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Investigation on surface roughness of Aluminium alloy for End milling

Parth Shah[1], Falgun Jani[2]

[1,2]*Assistant Professor, Mechanical Engineering Department, Sigma Institute Of engineering, Vadodara*

Abstract - *From different industrial manufacturing operations, milling is an important operation. In that, end milling is the mostly used method for metal removal. In this paper, different practicals for the end milling operation have been done to get idea about the surface roughness on material. The main aim of this research is to have a better idea of the effect of machining parameters such as speed, feed and depth of cut. Here in this experiment, Design Expert software was used and Response Surface Methodology was used among different Design of Experiments (DOE),. The effect of speed, feed and depth of cut for finding surface roughness was considered in this study and interactions between two variables are also found out. The equation in terms of actual factors was also generated and optimization was done to find out the best value after using analysis of variance (ANOVA),. It was observed that feed was dominating factor when minimization of surface roughness was taken into consideration.*

Keywords- *Surface roughness; Design Expert; end milling;*

I. INTRODUCTION

Metal cutting is one of the most important manufacturing operation in the area of material removal [1]. Metal cutting is defined as the removal of metal chips from a workpiece in order to obtain a finished product with desired attributes of size, shape, and surface roughness [2]. In different machining operation, end milling is one of the significant machining operations. In end milling operation, the milling cutters used are end milling cutters or end mills which are widely used in industry for high-speed machining. End milling cutters are milling cutters with more than one cutting edge called multi-edge. They have edges both on the periphery as well as on the face end. End mills combine the capabilities of peripheral cutting, end cutting and face milling into one tool. It is widely used in different manufacturing industries including the aerospace and automotive sectors, where quality is an important factor in the production of dies and slots. The quality of the surface plays a significant role in the performance of milling as a surface having good finish mainly improves creep life, fatigue strength and corrosion resistance. Surface roughness also affects several functional features of parts, such as wearing, heat transmission ability of holding a lubricant, coating, or resisting fatigue.

II. WORKPIECE MATERIAL AND TOOL MATERIAL

The workpiece material selected for the experiment is Aluminium alloy 6061-T6 material. Two plates of dimension 120 × 100 mm having a 30 mm thickness were used. Alloy 6061 is one of the most commonly used alloys in the 6000 series. This aluminium alloy is one of the most versatile of the alloys which are heat-treatable. As this alloy has good toughness properties, it is widely used for medium to high strength requirements. 6061-T6 aluminium is widely used in airplane construction. Although mostly used in private aircrafts, its strength-to-weight ratio is very high, making it ideal for large parts that need to be very light, such as the plane's fuselage and wings.

The tool material used here is Solid carbide end mill. Most of the time carbide cutters will leave a better surface finish on the part and allow faster machining than high-speed steel or other tool steels. Carbide tools are very abrasion resistant can withstand higher temperatures at the cutter-workpiece interface than standard high-speed steel tools. Carbide is usually superior for the cutting of tough materials such as carbon steel or stainless steel, as well as in situations where other cutting tools would wear away faster, such as high-quantity production runs.High stock removal rates at high speeds and feeds, excellent finish quality and extended tool life are the major benefits of carbide tools. The dimension of the Solid Carbide tool used in experiment are: Milling Diameter–12 mm, Shank Diameter–12 mm, Length of Cut –25 mm, Overall length–75 mm, No of Flutes–4, Straight Shank, Helix angle –35 degree.

III. EXPERIMENTAL SETUP AND PROCEDURE

Experimental trials have been done in order to understand the effects of spindle speed, feed and depth of cut on the surface quality of the workpiece material. Often, the experimental design does not give knowledge about the interaction between variables. The experimental setup is shown in figure. 1. The response variable was Surface roughness, Ra measured in µm. The surface roughness values was found out by 27 machining conditions which is given by 3 speeds × 3 feed × 3 depth of cuts. The values of speed were 250, 500 and 750 rpm. The values of feed taken were 100, 200 and 315 mm/min. The values of depth of cut taken were 0.5, 1 and 1.5mm. Here, the assignment of factors was carried out by user defined Response Surface Methodology in Design Expert 10 Software. The milling machine used was UF1 of Bharat Fritz Werner company and surface roughness tester used was Surftest SJ-210 from Mitutoyo company.

IV. RESULTS AND ANALYSIS

The below Table 1 gives values of surface roughness which was measured by surface roughness tester and the value ranges from 0.808 to 4.572 μm. After getting values, analysis was done in Design Expert software and results obtained are as shown in Table 2. From Table 2, we infer that the Model F-value of 4.78 implies the model is significant. There is only a 0.35% chance that an F-value this large could occur due to noise. Values of "Prob > F" less than 0.050 shows that model terms are significant. In this case B, C are significant model terms. Values greater than 0.1 shows the model terms are not significant. We also see that the "Pred R-Squared" of 0.3054 is in reasonable agreement with the "Adj R-Squared" of 0.4662; i.e. the difference is less than 0.2 which is a necessary condition. "Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. Your ratio of 7.676 indicates an adequate signal. This model can be used to navigate the design space. The final equation we get in terms of actual factors is given below:

Surface Roughness = 4.22199 - 0.14442 * Depth of cut - 2.21387E-003 * Feed - 5.84358E-003 * Speed +4.94744E-004 * Depth of cut * Feed +1.14267E-003 * Depth of cut * Speed +1.12023E-005 * Feed * Speed

The equation in terms of actual factors can be used to make predictions about the response for given levels of each factor. Here, the levels should be specified in the original units for each factor.

Table -1 Surface Roughness Values

Experiment no	Speed	Feed	Depth of cut	R_a	Experiment no	Speed	Feed	Depth of cut	R_a
B1	250	100	0.5	3.132	B15	500	200	1.5	4.572
B2	250	100	1	2.188	B16	500	315	0.5	3.234
B3	250	100	1.5	2.865	B17	500	315	1	2.343
B4	250	200	0.5	3.213	B18	500	315	1.5	3.282
B5	250	200	1	3.707	B19	750	100	0.5	0.808
B6	250	200	1.5	3.739	B20	750	100	1	1.149
B7	250	315	0.5	3.047	B21	750	100	1.5	0.832
B8	250	315	1	2.673	B22	750	200	0.5	1.467
B9	250	315	1.5	2.971	B23	750	200	1	2.545
B10	500	100	0.5	2.019	B24	750	200	1.5	3.003
B11	500	100	1	1.607	B25	750	315	0.5	2.054
B12	500	100	1.5	2.036	B26	750	315	1	2.466
B13	500	200	0.5	1.962	B27	750	315	1.5	2.391
B14	500	200	1	2.814					

Table -2 Analysis of Variance(ANOVA)

	Sum of		**Mean**	**F**	**p-value**		Std. Dev.	0.65		R-Squared	0.5894
Source	**Squares**	**df**	**Square**	**Value**	**Prob > F**		Mean	2.52		Adj R-Squared	0.4662
Model	12.24	6	2.04	4.78	0.0035		C.V. %	25.88		Pred R-Squared	0.3054
A-Depth of cut	*1.26*	*1*	*1.26*	*2.96*	*0.1009*		PRESS	14.43		Adeq Precision	7.676
B-Feed	*3.14*	*1*	*3.14*	*7.36*	*0.0134*						
C-Speed	*6.35*	*1*	*6.35*	*14.89*	*0.0010*						
AB	*8.500E-003*	*1*	*8.500E-003*	*0.020*	*0.8891*						
AC	*0.24*	*1*	*0.24*	*0.57*	*0.4575*						
BC	*1.09*	*1*	*1.09*	*2.55*	*0.1257*						
Residual	8.53	20	0.43								
Cor Total	20.77	26									

The normal plot of residuals is illustrated in Figure 2. It is expected that data from experiments form a normal distribution. It reveals that the residuals fall on a straight line, implying that they are spread in a normal distribution. According to Figure 4 of the residuals versus run, we can see that there is not any pattern above or below 0 and that the residuals are uncorrelated with each other. Figure 3 reveals that there is no obvious pattern and it is unusual structure.. From the Figure 3 analysis of the residual plots, it can be established that there is no irregular variation between the residuals and predicted values we can see that the residuals have a constant variance and hence the developed model is highly significant and can be used for the prediction. Figure 5 shows the plot of Predicted vs Actual values. Figure 6,7 and 8 shows the contour plots for interactions between two variables. Now, optimization is done and we get the best value of surface roughness 0.829µm with desirability 0.992 for speed at 750 rpm, feed at 100mm/min and depth of cut at 0.5mm as shown in Figure 9.

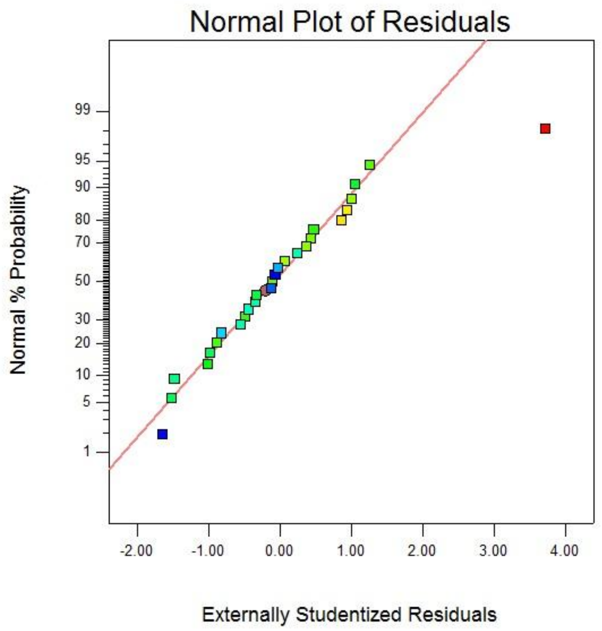

Figure 2 Normal plot

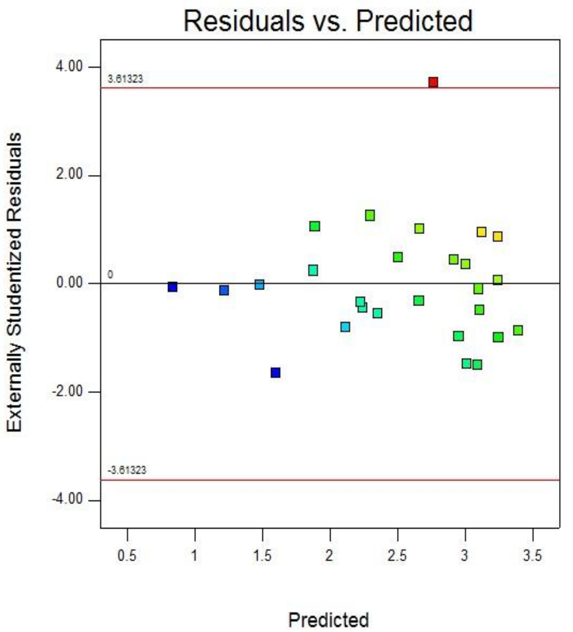

Figure 3 Residuals vs Predicted plot

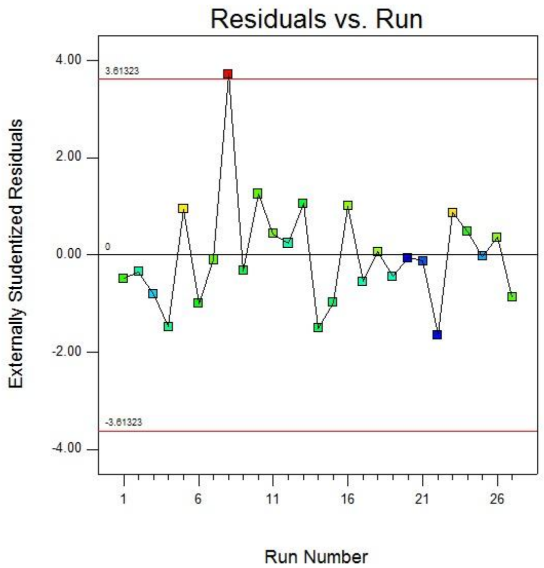

Figure 4 Residuals vs run plot

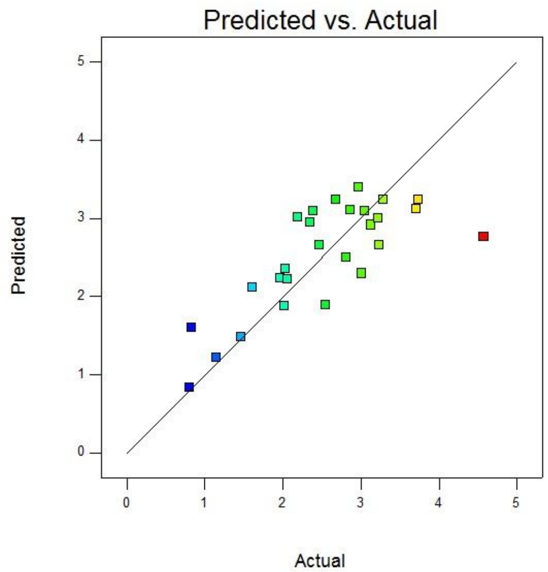

Figure 5 Predicted vs Actual plot

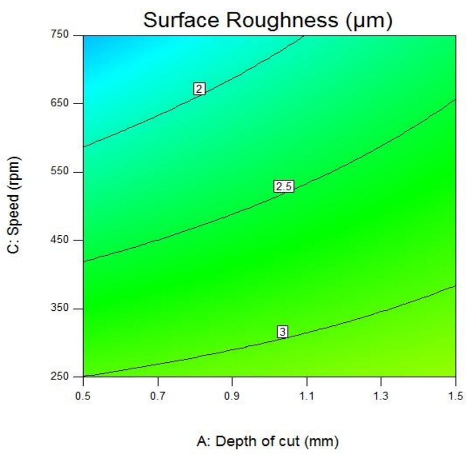

Figure 6 Contour plot (Speed and depth of cut)

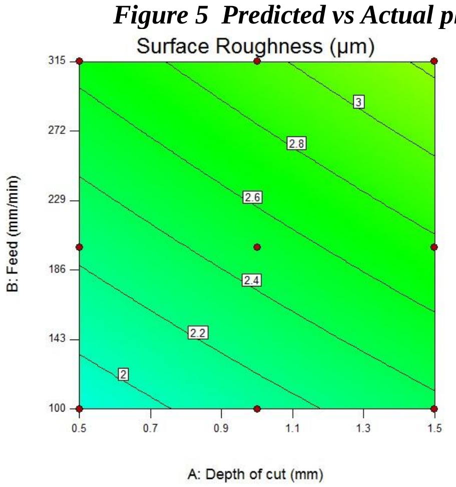

Figure 7 Contour plot (feed and depth of cut)

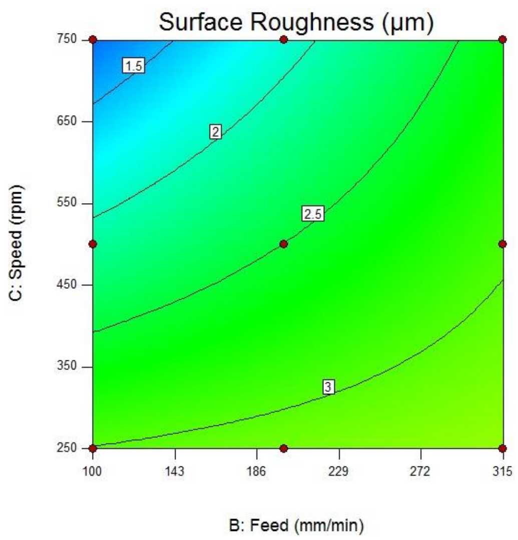

Figure 8 Contour plot (Speed and feed)

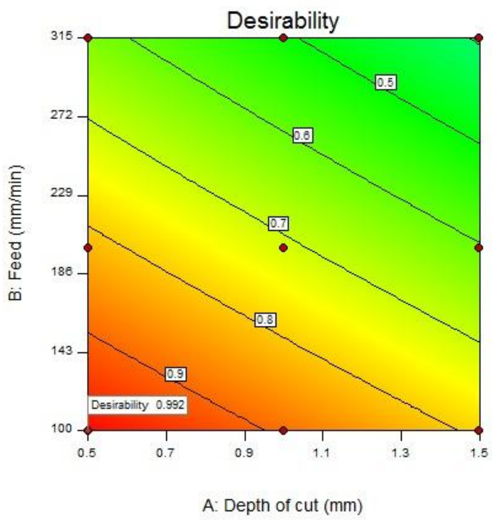

Figure 9 Desirability plot

IV. CONCLUSION

From the experimental runs, we found that the lowest value of Ra obtained was 0.808µm at speed of 750 rpm, feed of 100mm/min and depth of cut of 0.5 mm. It is observed through ANOVA that feed, and speed are significant and the speed is the most influential control factor among the three milling process parameters investigated in the present study, when minimization of surface roughness is considered.

By optimization, 57 solutions with desirability near to 1 were available but it was necessary to select the feasible and the lowest surface roughness value so that better surface quality is achieved and so the optimized value found using ANOVA was 0.829µm at speed of 750 rpm, feed of 100mm/min and depth of cut of 0.5 mm. The above value conforms with the experimental data input parameter values.

REFERENCES

[1]. J. C Chen and R. A. Smith: Journal of Industrial Technology, vol. 13, No.3, 1997, 15-19.
[2]. J. T. Black: Journal of Engineering for Industry, vol. 101, No 4, 1979, 403-415.
[3]. P. L. B. Oxley: The Mechanics of Machining An Analytical Approach to Assessing Machinability, Ellins Horwood Ltd., Chichester West Sussex, England, 1989.
[4]. E. M. Trent: Metal Cutting, Butterworth-Heinemann Ltd., Oxford. England, 1991.
[5]. V. P. Astakhov and M. O Osman: Journal of Materials Processing Technology, vol. 62, No 3, 1996, 175-179.
[6]. Giunta et al., 1996; van Campen et al., 1990, Toropov et al., 1996.
[7]. N Tabenkin: Carbide and Tool, vol. 21, 1985. 12-15.
[8]. P. Balakrishnan and M. F. De Vries: Analysis of Mathematical Model building Techniques Adaptable to Machinability Data Base System, Proceeding of NAMRC-XI, 1983.
[9]. V. M. Huynh and Y. Fan: The International Journal of Advanced Manufacturing Technology, vol. 7, 1992. 2-10.
[10]. G. Boothroyd and W. Knight: Fundamentals of Machining and Machine Tools. Second Edition, Marcel Dekker Inc., New York. 1989.

