ISSN: 2455-5703

Optimization of Machining Parameter for AL Material with the Use of End Mill Cutter

Patil Manish S.
M E Student
Department of Mechanical Design Engineering
Jaihind College of engineering, Kuran, Pune Maharashtra, India

Hredeya Mishra
Professor
Department of Mechanical Design Engineering
Jaihind College of engineering, Kuran, Pune Maharashtra, India

Abstract

Surface finish and material removal rate are two important factors in the manufacturing which affect acceptability of the product which in turn reflects on the profitability of the organization. The worth of the production setup to produce the components with high material removal rate (MRR) without sacrificing the surface requirements can play vital role in sustainability and profitability of the organization. In this paper, the effect of process parameters on metal removal rate and surface roughness has been investigated in milling of AL material with Carbide end mill cutter. Cutting speed, feed and depth of cut have been taken as input factors in three level response surface methodologies used for experimentation. Mathematical models have been developed using response surface methodology to predict surface finish, and metal removal rate in term of machining parameters. Depth of cut and feed rate are found to be a dominant parameter for surface roughness; whereas feed rate mainly affects the metal removal rate.

Keywords- Cutting Speed, Depth of Cut, Feed, Response Surface Design, Surface Roughness Etc.

I. INTRODUCTION

Machining parameters such as speed feed, depth of cut and nose radius play a vital role in machining the given work piece to the required shape. These have a major effect on the quantity of production, cost of production and production rate; hence their judicious selection assumes significance. In manufacturing industries, manufacturers focus on both the quality and productivity. To increase the productivity, computer numerically control (CNC) 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 influence the surface roughness obtained in a CNC milling operation. These can be categorized as controllable factors (spindle speed, feed rate, depth of cut and nose radius) and uncontrollable factors (tool geometry and material properties of both tool and work piece).

As the milling process is the most productive process, the study is expected to be quite beneficial. Here, end milling has been selected for the study to determine the impact of process parameters on the surface quality of the product

A. Milling

Milling is the most common form of machining, a material removal process, which can create a variety of features on a part by cutting away the unwanted material. By feeding the work piece into the rotating cutter, material is cut away from the work piece in the form of chips to create the desired shape.

B. End Milling

An end mill makes either peripheral or slot cuts, determined by the step-over distance, across the work piece in order to machine a specified feature, such as a profile, slot, pocket, or even a complex surface contour. The depth of the feature may be machined in a single pass or may be reached by machining at a smaller axial depth of cut and making multiple passes.

C. Factors Affecting Surface Roughness

Whenever two machined surfaces come in contact with one another the quality of the mating parts plays an important role in the performance and wear of the mating parts. The height, shape, arrangement and direction of these surface irregularities on the work piece depend upon a number of factors such as:

1) The Machining Variables Which Include

1) Cutting speed
2) Feed, and
3) Depth of cut.

2) The Tool Geometry

Some geometric factors which affect achieved surface finish include:
1) Nose radius
2) Rake angle
3) Side cutting edge angle, and
4) Cutting edge.

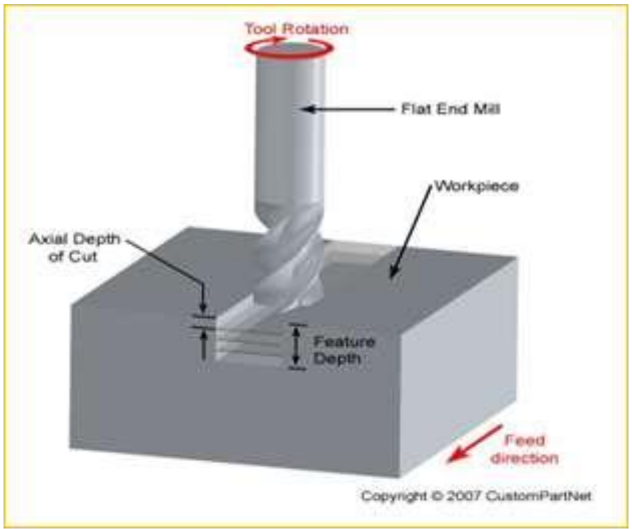


Fig. 1: Factors affecting surface roughness

II. LITERATURE REVIEW

Many researchers investigated and formulated the effect of cutting variables for the optimization of the surface roughness. Published work of different authors in the referred area is mentioned here.

Deepak Kumar et al. study the influence of Spindle speed feed rate, depth of cut on surface roughness and flat ness of end milled work piece of AL 6063 –T6 material and develop the model for their optimal selection. [1]

N.SV.Hanuman et al. studied the effect of process parameter on material removal rate and surface roughness has been investigated in milling of AL7075 –MMC with WC as reinforcement material. This results are compared with experimental results. [2]

Kanan s et al. Optimize the machine parameter for face milling operation with HSS cutter. They use the Surface response method and Genetic algorithm as an optimization technique.

S Jeyakumar et al. develop the model to determine the surface roughness. This model is develop using RSM and artificial neural network. Then author compare this result with experimental results.

D Bhanu Prakash et al. studied and optimize the cutting parameters in CNC end milling of AL alloy 6082. Author use the RSM and GA for developing the model and results are compare to the experiment outputs.

III. DESIGN OF EXPERIMENT

Design of Experiment is a powerful approach to improve product design or improve process performance where it can be used to reduce cycle time required to develop new product or processes. Design experiment is a test or series of test where changes are made in the input variable (parameter) of a process for observing and identifying corresponding changes in the output response. The main objectives of DOE are –
1) Determination of factors that have an influential effect on the response.
2) Determination of the appropriate settings of the influential factors for optimization of the response.
3) Determination of the appropriate settings of the influential factors for minimization of the responses variability.

There are several statistical techniques available in design of experiments for the optimization i.e. Factorial designs, Taguchi method, Response Surface Methodology etc. Response surface Methodology has been selected in the present work.

A. Response Surface Methodology (RSM)

This method is used to determine the optimum contribution of factors that yield a desired response and describes the response near the optimum. RSM consists of a group of empherical techniques devoted to the evaluation of relations existing between a cluster of controlled experimental factors and measured responses, according to one or more selected criteria. If the model contains coefficients for main effects, coefficients for quadratic effects and coefficients for two factor interactions, a full factorial design with all the factors at three levels would provide estimation of all the required regression parameters.

B. Central Composite Rotatable Design (CCRD)

A central composite rotatable design is an experimental design useful in RSM for building a second order (quadratic) model for the response variable without the need to use a complete three level factorial experiment. The total number of treatments combinations is reduced significantly by employing these designs.

C. Analysis of Variance (ANOVA)

ANOVA is a collection of statistical models, and their associated procedures, in which the observed variance is partitioned into components due to different explanatory variables. Analysis of variance (ANOVA) consists of simultaneous hypothesis tests to determine if any of the effects are significant. Several calculations will be made for each main factor and interaction term.

D. Process Parameters

The following table (Table 3.1) shows the levels of the cutting parameters chosen.

Table 3.1:

Code	Parameters	Level(+1)	Level (-1)
Vc	Cutting speed (m/min)	500	2000
F	Feed (mm/rev)	0.05	0.15
D	Depth of cut(mm)	0.05	1

E. Lay out of Experiment for RSM

The experiment layout was obtained in accordance with the 2-level full-factorial Central Composite Design with 8 cube points, 6 axial points, 4 center points, and 2 center points in axial, resulting in a total of 20 runs. α was chosen as 1 to make design face center. Table 3.2 below contains the experimental layout used.

Table 3.2:

Run Order	V_c	F	D	Ra	FITS Ra
1	1250	0.1	0.525	0.015	0.460
2	2000	0.15	1	0.92	0.857
3	1250	0.1	0.525	1	0.460
4	2000	0.05	0.05	0.98	0.947
5	500	0.05	1	0.65	0.517
6	500	0.15	0.05	0.75	0.659
7	2000	0.15	0.05	0.398	0.603
8	500	0.15	1	0.486	0.592
9	1250	0.1	0.525	0.54	0.460
10	500	0.05	0.05	0.548	0.683
11	2000	0.05	1	0.94	1.103
12	1250	0.1	0.525	0.246	0.460
13	500	0.1	0.525	0.34	0.378
14	1250	0.1	0.525	0.46	0.460
15	1250	0.1	1	0.56	0.541
16	1250	0.15	0.525	0.67	0.568
17	1250	0.05	0.525	0.78	0.703
18	2000	0.1	0.525	0.86	0.643
19	1250	0.1	0.05	0.657	0.496
20	1250	0.1	0.525	0.354	0.460

IV. RESULT

Analysis of Variance Table

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	11	0.7022	0.0638	0.81	0.635
Blocks	2	0.136	0.068	0.87	0.457
Linear	3	0.2257	0.0752	0.96	0.458
Vc	1	0.1753	0.1752	2.23	0.174

F	1	0.0454	0.0454	0.58	0.469
D	1	0.0049	0.0049	0.06	0.808
Square	3	0.2503	0.0834	1.06	0.418
Vc*Vc	1	0.0068	0.0068	0.09	0.775
F*F	1	0.0828	0.08281	1.05	0.335
D*D	1	0.00939	0.009390	0.12	0.739
2-Way Interaction	3	0.1078	0.035948	0.46	0.720
Vc*F	1	0.0512	0.051200	0.65	0.443
Vc*D	1	0.0518	0.051842	0.66	0.440
F*D	1	0.0048	0.004802	0.06	0.811
Error	8	0.6290	0.078634		
Lack-of-Fit	5	0.0951	0.019024	0.11	0.983
Pure Error	3	0.5339	0.177983		
Total	19	1.3313			

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		0.46	0.108	4.240	0.003	
Blocks						
1		-0.1235	0.0944	-1.310	0.227	1.56
2		0.0693	0.0944	0.730	0.484	1.56
Vc	0.2648	0.1324	0.0887	1.490	0.174	1
F	-0.1348	-0.0674	0.0887	-0.760	0.469	1
D	0.0446	0.0223	0.0887	0.250	0.808	1
Vc*Vc	0.101	0.051	0.171	0.300	0.775	1.86
F*F	0.351	0.176	0.171	1.030	0.335	1.86
D*D	0.118	0.059	0.171	0.350	0.739	1.86
Vc*F	-0.16	-0.08	0.0991	-0.810	0.443	1
Vc*D	0.161	0.0805	0.0991	0.810	0.44	1
F*D	0.049	0.0245	0.0991	0.250	0.811	1

Then Regression Equation in Un-coded Units
Ra=1.2+0.000046Vc-13.3F-0.614D+70.3F*F+0.262 D*D -0.00231Vc*F+0.000226Vc*D+1.03F*D
Solution given by RSM
At Vc=5000, F= 0.0964646, D=0.76967 Ra will be minimum its value in *0.362615* micron and the composite durability will be 64 .7%

A. Optimization Plots

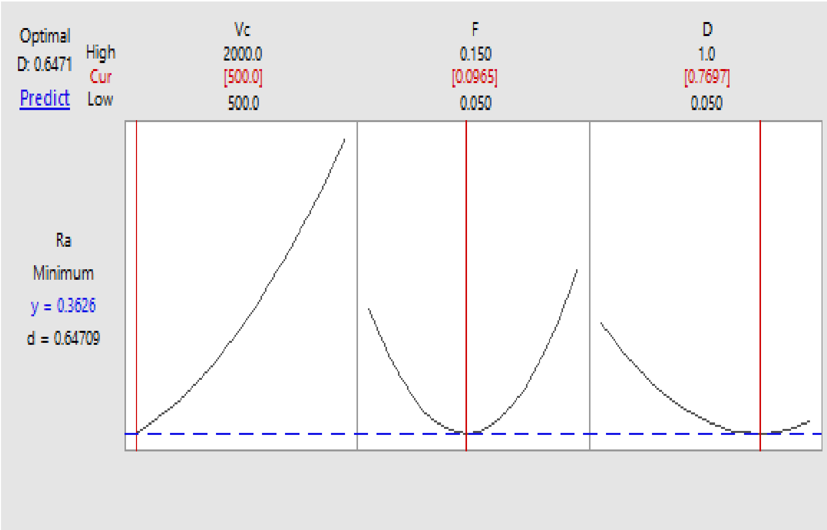


Fig. 2: Optimization Plots

B. Factorial Plot

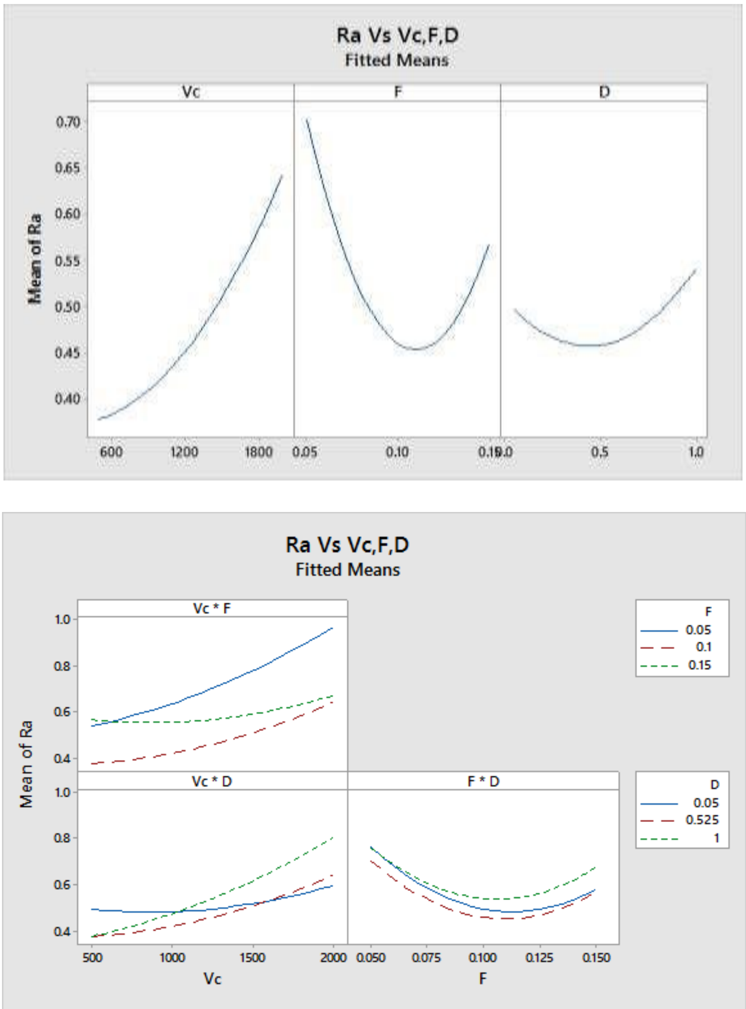
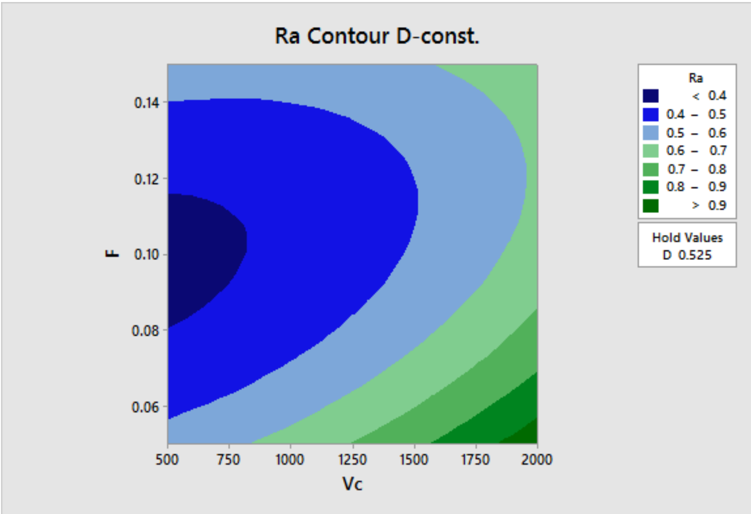


Fig. 3: Factorial plot

C. Contour Plots



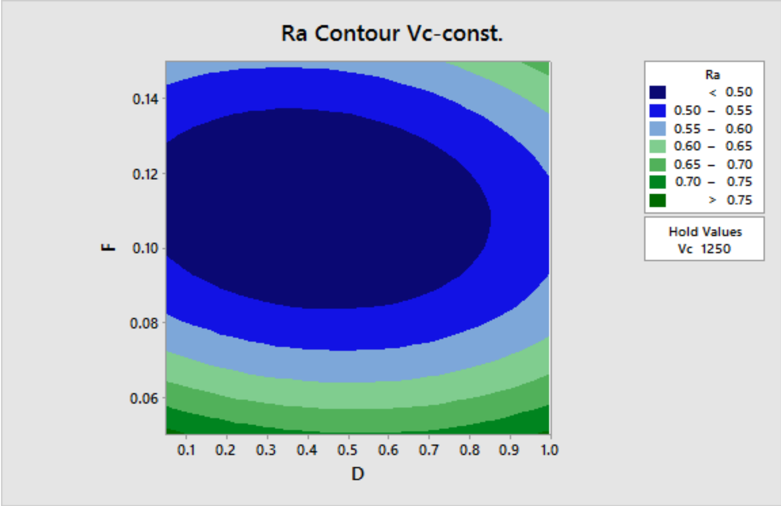
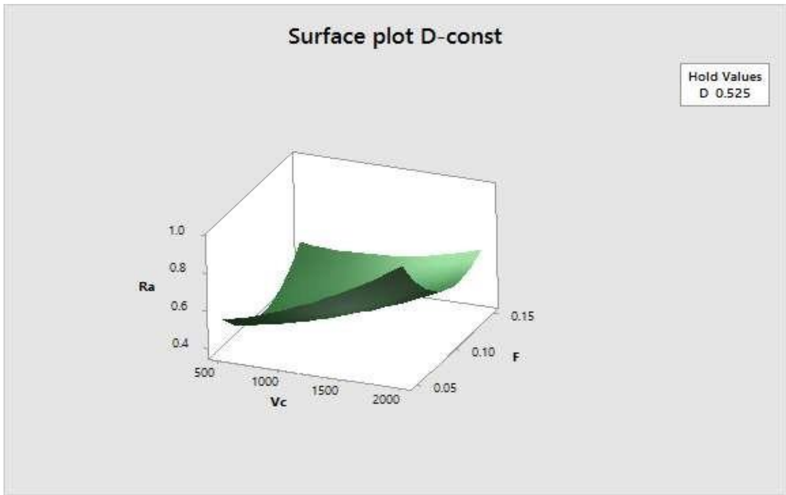


Fig. 4: Contour plots

D. Surface Plots



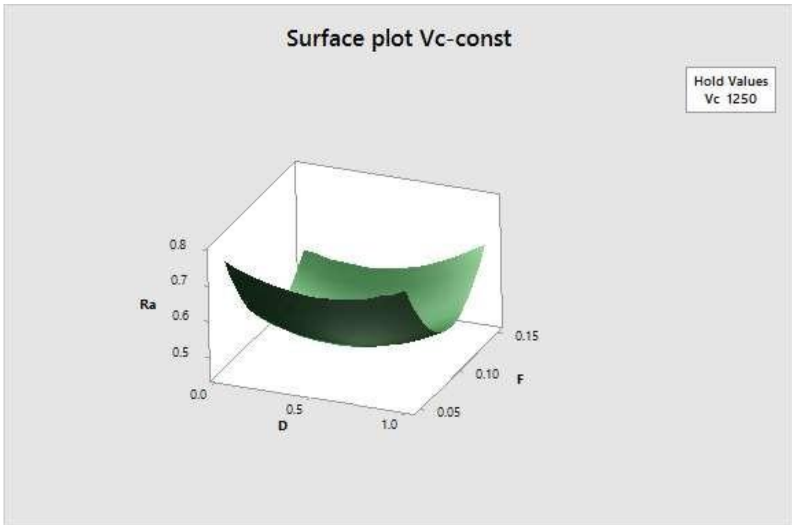


Fig. 5: Surface plots

V. CONCLUSIONS

The important conclusions drawn from the present work are summarized as follows:

1) Out of three variables considered cutting speed seems to be the most significant and influential machining parameter followed by feed rate.
2) The depth of cut has insignificant influence on the surface roughness.
3) The mathematical models developed clearly show that surface roughness increases with increasing the feed but decreases with increasing the cutting speed.
4) The results of ANOVA and the confirmation runs verify that the developed mathematical model for surface roughness show excellent fit and provide predicted values of surface roughness that are close to the experimental values, with a 95 per cent confidence level.
5) The percentage error between the predicted and experimental values of the response factor during the confirmation experiments are within 5 per cent.
6) The model can be used for direct evaluation of Ra under various combinations of machining parameters during end milling of Aluminum material.

REFERENCES

[1] Depak Kumar et al. (2015). Optimization of surface roughness and flatness in end milling of aluminum alloy 6063 –T6,Internation journal of advance in Engineering and technology , Vol.8, Issue6, pp.937-949
[2] N.S.V.N Hanuman et al(2017) On modeling the CNC end milling characteristics of AL-7075/WC Powder metallurgy composite, International conference on functional materials , characterization, solid state physics , power , Thermal and combustion energy. , AIP 179
[3] Kanan S et al (2016).Selection of machining parameter of face milling operation for aluminum with HSS cutter using Response surface methodology and Genetic algorithm., Journal of advance in chemistry Vol-12, pp.4938-4949
[4] S.Jeyakumar et al (2015). Optimization of machine parameter of AL6061composite to minimize the surface roughness –modeling using RSM and ANN , Indian Journal of engineering and material science , Vol.22, pp.29-37
[5] D.Bhnau Prakash et al. (2013). Optimization of machine parameter for aluminum alloy 6082 in CNC end milling , International journal of engineering research and applications , vol.3, issue-1, pp.505-510

