SURFACE ROUGHNESS ANALYSIS IN MACHINING OF ALUMINIUM ALLOYS (6061&6063)

Vimal kumar.D(Assistant professor/Mechanical, Gnanamani college of technology)
Naveen.T[1],Naveenkumar.S[2],Sethupathi.S[3],Srinivasan.S[4]
Gnanamani college of technology, Namakkal.

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 is used to 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.

1. INTRODUCTION

The end milling operation is one of the most widely-used material removal processes in industry. The cutting operations by end mills are employed for finish machining of sculptured surfaces such as dies, moulds, and turbine blades, aerospace and automotive parts. These products have very demanding specifications in surface quality, which in most cases represents for them. Several factors will influence the final surface roughness in a milling operation. Factors such as spindle speed, feed rate, and depth of cut are easily controllable factors such as cutting speed, feed rate and depth of cut are considered in this study and surface roughness is measured at various levels of the factors. Surface roughness which is used to determine and evaluate the quality of a product, is one of the major quality attributes of on end-milled product.

2 RESPONSE SURFACE METHODOLOGY TYPES

It is classified two types

- Central Composite Design
- Box-Behnken designs

2.1CENTRAL COMPOSITE DESIGN

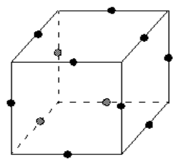
Central composite design are often recommended when the design plan calls for sequential experimentation, because these designs can incorporate information from a property planned factorial experiment . The factorial and center points may serve as a preliminary stage where we can fit a first-order (linear) model, but still provide evidence regarding designs can be created blocked or unblocked. Central composite designs consist of

- 2K or 2K-1 factorial points (also called cube points), where K is the number of Factors.
- Axial points (also called star points)
- Center points
- Methodology
- Response surface methodology Response Surface Methodology validation process.

2.2BOX-BEHNKEN DESIGN

Box-behnken designs is normally used 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.

Points on the diagram represent the experimental runs that are performed:



Three-factor Box-Behnken design

Box-Behnken designs can also prove useful for the safe operating zone of the process. Central composite designs usually have axial points outside the "cube" (unless we specify an a that is less than or equal to one). These points may not be in the region of interest, or may be impossible to run because they are beyond safe operating limits. Box-Behnken designs also ensure that all factors are never set at their high levels simultaneously. The proposed linear model correlating

CONTROLLABLE FACTORS	LEVEL (0)	LEVEL (+)	LEVEL (-)
A: CUTTING SPEED B: FEED RATE C: DEPTH OF CUT	1500 80 1	2000 100 1.5	2500 120 2

the responses and independent variables can be represented by the following equation [1]:

y = m* Cutting speed + n * Feed rate + p * Axial depth + C …….. [1]

Where,

y is the response, and

C, m, n, and p are the constants.

The form of the first order model in equation (1) is sometimes called a main effects model, because it includes only the main effects of the three variables x_1, x_2 and x_3.

Equation (1) can be written as Equation (2):

$$y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \quad ....[2]$$

Where,

y = is the response,

x_0 = 1(dummy variable),

x_1 = cutting speed,

x_2 = feed rate,

and x_3 = axial depth.

β_0 = C, and β_1 ,β_2 ,and β_3 are the model parameters.

The second-order model can be expressed as Equation (3)

$$y'' = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_{11} x_1^2 + \beta_{22} x_2^2 + \beta_{33} x_3^2 + \beta_{12} x_1 x_2 + \beta_{13} x_1 x_3 + \beta_{23} x_2 x_3 \quad ....[3]$$

This model would likely be useful as an approximation to the true response surface in a relatively small region and it is easy to estimate the parameters (the β's) in the second-order model. The method of least squares can be used for this purpose.

3. SELECTION OF FACTORS

In this project, the controllable factors are cutting speed (A), feed rate(B) and depth of cut (C), which were selected because they can potentially affect surface roughness performance in end milling operations.

The variable factors levels as shown in table 3.1

Table 1: VARIABLE FACTORS LEVELS

4. MATERIAL SELECTION

6061 Aluminum alloy

6063 Aluminum alloy

4.1 ALUMINIUM ALLOY OF 6061

6061is a precipitation hardening aluminium alloy, containing manganese and silicon as its major alloying elements originally called "alloy 61s,".it has good mechanical properties and exhibits good weld ability. it is one of the most common alloys of for aluminium general purpose use. It is commonly available in pre-tempered grades such as 6061-O (annealed) and tempered grades

Table 2:MECHANICAL PROPERTIES OF 6061

Hardness (BHN)	95
Ultimate Tensile Strength	310 Mpa
Tensile Yield	276 Mpa
Elongation at Break	10 %
Modulus of Elasticity	68.9 Gpa
Density	2.7 g/cm

4.2 ALUMINIUM ALLOY OF 6063

Al 6063 is an aluminium alloy, with magnesium and silicon as the alloying elements. The standard controlling its composition is maintained by The Aluminum Association. It has generally good mechanical properties and is heat treatable and weld able. It is similar to the British aluminium alloy HE9.6063 is mostly used in extruded shapes for architecture, particularly window frames, door frames, roofs, and sign frames. It is typically produced with very smooth surfaces fit for anodizing.

Table 3:PHYSICAL PROPERTIES OF 6063

S.NO	Physical properties	Weight
1	Density	2685 kg/m^3
2	Solidus temperature	615 ^{0}C
3	Liquid use temperature	655 ^{0}C

Table 4: MECHANICAL PROPERTIES OF 6063

S.No	NAME OF MECHANICAL PROPERTIES	UNITS
1	Tensile Strength	131 Mpa
2	Yield Strength	150 Mpa
3	Elongation	18 inc
4	Shear strength	69 Mpa
5	Electrical conductivity	58 /iacs

.

Table 5:MECHANICAL PROPERTIES OF 6061 AND 6063

Yield Strength	280 Mpa
Tensile Strength	700 Mpa
% of Elongation	20%
Hardness (BHN)	207 BHN
Modulus of Elasticity	85Gap

4.3TOOL MATERIAL

The tool used in this experiment was a four-flute high speed end mill cutter.

End Milling Cutter

Diameter (Φ) = 10 mm

Length (L) = 60 mm

5. SPECIFICATION

5.1 WORKPIECE MATERIAL

The materials used for the experiment were 70mm length x 50mm widthx12mm thick of aluminium alloy.

5.2 PREDICTION BY USING RESPONSE SURFACE METHODOLOGY

The parameters of equations (2) and (3) have estimated by method of least squares using MINITAB computer package.

The first and second order linear equation used to predict the surface roughness is expressed.

First order linear equation

$y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3$

Ra = $0.379667 - 0.000x_1 - 0.00225x_2 + 0.3400\, x_3$

Second order linear Interaction equation

$y = \beta_0 x_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_1 x_1 x_2 + \beta_2 x_1 x_3 + \beta_3 x_2 x_3$……………..……………………

Ra= $0.154667 - 0.000\, x_1 - 0.000\, x_2 + 0.490\, x_3 + 0.000\, x_1 x_2 - 0.000\, x_1 x_3 - 0.15\, x_2 x_3$

5.3. MODEL CALCULATIONS

5.3.1 First order model (1st trial)

Ra = (0.379667) - (0.000*2000) - (0.00225*80) + (0.340*2)

= 0.879 µm

5.3.2Second order model (1st trial)

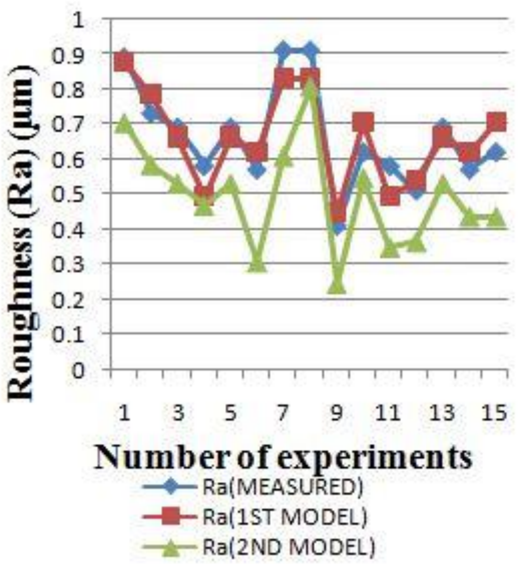
Ra = (0.154667)-(0.000 *2000)-(0.000 *80)+(0.490 *2)+(0.000 *2000* 80)-(0.000 *2000 *2)-(0.15 *80*2)

Ra= 0.894

Table 6:RESULTS FOR MEASURED AND PREDICTED

Exp No	Cutting speed(rpm)	Feed rate (mm/min)	Depth of cut(mm)	Ra(µm) measured	Ra(µm) Predicted (1st order)	Ra(µm) predicted (2nd 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

6. COMPARISION BETWEEN EXPERIMENTAL AND PREDICTED RESULTS



The above predicted surface roughness using the second order response surface methodology model is closely match with the experimental results

VALUES FOR SURFACE ROUGHNESS

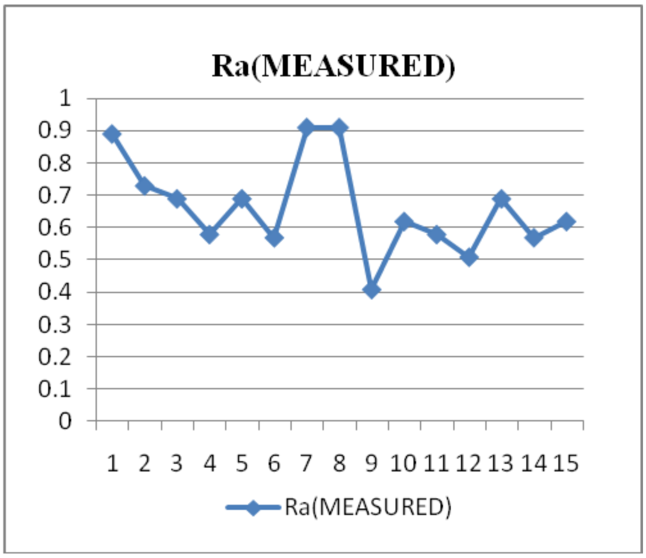
Table 7: ANOVA Results For First Order

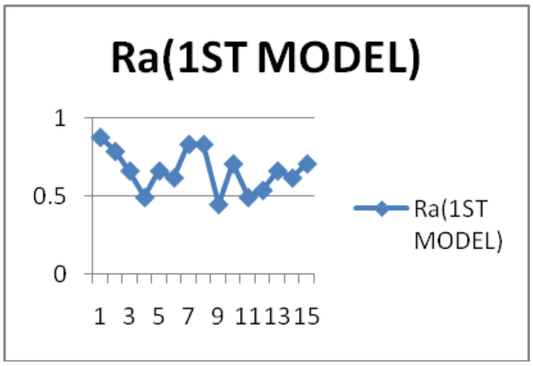
Source	Degree of freedom	Sum square	Mean square	F-ratio	P-value	R^2 (%)
Regression Linear Residual error Lack-of-fit Pure error	3 3 11 9 2	0.247400 0.247400 0.054973 0.054973 0.00000	0.082467 0.082467 0.004998 0.006108 0.0000	16.50 16.50	0.000 0.000	81.8
Total	14	0.30237				

Table 8: ANOVA Results For Second Order Mode

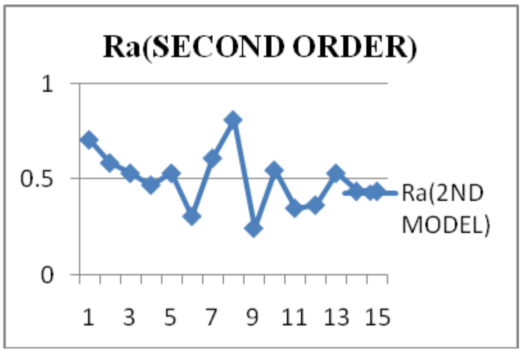
Source	Degree of freedom	Sum square	Mean square	F-ratio	P-value	R^2 (%)
Regression Linear Interaction Residual error Lack-of-fit Pure error	6 3 3 8 6 2		0.201202 0.018089 0.026838 0.045520 0.06093 0.000	4.42 0.40 0.59	0.029 0.759 0.639	76.8
Total	14	1.57137				

COMPARISON BETWEEN EXPERIMENTAL AND PREDICTED RESULTS GRAPH





First order results graph

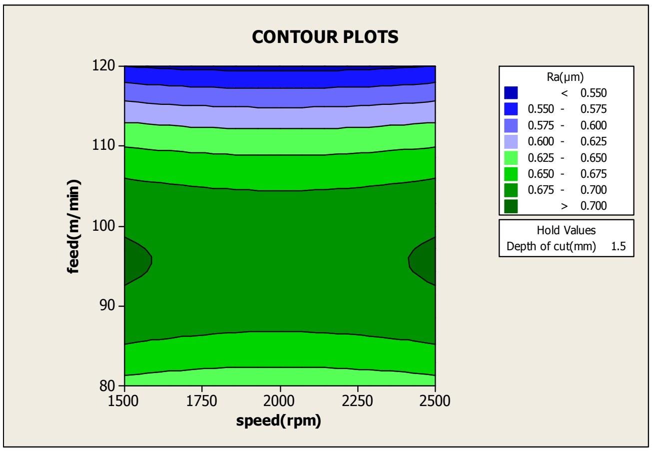


Second order results graph

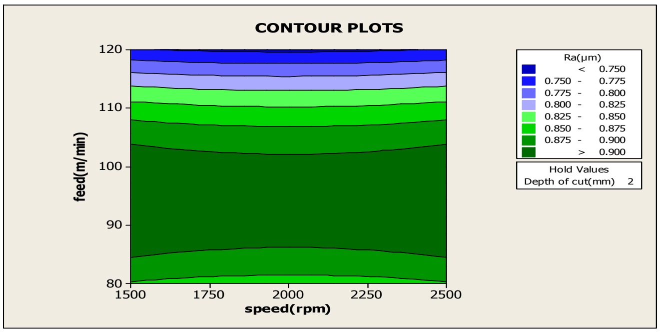
7. INTERPRETING THE RESULTS

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. 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.

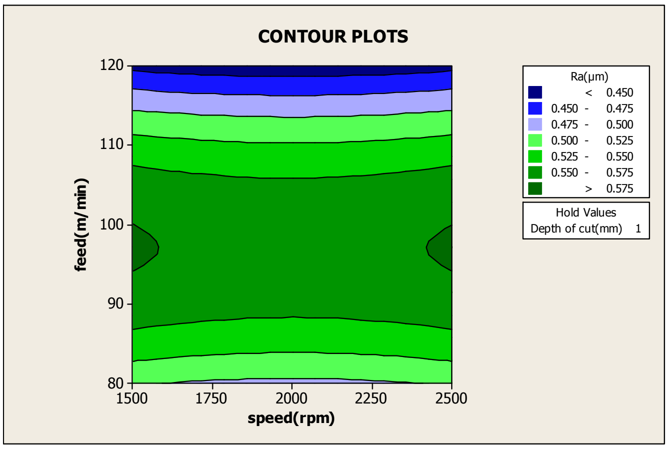
CONTOUR PLOT FOR FIRST ORDER MODEL

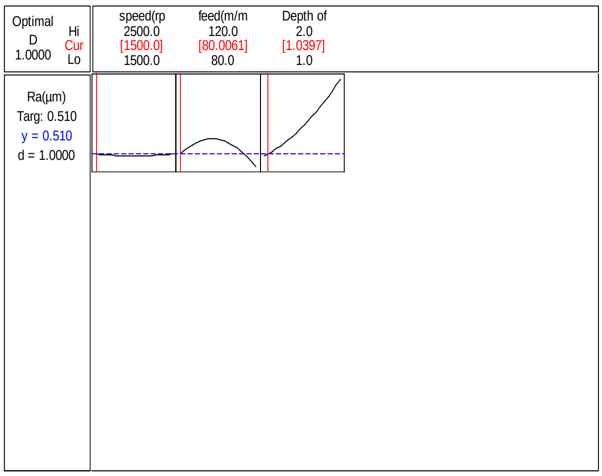


CONTOUR PLOT FOR FIRST ORDER MODEL



CONTOUR PLOT FOR SECOND ORDER MODE





7.1 ADVANTAGES

- Less Weight.
- Easy to machining process
- Low coefficient of thermal expansion
- Good resistance to wear.
- Good bearing properties.

8. FUTURE WORK

Response surface methodology will 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.

9. CONCLUSION

- 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.

10. REFERENCES

[1]Anil Antony Sequeira, Ravikantha Prabhu, N.S.Sriram, Thirumaleshwara Bhat "Effect of Cutting Parameters on Cutting Force and SurfaceRoughness of Aluminium Components using Face Milling Process - a Taguchi Approach"ISSN: 2278-1684 Volume 3, Issue 4 (Sep-Oct. 2012), PP 07-13.

[2]Dimitrios Vakondios a, Panagiotis Kyratsis b, Suleyman Yaldiz "Influence of milling strategy on the surface roughness in ball end milling of the aluminum alloy Al7075-T6" 27 January 2012.

[3]Doddapattar.N.B, Lakshmana swamy.N "An optimization of machinability of Aluminium Alloy 7075 and cutting tool parameters by using Taguchi Technique" Volume 3, Issue 2, May-August (2012), pp. 480-493.

[4]Issac Thamban, Biju Cherian Abraham, Sabu Kurian "Machining characteristics analysis of 6061-T6 aluminium alloy with diamond coated and uncoated tungsten carbide tool"Volume 2,Issue 1 :Page No.553-557 , January-February (2013).

[5]Jitendra Verma, Pankaj Agrawal, Lokesh Bajpai "Turning parameter optimization for surface roughness of astm a242 type-1 alloys steel by Taguchi method" March 2012.

[6]Natasa Naprstkova Iinfluence of inoculation alsi7mg0.3 alloy on roughness of mashining surface"Jelgava, 23.24.05.2013.

[7] Nikhlesh.A.Malli , V.Aaditya and R.Raghavan "Study and analysis of PCD 1500 and 1600 Grade inserts on turning Al 6061alloy with 15% reinforcement of SiC particles on MMC" IPCSIT vol.31 (2012).

[8] Rajendra Pawar and Raju Pawade "Surface Integrity Analysis in Dry High Speed Turning of Titanium Alloy Ti-6Al-4V" March 24-25, 2012.

.