OPTIMIZATION OF SURFACE ROUGHNESS IN FACE TURNING OPERATION IN MACHINING OF EN-8

K. Adarsh Kumar[1],Ch.Ratnam[2], BSN Murthy[3], B.Satish Ben[4], K. Raghu Ram Mohan Reddy[5]
[1] *Professor, Department Of Mechanical Engineering, Andhra University, Visakhapatnam.* ***chratnam@gmail.com***
[3] *Associate Professor, Department Of Mechanical Engineering, GITAM University, Visakhapatnam.,* ***Bsnmurthy_au@yahoo.co.in***
[2, 4, 5] *Assistant Professor, Department Of Mechanical Engineering, GITAM University, Visakhapatnam.*
adarsh@gitam.edu, satishben@yahoo.com, raghu.kappa@gmail.com

Abstract:

Surface finish is one of the prime requirements of customers for machined parts. The purpose of this research paper is focused on the analysis of optimum cutting conditions to get lowest surface roughness in facing by regression analysis. This present paper presents an experimental study to investigate the effects of cutting parameters like spindle speed, feed and depth of cut on surface finish on EN-8. A multiple regression analysis (RA) using analysis of variance is conducted to determine the performance of experimental measurements and to it shows the effect of cutting parameters on the surface roughness. Multiple regression modeling was performed to predict the surface roughness by using machining parameters. The investigation of influence of cutting conditions in facing operation of EN-8 in this paper. Machining was done using cemented carbide insert. The objective was to establish correlation between cutting speed, feed rate and depth of cut and optimize the turning conditions based on surface roughness. These correlations are obtained by multiple regression analysis (RA).

Key words: Machining; Dry Facing, EN-8, Surface roughness; Regression analysis (RA).

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1. INTRODUCTION:

Surface roughness has received serious attention for many years. It has formulated an important design feature in many situations such as parts subject to fatigue loads, precision fits, fastener holes, and aesthetic requirements. In addition to tolerances, surface roughness imposes one of the most critical constraints for the selection of machines and cutting parameters in process planning [3]. Surface finish is the method of measuring the quality of a product and is an important parameter in machining process. It is one of the prime requirements of customers for machined parts. Productivity is also necessary to fulfill the customers demand. For this purpose quality of a product and productivity should be high. In addition to the surface finish quality is also an important characteristic in turning operation and high MRR is always desirable[2]. Even in the occurrence of chatter or vibrations of the machine tool, defects in the structure of the work material, wear of tool, or irregularities of chip formation contribute to the surface damage in practice during machining [1].

1.1. Facing Operations:

Facing is the process of removing metal from the end of a work piece to produce a flat surface. Most often, the work piece is cylindrical, but using a 4-jaw chuck you can face rectangular or odd-shaped work to form cubes and other non-cylindrical shapes.

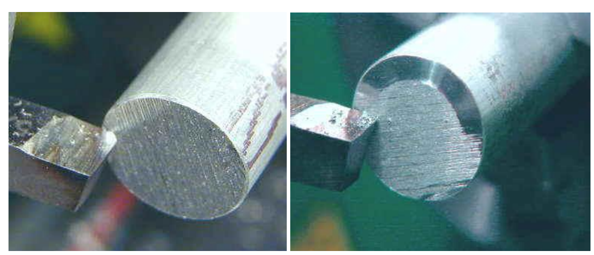

Figure 1: Facing Operation

When a lathe cutting tool removes metal it applies considerable tangential (i.e. lateral or sideways) force to the work piece. To safely perform a facing operation the end of the work piece must be positioned close to the jaws of the chuck. The work piece should not extend more than 2-3 times its diameter from the chuck jaws unless a steady rest is used to support the free end.

1.2. Measurement of Surface Roughness:

The surface roughness was done as coarse, rough, medium and fine. The hand feel and visional inspection were used for theses classifications. There are many ways to define surface roughness depending on its applications like Ra, Rt, Rq, Rk, but roughness average Ra is widely used in industry for the mechanical components for indication of surface roughness, also known as arithmetic aver-age (AA) or centre line average (CLA) [ISO-4287, 1997]. Is the area between surface profile and centre line [1], hence in this study Ra is used for indication of surface roughness [4]

$$Ra = \frac{1}{L}\int_0^L |Y(x)|\, dx$$

Whereas L is the sample length, Y(x) is the profile along the direction x. Also

$$Ra = \frac{1}{n}\sum_{i=1}^{n} |Y_i|$$

Where n is the total number of samples and Yi is the height of profile at ith position.

Surface roughness plays an important role in product quality. X. Wang [5] focuses on developing an empirical model for the prediction of surface roughness in finish turning. The model considers the following working parameters: work piece hardness (material); feed; cutting tool point angle; depth of cut; spindle speed; and cutting time. One of the most important data mining techniques, nonlinear regression analysis with logarithmic data transformation, is applied in developing the empirical model [5].

A popularly used model for estimating the surface roughness value is as follows [5] pp.634 and [1] pp.166.

$$Ri = \frac{f^2}{32r}$$

Where R_i = ideal arithmetic average (AA) Surface roughness (in or mm),

f = feed (in rev^{-1} or mm rev^{-1})

2. EXPERIMENTAL SET UP AND CUTTING CONDITIONS

The experiment was conducted using one work piece material namely EN-8 with coated ceramic tool. .The tests were carried for a length of 60X 60 mm in a Madras Machine tool mfrs. Ltd lathe. The cutting parameters are shown in the Table 1. Three levels of cutting speed, three levels of feed and three levels of depth of cut were used and are shown in the Table 1. The different alloying elements present in a work piece and cutting insert are shown in the table 2 & 3.

Cutting parameters	Level 1	Level 2	Level 3
Cutting speed (rpm)	100	360	560
Feed (mm/rev)	0.14	0.15	0.16
Depth of cut (mm)	0.5	1.0	1.5

Tab: 1 Cutting parameters

C	Si	Mn	S	P
0.4%	0.25%	0.8%	0.015%	0.015%

Tab: 2 Chemical composition of EN-8.

Co	TiC	WC
8%	15%	77%

Tab: 3 Typical composition of Cemented Carbide cutting

The surface roughness was measured by using Mitutoyo SJ-310 instrument. The dependent variable is surface roughness. In total 27 experiments were conducted and responses are shown in the Table 8. It gives the various cutting parameters for each experiment the results are measured and shown in the last column of the same Table 8. The different units used here are cutting speed (rpm) Feed-(mm/rev), depth of cut (DOC) – mm, surface roughness Ra - µm. Mini-Tab software was used for Regression analysis. Dry Facing process was used.

Fig 2: Experimental set up

Fig 3 : Mitutoyo SJ-310 for Surface roughness Measurement

3. REGRESSION ANALYSIS (RA):

It is used to investigate and model the relationship between a response variable and one or more predictors. Minitab provides least square, partial least square and logistic regression procedures. A multiple regression analysis was conducted on the tested data. Coefficients of The analysis of variance results of the regression model also supported linear relationships in the model (Table 5)

The regression equation is

Surface Roughness Ra (µm) = 9.59 - 0.00476 Speed (rpm) - 31.6 Feed (mm/rev) + 0.559 DOC (mm) ………. . ……….. (3.1)

Predictor	Coef	SE Coef	T	P	VIF
Constant	9.5868	0.2334	41.07	0.000	
Spindle speed(rpm)	-0.00476086	0.00006647	-71.63	0.000	1.000
Feed(mm/Rev)	-31.556	1.533	-20.58	0.000	1.000
DOC (mm)	0.55889	0.03066	18.23	0.000	1.000

S = 0.0650437 R-Sq = 99.6% R-Sq (adj) = 99.6%
PRESS = 0.137065 R-Sq (pred) = 99.45%

Source	DF	SS	MS	F	P
Regression	3	24.9027	8.3009	1962.08	0.000
Residual Error	23	0.0973	0.0042		
Total	26	25.0000			

Table 5: Analysis of Variance

Source	DF	Seq SS
Spindle speed(rpm)	1	21.7048
Feed(mm/Rev)	1	1.7924
DOC (mm)	1	1.4056

Table 6: Sequential sum of squares:

Obs	Spindle speed (rpm)	Surface Roughness (Ra)	Fit	SE Fit	Residual	St Resid
4	100	4.4900	4.6569	0.0254	-0.1669	-2.79R
6	100	5.3400	5.2158	0.0254	0.1242	2.08R

Table 7: Unusual Observations:

R denotes an observation with a large standardized residual

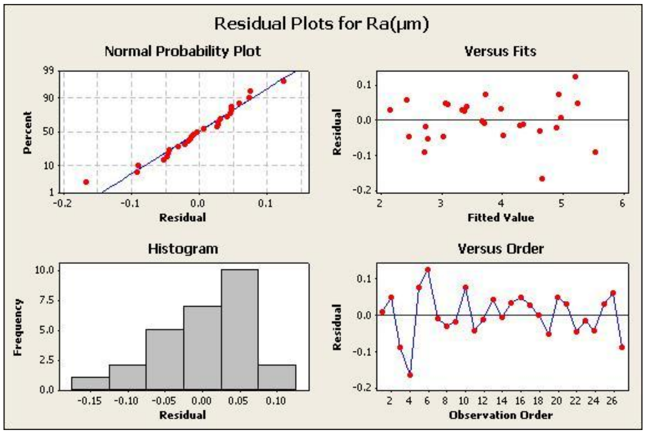

Fig 4: Residual plots for surface roughness

No of Experiments	Speed N(rpm)	Feed (mm/rev)	D.O.C(mm)	Experimental Ra (µm)	Predicted Ra (µm)	Error
1	100	0.14	0.5	4.98	4.9695	0.0105
2	100	0.14	1	5.3	5.249	0.051
3	100	0.14	1.5	5.44	5.5285	-0.0885
4	100	0.15	0.5	4.49	4.6535	-0.1635
5	100	0.15	1	5.01	4.933	0.077
6	100	0.15	1.5	5.34	5.2125	0.1275
7	100	0.16	0.5	4.33	4.3375	-0.0075
8	100	0.16	1	4.59	4.617	-0.027
9	100	0.16	1.5	4.88	4.8965	-0.0165
10	360	0.14	0.5	3.81	3.7319	0.0781
11	360	0.14	1	3.97	4.0114	-0.0414
12	360	0.14	1.5	4.28	4.2909	-0.0109
13	360	0.15	0.5	3.46	3.4159	0.0441
14	360	0.15	1	3.69	3.6954	-0.0054
15	360	0.15	1.5	4.01	3.9749	0.0351
16	360	0.16	0.5	3.15	3.0999	0.0501
17	360	0.16	1	3.41	3.3794	0.0306
18	360	0.16	1.5	3.66	3.6589	0.0011
19	560	0.14	0.5	2.73	2.7799	-0.0499
20	560	0.14	1	3.11	3.0594	0.0506
21	560	0.14	1.5	3.37	3.3389	0.0311
22	560	0.15	0.5	2.42	2.4639	-0.0439
23	560	0.15	1	2.73	2.7434	-0.0134
24	560	0.15	1.5	2.98	3.0229	-0.0429
25	560	0.16	0.5	2.18	2.1479	0.0321
26	560	0.16	1	2.49	2.4274	0.0626
27	560	0.16	1.5	2.62	2.7069	-0.0869
				Average error	= 0.047411	

Table 8: Values of Predicted Surface Roughness and error

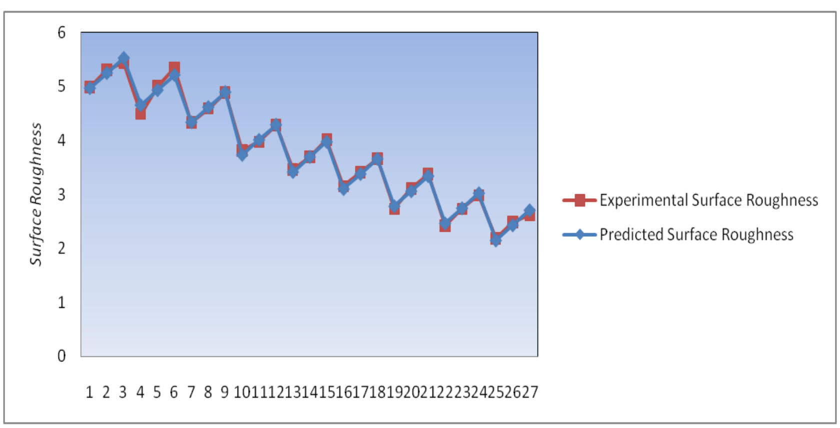

Fig 5: Comparison of Experimental surface roughness and Predicted Surface Roughness

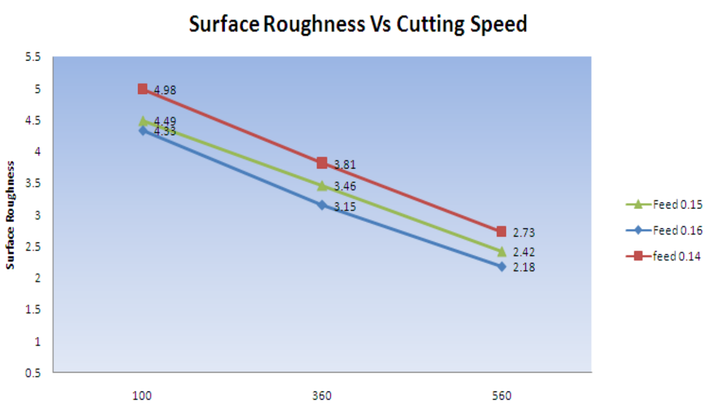

Fig 6: Surface roughness Vs Cutting speed at Constant Depth of cut = 0.5 mm

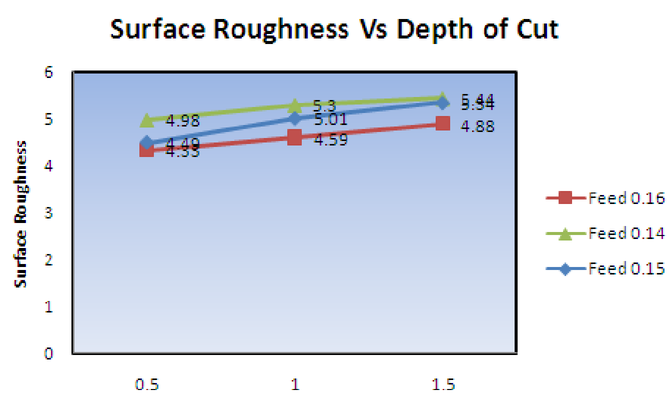

Fig 7 : Surface roughness Vs Depth of cut at Constant Cutting speed =100 rpm

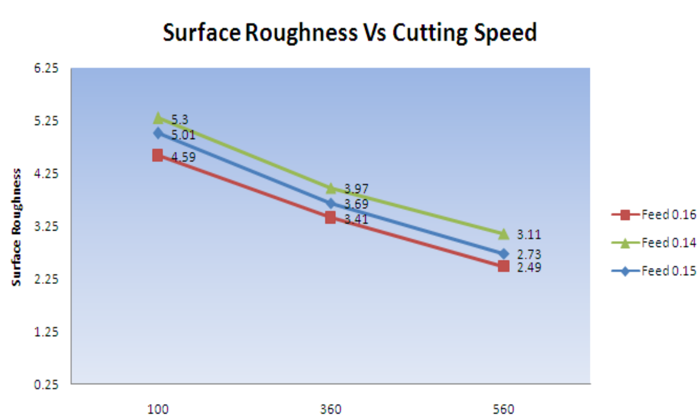

Fig 8: Surface roughness Vs Cutting speed at Constant Depth of cut = 1 mm

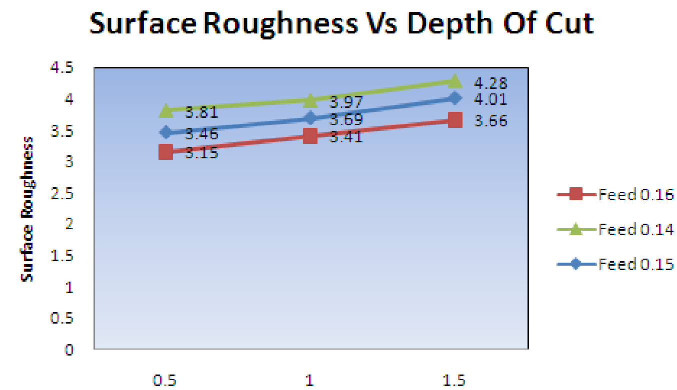

Fig 9: Surface roughness Vs Depth of cut at Constant Cutting speed =360 rpm

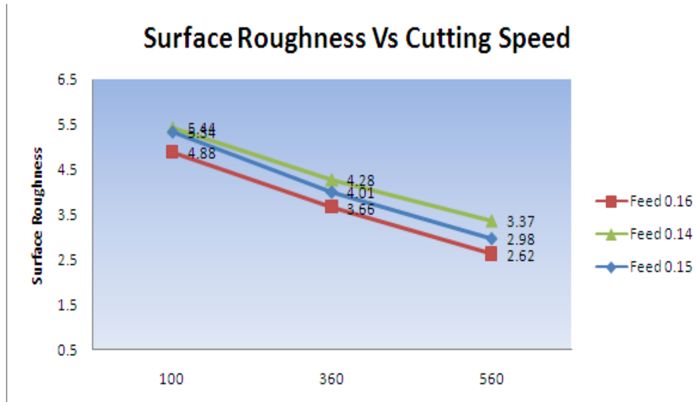

Fig 10: Surface roughness Vs Cutting speed at Constant Depth of cut = 1.5 mm

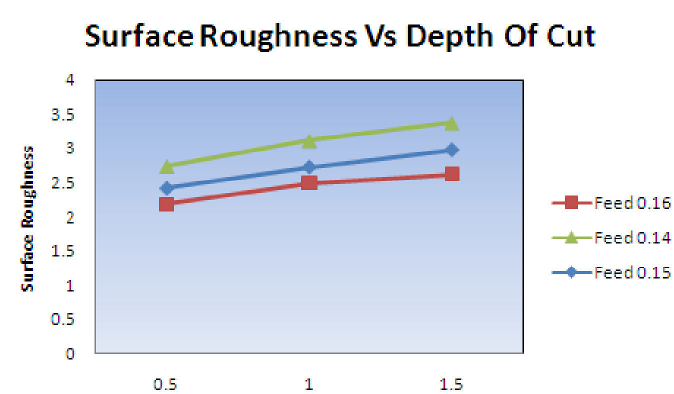

Fig 11: Surface roughness Vs Depth of cut at Constant Cutting speed =560 rpm

CONCLUSION:

In this paper the effect of machining parameters speed, feed, depth of cut, are studied on surface roughness for face turning operation using EN-8. Regression Analyses (RA) technique is used to study the effect of these parameters and their interaction on surface roughness. An empirical equation is formed by using Regression Analyses (RA) in Mini-Tab software to predict the surface roughness. The surface roughness model produced during this research work may be used in enhancing the surface quality of a product as cutting parameters are optimized and can give better surface finish. In this paper observed the results the influence of cutting speed and feed rate and depth of cut on surface roughness, the test was performed and it was seen that the effect of feed rate is greater than the effect of cutting speed from figure 6 to 11 shows a result, to improve the surface roughness, a good combination of cutting speed and feed rate needs to be selected. The feed has the variable effect on surface roughness. The relationship between feed rate and surface roughness is proportional, figure 6,8,10 shows the relation that increasing the feed rate, increases the surface roughness. On surface roughness, the effect of feed rate is more considerable than cutting speed.

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