.0	49.6	-33.9096
9	0.8	780	0.5	4	1.0	40.0	-32.0412
10	0.8	780	0.5	7	0.5	47.5	-33.5339
11	0.8	780	1.0	4	0.5	25.2	-28.0280
12	0.8	780	1.0	7	1.0	35.2	-30.9309
13	0.8	1560	0.5	4	0.5	129.2	-42.2253
14	0.8	1560	0.5	7	1.0	122.0	-41.7272
15	0.8	1560	1.0	4	1.0	75.2	-37.5244
16	0.8	1560	1.0	7	0.5	105.2	-40.4403

Table 2.3: Response Table for Signal to Noise Ratios

Level	Feed Rate (mm/rev) (A)	Spindle speed (rpm) (B)	Depth of Cut (mm) (C)	Rake Angle (degrees) (D)	Pressurized Coolant Jet (bar) (E)
1	-35.42	-37.85	-35.67	-34.05	-37.25
2	-35.81	-33.37	-35.55	-37.18	-33.97
$\Delta_{max-min}$	0.39	4.48	0.12	3.13	3.28
Rank	4	1	5	3	2

Table 2.4: Response Table for Means

Level	Feed Rate (mm/rev) (A)	Spindle speed (rpm) (B)	Depth of Cut (mm) (C)	Rake Angle (degrees) (D)	Pressurized Coolant Jet (bar) (E)
1	66.56	86.34	69.96	58.61	83.40
2	72.44	52.66	69.04	80.39	55.60
$\Delta_{max-min}$	5.88	33.67	0.92	21.78	27.80
Rank	4	1	5	3	2

Table 2.5 Analysis of Variance for SN Ratio

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Feed Rate (mm/rev)	1	138	138	138	0.09	0.776
Spindle speed (rpm)	1	4536	4536	4536	2.89	0.133
Depth of Cut (mm)	1	3	3	3	0.00	0.964
Rake Angle (degrees)	1	1897	1897	1897	1.21	0.308
Pressurized Coolant Jet (bar)	1	3091	3091	3091	1.97	0.204
Depth of Cut (mm)*Rake Angle (degrees)	1	14	14	14	0.01	0.926
Depth of Cut (mm)* Pressurized Coolant Jet (bar)	1	382	382	382	0.24	0.637
Rake Angle (degrees)* Pressurized Coolant Jet (bar)	1	18	18	18	0.01	0.918
Errors	7	11004	11004	1572		
Total	15	21084				

($\Delta_{max-min}$ = 3.28), rake angle ($\Delta_{max-min}$= 3.13), feed rate ($\Delta_{max-min}$=0.39) and depth of cut ($\Delta_{max-min=}$0.12).

Table 2.4 indicates the same result in terms of the difference of Mean between level 1 and 2 indicates that spindle speed contributes the highest effect ($\Delta_{max-min}$=33.67) on the surface roughness followed by pressurized coolant jet ($\Delta_{max-min}$ = 27.80), rake angle ($\Delta_{max-min}$ = 21.78), feed rate ($\Delta_{max-min}$=5.88) and depth of cut ($\Delta_{max-min=}$0.92).

Therefore the Predicted optimal value of Means of Surface Roughness

$\eta_{p(Surface\ Roughness)}$

= 69.5+[66.56-69.5]+[52.66-69.5]+[69.04-69.5]+[58.61-69.5]+[55.60-69.5]

= 24.54

Therefore the optimal Predicted value of average Surface roughness for SN Ratio

$\mu_{p(SN\ Ratio)}$ =-35.61+[-35.42+35.61]+[-33.3+35.61]+[-35.55+35.61]+[-34.05+35.61]+[33.97+35.61] = -29.92

Thus the optimal predicted value of is $\mu_{p(Surface\ Roughness)}$ = -29.92

Table 2.6: Response Table for Signal to Noise Ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Feed Rate (mm/rev)	1	0.61	0.61	0.61	0.02	0.884
Spindle speed (rpm)	1	80.39	80.39	80.39	3.05	0.124
Depth of Cut (mm)	1	0.05	0.05	0.05	0.00	0.965
Rake Angle (degrees)	1	39.21	39.21	39.21	1.49	0.262
Pressurized Coolant Jet (bar)	1	43.01	43.01	43.01	1.63	0.242
Depth of Cut (mm)*Rake Angle (degrees)	1	0.47	0.47	0.47	0.02	0.897
Depth of Cut (mm)*Pressurized Coolant Jet (bar)	1	1.07	1.07	1.07	0.04	0.846
Rake Angle (degrees)*Pressurized Coolant Jet (bar)	1	0.62	0.62	0.62	0.02	0.882
Error	7	184.38	184.38	26.34		
Total	15	349.82				

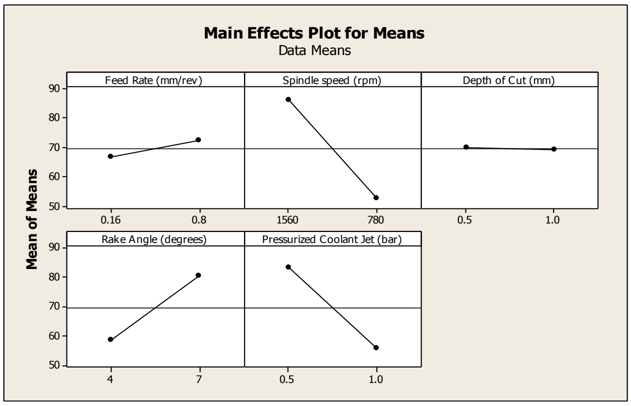

Figure 1.1 Main Effects Plot for Means

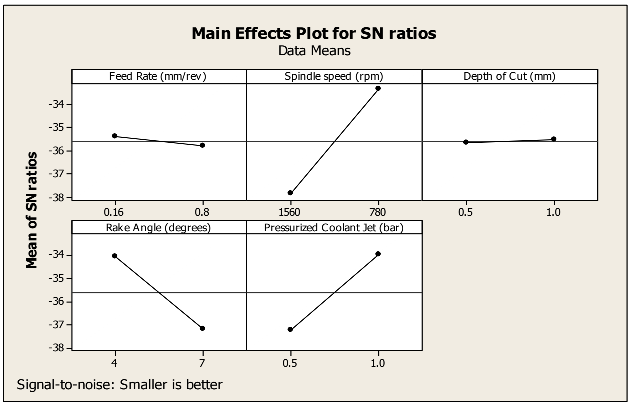

Figure1.2: Main Effects Plot for SN ratio

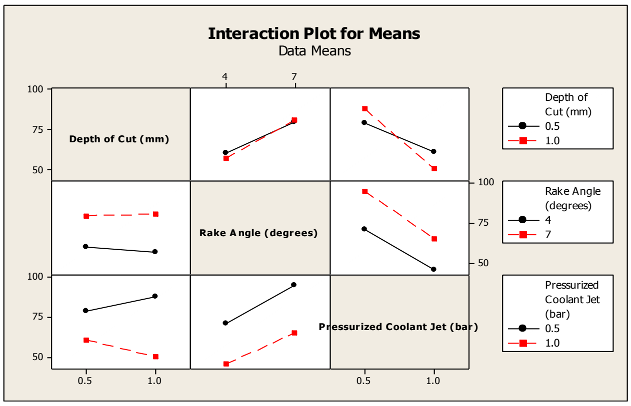

Figure 1.3: Interaction plot for Means

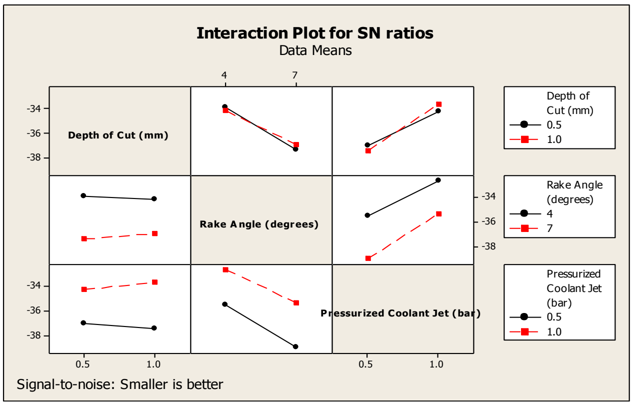

Figure 1.4: Interaction plot for SN ratio

3. Results and Discussion

The combination of the optimum levels of the parameters is found in the trial number seven of the table no. 2.2.Comparing the ($F_{0.05;1;15}$ = 4.96)values of ANOVA Table 2.5 and 2.6 of Surface Roughness with the suitable F values shows that none of the factor was found to be significant moreover none of the interaction were found to be significant.

Table 2.7: Results of the Confirmation Tests for the optimal levels of the factors

Feed rate (mm/rev)	0.16	0.16	0.16	0.16
Spindle Speed (rpm)	1560	1560	1560	1560
Depth of Cut (mm)	1	1	1	1
Rake Angle (degree)	4	4	4	4
Pressurized Coolant Jet (bar)	0.5	0.5	0.5	0.5
Surface Roughness	87.2	86.1	87.3	87

Results

- All the factors and the confirmation test satisfy and confirm that the obtained results were satisfactory.
- The research work can be used to minimize the surface roughness by using within preset conditions.
- EN19 steel having 0.39% carbon was used as the specimen; it can also be applied to the other materials having different chemical compositions.

- Research work can be expanded by including more number of interactions of different levels of the factors.

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