

# Surface Roughness Analysis In Machining Of Aluminium Alloys(6061 & 6063)

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**Abstract**— Surface is one of the most significant requirements in metal machining operations. In order to attain enhanced surface quality, the appropriate setting of machine parameters is important before the cutting operation take place. The objective of this research is to analyze the effect of machining parameters on the surface quality of aluminum alloy in CNC milling operation with HSS tool. A multiple regression model developed with spindle speed, feed rate and depth of cut as the independent variable and surface roughness parameter 'Ra' as the dependent variable. The prediction ability of the model has been tested and analyzed using 'Mini Tap' and it has been observed that there is no significant different between the

mean of 'Ra' values of theoretical and experimental data at 5% level of significance. In addition to that, they are going to use Box-Behnken designs method which analyze the surface roughness and it designs when performing non-sequential experiments. That is, performing the experiment once. These designs allow efficient estimation of the first and second-order coefficients. Because box-behnken designs have fewer design points, they are less expensive to run than central composite designs with the same number of factors.

**Keywords** – Surface roughness, Machining Parameters, CNC Milling

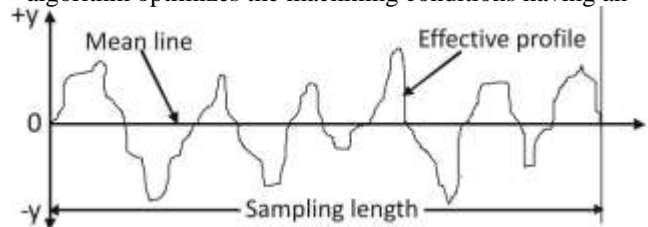
## I. INTRODUCTION

Now-a-days, due to the growing demand of superior quality components for its functional aspect, surface roughness of a machined part plays a significant role in the modern manufacturing process. A good quality machined surface appreciably improves fatigue strength, corrosion resistance, and creep life. Surface roughness also influences some functional characteristics of parts, such as, contact causing surface friction, wearing, light reflection, heat transmission, ability of distributing and holding a lubricant, load bearing is generally specified and the appropriate cutting parameters are preferred to attain the required quality[1]. In manufacturing industries, manufacturers focused on the quality and productivity of the product. To increase the productivity of the product, computer numerically machine tools have been implemented during the past decades. Surface roughness is one of the most important parameters to determine the quality of product. The mechanism behind the formation of surface roughness is very dynamic, complicated, and process dependent. Several factors will influence the final surface roughness in a CNC milling operations such as controllable factors (spindle speed, feed rate and depth of cut) and uncontrollable factors (tool geometry and material properties. This method can find the best conditions required for the machining independent variables such as speed, feed and depth of cut that would result in the best machining response.

## II. RELATED WORK

Surface finish of milled components has massive influence on the quality of the finished product. Surface finish in milling had been found to be influenced in varying amounts by a number of factors such as feed rate, work hardness, built-up edge, coolant used, cutting speed, depth of cut, cutting time, cutting edge. According to these parameters, a comprehensive literature survey is carried out as follows. Srikanth and Kamala [3] developed a Real Coded Genetic Algorithm (RCGA) to locate optimum cutting parameters and explained its advantages over the existing approach of binary coded genetic algorithm (BCGA). Franic and Joze [4] used Binary Coded Genetic Algorithm (BCGA) for the

optimization of machining parameters. This genetic algorithm optimizes the machining conditions having an



influence on production cost, time and quality of the final product. David et al. [5] addressed a methodology to calculate surface roughness in a high speed end-milling process and used Artificial Neural Networks (ANN) and statistical tools to develop different surface roughness predictors. Oktem et al. [6] used response surface methodology to generate a mathematical model for surface roughness in terms of cutting parameters: Feed, cutting speed, axial depth of cut, radial depth of cut and machining tolerance.

## III. PROBLEM FORMATION

The goal of present analysis is to develop a technique to predict the surface roughness of a part to be machined and to avoid trial and error approaches to set-up machining conditions in order to achieve the desired surface roughness. The objective is to predict surface roughness parameter ( $R_a$ ) under multiple cutting conditions determined by spindle speed, feed rate and depth of cut. Surface roughness would be measured directly by surface roughness measuring instruments. Experimental results are expected to show that parameters of spindle speed, feed rate and depth of cut that could calculate surface roughness ( $R_a$ ) under different combinations of cutting parameters

## IV. METHODOLOGY

Experiments have been carried out in order to examine the impact of one or more factors of the process parameters (spindle speed, feed rate and depth of cut) on the surface finish of the machined surface in vertical milling operation. When an experiment involves two or

more factors, the factors can influence the response individually or interactally.



Figure 1.1 Defines the steps involved in the process.

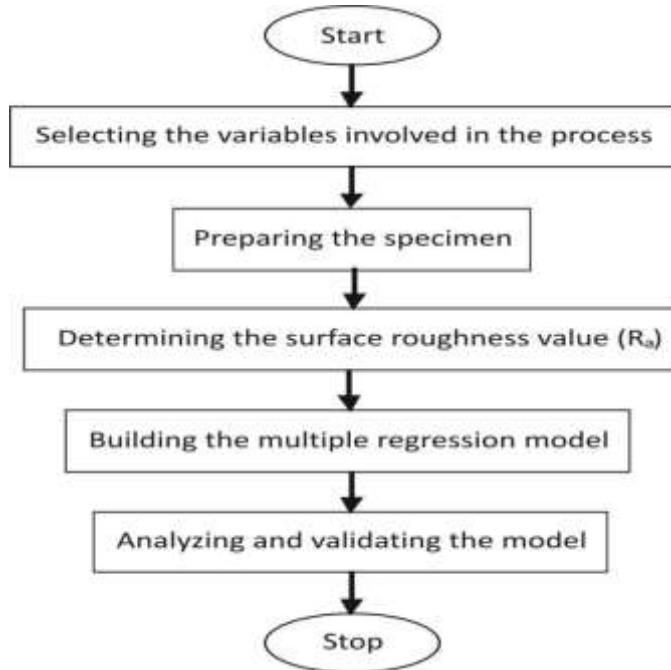


Fig 1.2 : Steps involved in the process

### SELECTING THE VARIABLES

In this study the dependant variable is the surface roughness ( $R_a$ ) and the independent variables are the spindle speed, feed rate and depth of cut. Because these variables are controllable machining parameters, they can be used to calculate the surface roughness in vertical milling which will then improve the product quality. The variables are defined as follows:

**Spindle speed:** The rate at which the machine spindle rotates. Spindle speed is typically measured in rpm.

**Feed:** It is the relative velocity at which the cutter is advanced along the workpiece. Feed rate is measured in mm/min.

**Depth of cut:** It is the thickness of the metal that is removed in one cut. It is the perpendicular distance measured between the machined surface and non-machined surface of the work piece.

**$R_a$ (surface roughness parameter):** This parameter is also known as arithmetic roughness surface value.

### V.EXECUTION OF EXPERIMENTS

The test specimens are prepared on a CNC vertical milling machine (Figure 3). A groove 10 mm X 1.5 mm is cut on aluminium workpiece using HSS milling

cutter of diameter 10 mm. The dimensions of the workpiece is shown in Figure 4 and actual workpiece is shown in Figure 5. Surface roughness measurement is done off line with the usage SJ201 surface roughness tester (Figure 6). A computer numeric control (CNC) program has been written to perform the grooving operation. The parameters defined in the CNC machine are: Spindle speed (N), feed rate (F), depth of cut (D). Different levels of cutting parameters are shown. All specimens in this experiment are machined under dry cutting conditions.



Figure 3: Machining process on the workpiece in CNC machine

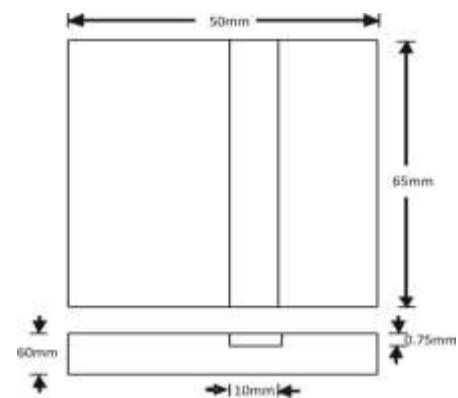


Figure 4: Dimensions of workpiece

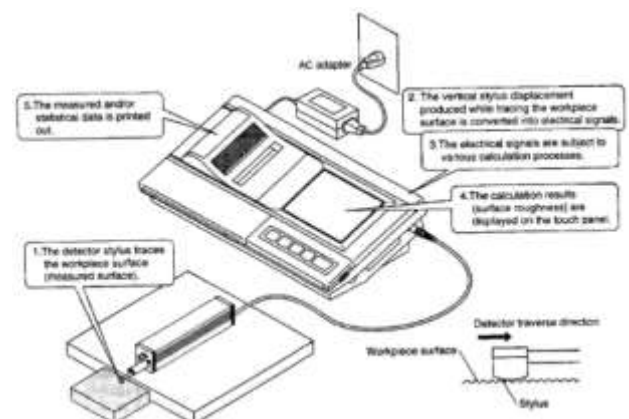


Figure 6: Arrangement of surface roughness tester and workpiece

Also, after every specimen, the cutting tool was cleaned to avoid chip formation or a built-up edge (BUE) which might affect the surface roughness of the specimens. In addition, the following assumptions are made:

- 1.The cutting tools used are identical in property.
- 2.The hardness of each work piece is same throughout the length of the work piece.

**BUILDING THE MULTIPLE REGRESSION MODEL**

The general equation of multiple regression model is as follows:

$$R_a = a + b \times N + c \times F + d \times D + e \times N \times F + f \times N \times D + g \times F \times D$$

Where a,b,c,d,e,f and g are constants, N is spindle speed in rpm, F is the feed rate in mm/min and D is the depth of cut in mm.

**Table 1: RESULTS FOR MEASURED AND PREDICTED VALUES FOR SURFACE ROUGHNESS**

Exp No	Cutting speed (rpm)	Feed rate (mm/min)	Depth of cut (mm)	Ra(μm) Measured	Ra(μm) Predicted (1 <sup>st</sup> order)	Ra(μm) predicted (2 <sup>nd</sup> order)
1	2000	80	2	0.89	0.879	0.894
2	2000	120	2	0.73	0.789	0.774
3	2000	100	1.5	0.69	0.664	0.665
4	1500	100	1	0.58	0.494	0.495
5	2000	100	1.5	0.69	0.664	0.665
6	2500	120	1.5	0.57	0.619	0.619
7	2500	100	2	0.91	0.834	0.834
8	1500	100	2	0.91	0.834	0.834
9	2000	120	1	0.41	0.449	0.465
10	1500	80	1.5	0.62	0.709	0.709
11	2500	100	1	0.58	0.494	0.495
12	2000	80	1	0.51	0.539	0.524
13	2000	100	1.5	0.69	0.664	0.665
14	1500	120	1.5	0.57	0.619	0.619
15	2500	80	1.5	0.62	0.709	0.709

**Table.2:ANOVA Results For First Order Model**

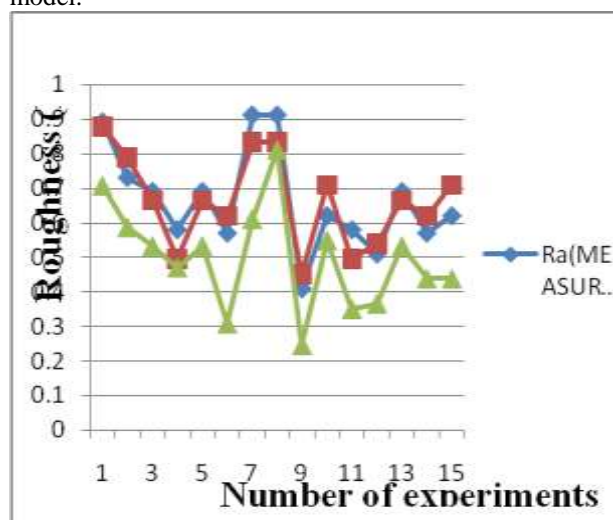
Source	DOF	Sum square	Mean square	F-ratio	P-value	R <sup>2</sup> (%)
Regression	3	0.247400	0.082467	16.50	0.000	81.8
Linear	3	0.247400	0.082467	16.50	0.000	
Residual error	11	0.054973	0.004998			
Lack-of-fit	9	0.054973	0.006108			
Pure error	2	0.00000	0.00000			
Total	14	0.302373				

**Table.3. ANOVA Results For Second Order Model**

Source	DOF	Sum square	Mean square	F-ratio	P-value	R <sup>2</sup> (%)
Regression	6		0.20120	4.42	0.029	76.8
Linear	3		0.01808	0.59	0.759	
Interaction	8		0.02683		0.639	
Residual error	6		0.04552			
Lack-of-fit	2		0.06093			
Pure error	2		0.000			
Total	14	1.57137				

**VI. COMPARISON BETWEEN EXPERIMENTAL AND PREDICTED RESULTS**

From figure the predicted surface roughness using the second order response surface methodology model is closely match. It exhibits the better agreement as compared to those from the first order response surface methodology model.



**Fig6 Comparison between experimental and predicted results graph**

## VII. INTERPRETING THE RESULTS

In a contour plot, the values for two variables are represented on the x-and y- axes, while shaded regions and contour lines are represent the values for a third variable, called contours.

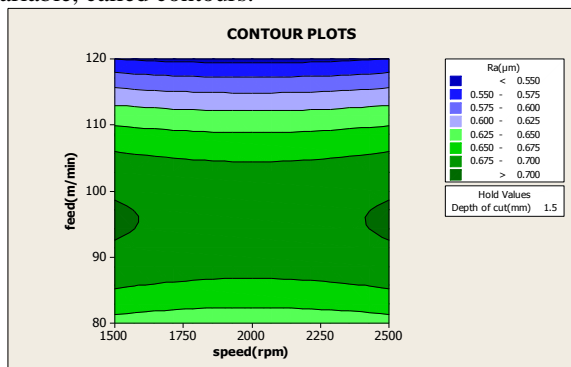


fig:7 Interpreting The Results

The contour plots are indicate that the highest yield is obtained when responses are maximum or minimum with respect to input variables. These areas appear at the dark to light region. These regions may left or right or up or down or corner of the plot.

## VIII. CONCLUSION AND FUTUTRE WORK

Response Surface methodology has been implemented to analyze the surface roughness with various combinations of design variables (cutting speed, feed rate, and depth of cut).The first and second order models found to be adequately representing the surface roughness with experimental results.

Response surface methodology model reveal that feed rate is most significant design variable to predict the surface roughness response as compared to others. Second order model found to be no interaction between the variables. With model equations obtained, a designer can subsequently select the best combination of design variables for achieving optimum surface roughness. This eventually reduces the machining time, machining cost and save the cutting tools.

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