To Study the Effect of Cutting Tool Geometry on Surface Roughness of Aluminium

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Abstract— Present study is focused to investigate the effect of single point cutting tool geometry on the surface roughness of Aluminium during turning operation. The single point cutting tools with different rake angle, clearance angle and nose radius is used. Using full factorial technique mathematical model is developed from the data obtained by experiments. Adequacy of developed model and significance of coefficients has been checked using student's't' test and 'F' test respectively at 95% confidence level. It is found that surface roughness is decrease with increase in rake angle and it is increases with increases in nose radius

Key words: CNC Turning Machine, Cutting Tool, Surface Roughness of Aluminium

I. INTRODUCTION

To achieve required surface quality with machining processes cutting tool geometry should be chosen properly. Nose radius, rake angle, clearance angle, cutting speed, feed, cutting tool material has influence on surface quality of work piece which helps to determine the machining cost. [1,6]. To decrease the production cost without compromising product quality many researchers have worked on surface roughness by chip removal methods and influence of cutting parameters on surface roughness. [2]. some study conducted to determine optimum combination of tool rake angle and nose radius for desired surface finish. Problems during cutting process have been reduced by CNC turnind machine. [3].

The present study shows influence of tool rake angle, nose radius and clearance angle on surface roughness during machining of Aluminium on CNC turning machine. [4].

II. EXPERIMENTATION

25 mm diameter and 80 mm length aluminium rods is machined with CNC machine using single point cutting tool with different rake angle, clearance angle and nose radius. The range of cutting tool parameters is shown in table 1. [5]. The objective of study is to optimise the cutting tool geometry on turning operation for surface roughness. [7].

A two level factorial design ($2^3 = 8$) eight trials is selected for studying the effect of cutting tool parameter on surface roughness. The set of eight trials are repeated three times for determining the variance of optimisation parameter and once for variance of adequacy. To avoid any systematic error the experiments are performed in a random order. Table 2 shows the responses of three sets of experiments.

Parameter	Unit	Symbol	Upper Limit	Lower Limit
Rake angle	Degree	R	5	30
Nose radius	Milimeter	N	0.04	0.08
Clearance angle	Degree	C	15	20

Table 1: Cutting Tool Parameters and Range.

Experiment no.	S1 (μm)	S2 (μm)	S3 (μm)
1	1.779	1.850	1.710
2	1.431	1.581	1.527
3	0.770	0.830	0.859
4	1.291	1.420	1.312
5	1.185	1.085	1.244
6	1.706	1.840	1.758
7	0.617	0.750	0.630
8	1.500	1.463	1.551

Table 2: Surface Roughness

S1 = Surface Roughness of Set 1
S2 = Surface Roughness of Set 2
S3 = Surface Roughness of Set 3

III. DEVELOPMENT OF MATHEMATICAL MODEL

The response function representing the surface roughness is:

$$Y = f(R, N, C)$$

Taking into account all possible two factors interactions and assuming a linear relationship in the first instant.

$$Y = a_0 + a_1 R + a_2 N + a_3 C + a_{12} RN + a_{13} RC + a_{23} NC \quad (3.1)$$

Where a_0 is combined effect of all parameter and a_1, a_2, a_3 are main effects and a_{12}, a_{13}, a_{23} are interactive effects of two parameters. The regression coefficients of the selected model are calculated on the basis of least square methods and shown in table 3.

Coefficient	Factor	Value
a_0	Combined effect of all factor	1.315
a_1	Rake angle (R)	-0.213
a_2	Nose Radius (N)	0.240
a_3	Clearance angle (C)	0.052
a_{12}	Interaction of R & N	0.129
a_{13}	Interaction of R & C	0.150
a_{23}	Interaction of C & N	0.052

Table 3: Regression Coefficient for Surface Roughness.

The significance of the coefficients can be tested by student's't' test. After dropping insignificant coefficients, the developed model of surface roughness is:

$$Y = 1.315 – 0.213R + 0.240N + 0.129RN + 0.150RC \quad (3.2)$$

Using the analysis of variance technique the adequacy of the developed model is tested according to which the calculated value of F-ratio of the model should not exceed the standard tabulated value of F-ratio of desired level 95% in this case. The results has been shown in table 4.

Degree of freedom		Variance of Adequacy	Variance of response	F-Ratio Model (F_m)	F-Ratio Table (F_t)	Adequacy of Model
F	N	σ^2_{ad}	σ^2_y	$F_m = \sigma^2_{ad} / \sigma^2_y$	At 4,8, 0.05	Whether $F_m < F_t$
4	8	0.00476	0.00570	0.84	3.9	Yes

Table 4: Adequacy Test Results.

IV. RESULT AND DISCUSSION

To predict the effect of cutting tool geometry on surface roughness, the mathematical model of surface roughness as shown in equation 2 can be used.

A. Effect of Rake Angle on Surface Roughness

With increases in rake angle surface roughness is decreases. The effect of rake angle on surface roughness is shown in Fig. 1.

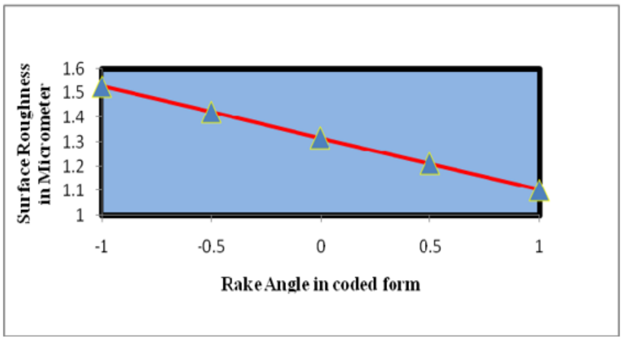

Fig. 1: Effect of rake angle on surface roughness.

B. Effect of Nose Radius on Surface Roughness

Fig. 2 shows the relationship between nose radius and surface roughness. With increases in nose radius, surface roughness is also increases. It is because the increase in nose radius the contact area increases which increases the friction between tool and work pieces and thus surface roughness.

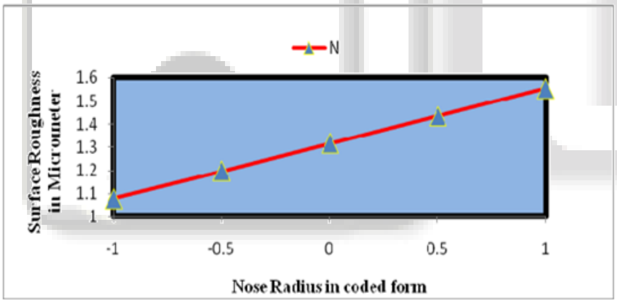

Fig. 2: Effect of nose radius on surface roughness.

C. Effect of Interaction of Rake Angle and Nose Radius on Surface Roughness

Using lower values of nose radius and increasing the rake angle, the surface finish can be improved. Fig. 3 shows the relationship between rake angle and nose radius on surface roughness.

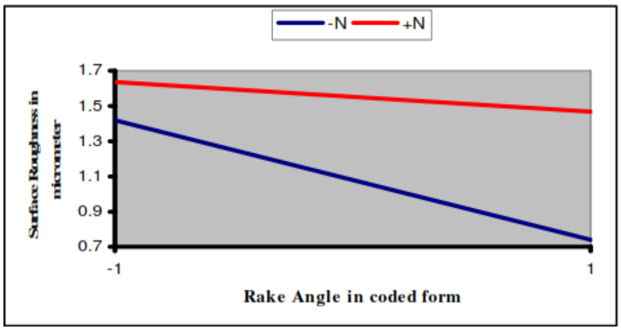

Fig. 3: Effect of interaction of rake angle and nose radius on surface roughness.

D. Effect of Interaction of Rake Angle and Clearance Angle on Surface Roughness

Fig. 4 shows the relationship between rake angle and clearance angle on surface roughness. It is clear from figure surface finish will improve with decrease in clearance angle and increase in rake angle.

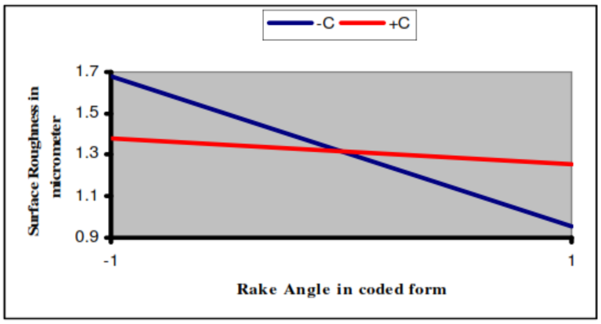

Fig. 4: Effect of interaction of rake angle and clearance angle on surface roughness.

V. CONCLUSION

The minimum value of surface roughness is obtained 1.103 µm at rake angle of 30° and maximum value of surface roughness is obtained 1.530 µm at rake angle of 5°. The minimum value of surface roughness is obtained 1.080 µm at nose radius of 0.04 mm and maximum value of surface roughness is obtained 1.555 µm at nose radius of 0.08 mm. The minimum value of surface roughness is obtained 0.705 µm at nose radius of 0.04 mm rake angle of 30° and maximum value of surface roughness is obtained 1.630 µm at nose radius of 0.08 mm and rake angle of 5°. The minimum value of surface roughness is obtained 0.950 µm at clearance angle of 15° and at rake angle of 30° and maximum value of surface roughness is obtained 1.670 µm at clearance angle of 15° and at rake angle of 5°. From above results it can be concluded that surface roughness decreases with increases in rake angle. Surface roughness increases with increases nose radius. Surface roughness decreases with combined effect of rake angle and nose radius. Surface finish will improve with decrease in clearance angle and increase in rake angle.

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