RESEARCHERID
THOMSON REUTERS

*[Singhal,* 6(6): June 2019] ISSN 2348 – 8034
IDSTM-2019 Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

# EFFECTS OF CUTTING TOOL SPECIFICATION ON SURFACE ROUGHNESS

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## ABSTRACT

This paper presents a study on the influence of the tool inclination angle, the tip radius and the angle of play on the surface roughness in the turning operation using a single-pointed cutting tool. The well-known material, aluminum was used for experimentation. Mathematical models were developed from the data generated using a complete factorial technique. The importance of the coefficients and the adequacy of the models developed were verified by the Student's t test and by the "F" test, respectively, with a 95% confidence level. It has been found that the developed models are adequate. The influences of the cutting parameters were presented in graphical form for a better understanding. It has been discovered from the present study that the surface roughness decreases with increasing angle of inclination and also increases with increasing nose radius.

***Keywords****: Rake angle, Nose radius, Aluminium, Mathematical model, Surface Roughness.*

## I. INTRODUCTION

To produce any part of the machine with a certain quality with any metal removal technique, the cutting parameters must be organized correctly. Depending on the material of the work piece and the desired geometry, the roughness of the surface has an important influence on the determination of the machining cost related to the radius of the tip, the angle of inclination, the angle of play, the cutting speed , feed speed, unformed chip thickness, cutting tool material, etc. In metal removal operations, many researches have been carried out in the past and many continue with the aim of reducing production costs without reducing the quality of the product. It has been observed in all the work on surface roughness with chip removal methods that the surface roughness is directly influenced by the cutting parameters such as the tip radius, the free angle, the cutting speed, the feed speed, depth of cut, angle of inclination of the tool. Cutting tools are subject to opposing forces and pressures during cutting, even if their cutting edges are sharp enough when processing metal and non-metallic materials. Many researchers have made an effort to determine the optimal combination of tilt and nose radius tools for better surface finish. Problems during the cutting process have been reduced to an acceptable level by transferring computer skills to CNC lathes. Many studies have been conducted on the effect of the cutting parameters (nose radius and angle of inclination) on the roughness of the surface. All results obtained from all these studies were evaluated. In this study, the influence of the tip radius of the tool tilt angle on the roughness of the surface was determined during processing of the aluminum material, which has well-known physical, chemical and workability properties. In the present study, a computerized numerically controlled machine (CNC) is used to machine an aluminum material bar.

## II. EXPERIMENTAL SET UP

The single point cutting tool trials were carried out using CNC Machine fitted with specially designed tool. The metal rod taken for investigation was aluminium having dimensions of 25mm diameter and length 80 mm was machined. The single point cutting tools with rake angle (in degree), clearance angle (in degree) and nose radius (millimeter) were used. The range of cutting tool parameters is shown in Table no. 1 [5]. The single point cutting tool was mounted on the tool post of CNC machine. The main objective is to optimize the parameters on turning operation for Surface roughness. [8]

The design of experiment is a procedure of selecting the number of trials and a condition running them, essential and sufficient for solving a problem that has been set with the required precision. The use of design of experiment makes

the behavior of investigator purposeful, organized and appreciably facilitates an increase in productivity of his work and reliability of results obtained.

We have selected a two-factor project of ($2^3$ = 8) eight tests, which is a standard statistical tool to investigate the effects of the number of parameters on the required response, to determine the effect of three parameters of independent direct instruments. The method commonly used to vary a parameter at a time, although popular, does not provide any information about the interaction between parameters. The selection of two-tier factor models also helped reduce experimental runs to the minimum possible.

The complete set of eight tests was repeated three times to determine the "parameter of variance of the optimization parameter" and once for "variance of adequacy" for this model. The experiments were performed in random order to avoid systematic errors. The answers for the three groups of experiments are shown in Table n. 2.

***Table 1 Cutting Tool parameters and their limits***

| **Parameters** | **Units** | **Symbol** | **Upper limit** | **Lower limit** |
|---|---|---|---|---|
| Rake angle | Degree | R | 5 | 30 |
| Nose radius | Millimeter | N | .04 | .08 |
| Clearance angle | Degree | C | 15 | 20 |

***Table 2 Surface roughness of three sets***

| **Experiment No.** | **$SR_1$ 1st Set (µm)** | **$SR_2$ 2nd Set (µm)** | **$SR_3$ 3rd Set (µm)** |
|---|---|---|---|
| 1. | 1.780 | 1.834 | 1.708 |
| 2. | 1.430 | 1.580 | 1.525 |
| 3. | 0.769 | 0.827 | 0.860 |

**$SR_1$** = Surface Roughness of Set-I
**$SR_2$** = Surface Roughness of Set-II
**$SR_3$** = Surface Roughness of Set-III

## III. DEVELOPMENT OF MATHEMATICAL MODEL

The response function that represents the roughness of the surface could be expressed as::

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

Assuming a linear relationship at the first moment and taking into account everyone possible interactions of only two factors, the above could be written as;

$$Y = b_o + b_1R + b_2N + b_3C + b_{12}RN + b_{13}RC + b_{23}NC \quad \text{----------} \quad (1)$$

Where b0 is the combined effect of all the parameters and b1, b2, b3 are the main effects and b12, b13, b23 are the interactive effect of two parameters. The regression coefficients of the selected model were calculated according to the least squares methods and are shown in Table 3.

*Table 3 Regression coefficients for Surface roughness*

| Coefficient | Factor | Value |
|---|---|---|
| $b_0$ | Combined effects of all factors | 1.316 |
| $b_1$ | Rake angle (R) | -0.212 |
| $b_2$ | Nose radius (N) | 0.238 |
| $b_3$ | Clearance angle (C) | 0.051 |
| $^b12$ | Interaction of R & N | 0.127 |
| $^b13$ | Interaction of R & C | 0.148 |
| $^b23$ | Interaction of N & C | 0.053 |

**Development of Final Models**

The statistical significance of the coefficients can be assessed by applying the student's "t" test. The importance level of a particular parameter can be evaluated by the magnitude of the "t" value associated with it. After discarding the negligible coefficients, the models developed for the roughness of the surface were presented as Equation 2. .

$$Y_{SR} = 1.316 - 0.212R + 0.238N + 0.127RN + 0.148RC \text{----------} \quad (2)$$

The adequacy of the developed models was tested using the analysis of the variance technique. According to this technique, the calculated value of the F ratio of the developed model should not exceed the standard printout value of the F ratio for a desired level (95% in this case) of confidence. The fitness results were shown in Table No. 4

*Table 4 Analysis of Adequacy Test*

| Degree of Freedom | | Variance of Adequacy | Variance of Response | 'F'–Ratio Model ($F_m$) | 'F'-Ratio Table($F_t$) | Adequacy of Model |
|---|---|---|---|---|---|---|
| F | N | $S^2_{ad}$ | $S^2_y$ | $F_m = S^2_{ad}/ S^2_y$ | at 4, 8, 0.05 | Whether $F_m < F_t$ |
| 4 | 8 | 0 .00475 | 0.00572 | 0.83 | 3.8 | Yes |

## IV. RESULTS AND DISCUSSION

The final mathematical models proposed for surface roughness as shown in equation n. 2. Mathematical models can be used to predict the effects of the various parameters of the instrument on the roughness of the surface. In the mathematical model for surface roughness, the effects of the interaction of three parameters can be well explained..

**Influence of Rake Angle on Surface Roughness**

The influence of the angle of inclination on the desired response was observed in the mathematical model presented in Fig. 1. It is observed in Fig. 1 that as the inclination angle increases, the surface roughness decreases.

ISSN 2348 – 8034
Impact Factor- 5.070

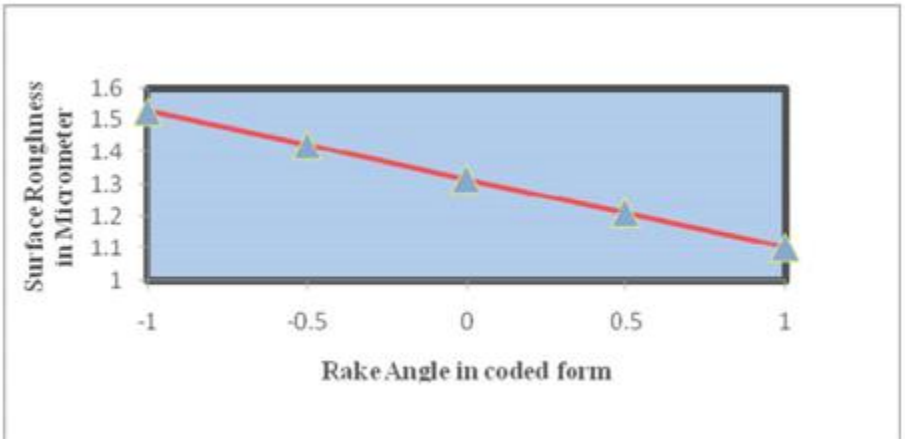


*Figure 1 Effect of Rake Angle on Surface roughness*

**Interaction effect of Rake Angle and Nose Radius on Surface Roughness**

The effects of the angle of inclination and the radius of the nose on the roughness of the surface were observed in Figure 2. It can be concluded that by using a lower value of the nose radius and increasing the angle of inclination, the roughness of the surface will be reduced and the surface finish will be improved. In the figure the effects of the angle of inclination and the angle of separation in the roughness of the surface were observed. No. 4. It is clear that the roughness of the surface will decrease, ie the surface finish will be improved by decreasing the rake angle value and increasing the angle of inclination value.

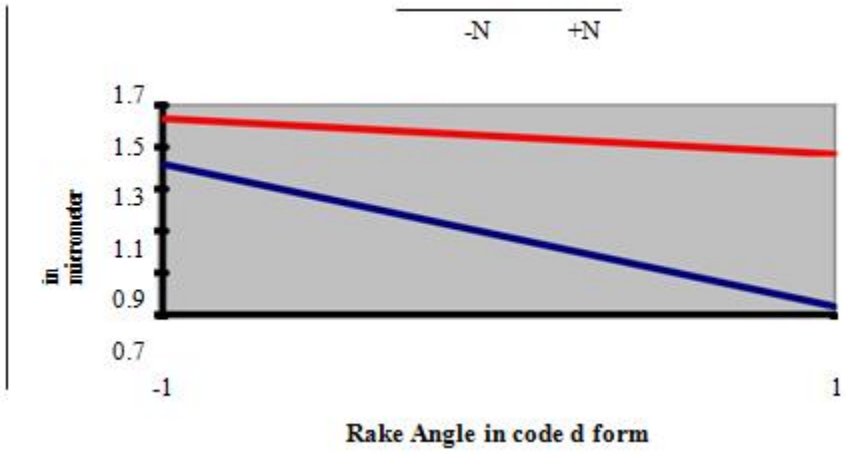


*Figure 2 Interactive effects of Rake Angle and Nose Radius on Surface roughness*

**Interaction effect of Rake Angle and Clearance Angle on Surface Roughness**

In the figure the effects of the angle of inclination and the angle of separation in the roughness of the surface were observed. No. 4. It is clear that the roughness of the surface will decrease, ie the surface finish will be improved by decreasing the rake angle value and increasing the angle of

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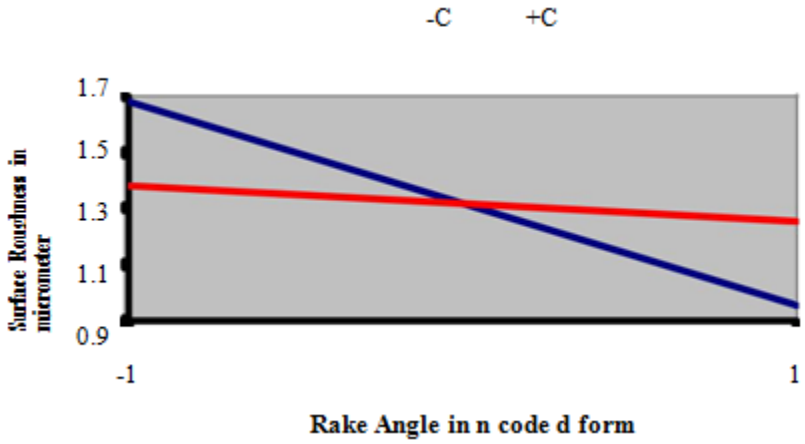


*Figure 3 Interactive effects of Rake Angle and Clearance Angle on Surface roughness*

## V. CONCLUSIONS

Two-level factorial design is believed to be an effective tool for investigating the effects of parameter interaction in the required response. The roughness of the surface decreases with the increase of the angle of inclination. The minimum value of the surface roughness obtained is 1,104 µm with an angle of inclination of 300 and the maximum surface roughness value is 1,528 µm with an angle of inclination of 50. The roughness of the surface increases with increase of the nose radius.. The lower limt value of surface roughness obtained is 1.078 µm at nose radius of 0.04 mm and maximum value of surface roughness is 1.554 µm at nose radius of 0.08 mm. The lower limit value of surface roughness obtained is 0.739 µm at nose radius of 0.04 mm and at rake angle of $30^0$ and maximum value of surface roughness is 1.639 µm at nose radius of 0.08 mm and at rake angle of $5^0$and combined effect of rake angle & clearance angle. The lower limit value of surface roughness obtained is 0.956 µm at clearance angle of $15^0$ and at rake angle of $30^0$.

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