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Experimental Analysis of Surface Roughness During CNC Milling of Brass Using Response Surface Methodology

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ABSTRACT :- *Optimization of machining parameters need to determine the most significant parameter for required output. The controllable parameters for the CNC milling machine are cutting tool variables, work piece material variables, and cutting conditions whereas the main desired output is surface roughness. Present work discusses the findings of an experimental investigation into the effects of cutting speed, feed rate and tool diameter during CNC milling of Brass keeping depth of cut constant. Response surface methodology (RSM) has been used to accomplish the objective of the experimental study. Face centered central composite design is used for conducting the experiments. The result from RSM revealed that tool dia. is the most significant factor followed by feed.*

Keywords:- *Surface Roughness(Rb); CNC Milling; Experimental Analysis; Brass; Response Surface Methodology;*

I. INTRODUCTION

Surface roughness, used to determine and evaluate the quality of a product, is one of the major quality attributes of a milling product. Previously trial and error approach was followed in order to obtain the optimal machining conditions for particular operations. Brass is specified because of the unique combination of properties, it is stronger and harder than copper, easy to form into various shapes, a good conductor of heat, and is generally resistant to corrosion from salt water. Owing to these properties, brass is usually a first-choice material for many components in equipment made in general.

In the electrical and precision engineering industries, brass is also used to make pipes and tubes, weather stripping, and other architectural trim pieces, screws, radiators, musical instruments, and cartridge casting for firearms. RSM is a collection of mathematical and statistical techniques that are useful for modeling and analysis of problems in which a response of interest is influenced by several variables and the objective is to optimize this response (Montgomery, 1997). RSM also quantifies relationships among one or more measured responses and the vital input factors. The steps in RSM are shown in figure1.

In RSM, polynomial equations, which explain the relations between input variables and response variables, are constructed from experiments or simulations and the equations are used to find optimal conditions of input variables in order to improve response variables. For the design of RSM, central composite design (CCD) is used in this experiment. CCD is widely used for fitting a second-order response surface. CCD consists of cube point runs, plus center point runs, and plus axial point runs. The three factors speed, feed rate, depth of cut, which were selected in the screening experiment, were used in CCD.

The factorial portion is a full factorial design with all factors at three levels, the star points are at the face of the cube portion on the design which correspond to value of -1. This is commonly referred to as a face centered CCD. The center points, as implied by the name, are points with all levels set to coded level 0, the midpoint of each factor range, and this is repeated six times. Twenty experiments to be performed. For each experimental trial, a new cutting edge to be used. The latest version of the Minitab or Design Expert may be used to develop the experimental plan for response surface methodology. The same software can also be used to analyze the data collected.

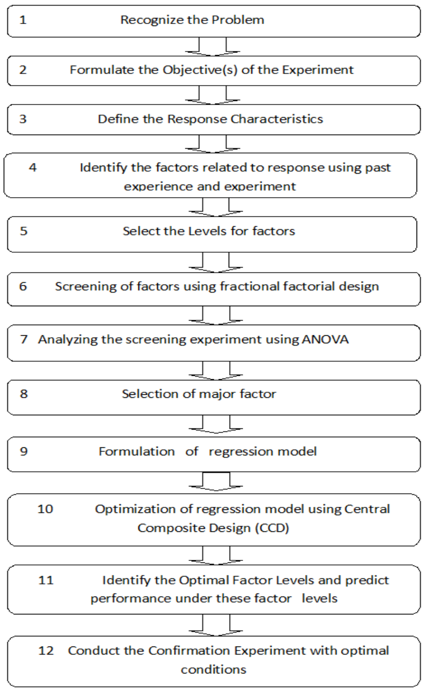

Figure 1. Steps in Response Surface Methodology (RSM).[6]

Present work discusses the findings of an experimental investigation into the effects of cutting speed, feed rate and tool diameter during CNC milling of Brass keeping depth of cut constant. Response surface methodology (RSM) has been used to accomplish the objective of the experimental study. Face centered central composite design is used for conducting the experiments.

II. EXPERIMENTAL SETUP

Experiments were conducted on CNC Milling Machine. Brass is taken as work piece material, HSS end milling cutter is used. Machining has been done as per the Design Matrix. The influencing parameters considered are speed, feed and tool diameter whereas depth of cut are taken constant. Table 1 shows the process parameters and their values.

The process was studied with a standard RSM design called a Central composite design (CCD). The factorial portion is a full factorial design with all factors at three levels, the star points are at the face of the cube portion on the design which correspond to value of -1. This is commonly referred to as a face centered CCD. The center points, as implied by the name, are points with all levels set to coded level 0, the midpoint of each factor range, and this is repeated six times.

Table 1: The process parameters and their values

Levels	Speed (A) (revolution/min)	Feed (B) (mm/min.)	Tool Diameter (C) (mm)	Depth of cut (mm)
1	1400	40	8	0.7
2	1550	55	10	0.7
3	1700	70	12	0.7

Figure 2: CNC Milling Machine

Twenty experiments were performed. For each experimental trial, a new cutting edge was used. The Minitab-17 was used to develop the experimental plan for response surface methodology. The same software was also used to analyze the data collected.

III. RESULTS AND ANALYSIS

The results from the machining trials performed as per the experimental plan are shown in Table 3. These results were used as input in the Minitab Software for further analysis. Without performing any transformation on the response, examination of the fit summary output revealed that the quadratic model is statistically significant for all the conditions and, therefore, it has been used for further analysis. An ANOVA table is commonly used to summarize the tests performed. Table 4 shows the Analysis of Variance (ANOVA). The Model F value of 27.60 implies the model is significant. Significance of Model is desirable as it indicates that the terms in the model have a significant effect on the response. From ANOVA table B, C and CC were found to be significant. From the ANOVA table tool dia. was found to be the most significant factor followed by feed.

Table 2: Central Composite Design Details

Factors: 3	Replicates: 1
Base runs: 20	Total runs: 20
Base blocks: 1	Total blocks: 1
Two-level factorial: Full factorial	
Cube points: 8	
Center points in cube: 6	
Axial points: 6	
Center points in axial: 0	

Table 3: Design Table

S.No	StdOrder	RunOrder	PtType	Blocks	A	B	C	Rb(µm)
1	20	1	0	1	0	0	0	0.458
2	18	2	0	1	0	0	0	0.458
3	1	3	1	1	-1	-1	-1	0.549
4	17	4	0	1	0	0	0	0.458
5	14	5	-1	1	0	0	1	1.5
6	13	6	-1	1	0	0	-1	0.562
7	16	7	0	1	0	0	0	0.458
8	19	8	0	1	0	0	0	0.458
9	9	9	-1	1	-1	0	0	0.382
10	2	10	1	1	1	-1	-1	0.675
11	11	11	-1	1	0	-1	0	0.36
12	15	12	0	1	0	0	0	0.458
13	4	13	1	1	1	1	-1	0.684
14	6	14	1	1	1	-1	1	2.09
15	5	15	1	1	-1	-1	1	1.22
16	8	16	1	1	1	1	1	3.01
17	3	17	1	1	-1	1	-1	0.621
18	7	18	1	1	-1	1	1	3.27
19	12	19	-1	1	0	1	0	0.699
20	10	20	-1	1	1	0	0	0.619

Table 4: Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	9	13.6145	1.51272	27.60	0.000
Linear	3	7.6549	2.55165	46.55	0.000
A	1	0.1073	0.10733	1.96	0.192
B	1	1.1492	1.14921	20.97	0.001
C	1	6.3984	6.39840	116.73	0.000
Square	3	4.7162	1.57207	28.68	0.000
A*A	1	0.0862	0.08615	1.57	0.238
B*B	1	0.1167	0.11670	2.13	0.175

C*C	1	1.3765	1.37653	25.11	0.001
2-Way Interaction	3	1.2434	0.41445	7.56	0.006
A*B	1	0.1779	0.17791	3.25	0.102
A*C	1	0.0222	0.02216	0.40	0.539
B*C	1	1.0433	1.04329	19.03	0.001
Error	10	0.5481	0.05481		
Lack-of-Fit	5	0.5481	0.10963	*	*
Pure Error	5	0.0000	0.00000		
Total	19	14.1626			

Table 5: Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.234121	96.13%	92.65%	55.78%

Regression Equation

*Rb = 0.4042 + 0.1036 Speed + 0.3390 Feed + 0.7999 Tool diameter + 0.177 Speed*Speed + 0.206 Feed*Feed + 0.707 Tool diameter* Tool diameter - 0.1491 Speed*Feed + 0.0526 Speed* Tool diameter + 0.3611 Feed* Tool diameter*

(Where Rb is Surface roughness of brass.)

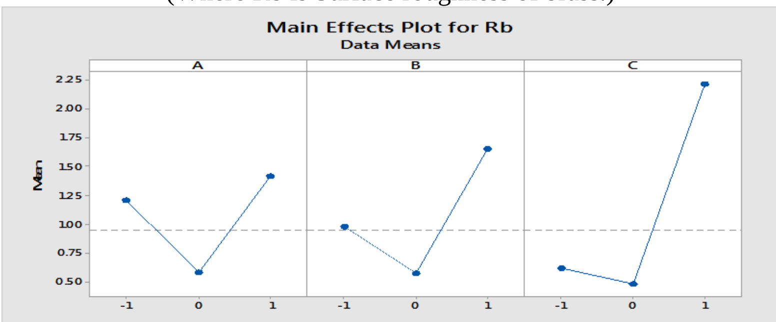

Figure 3: Main Effects Plots for Rb (Data Means)

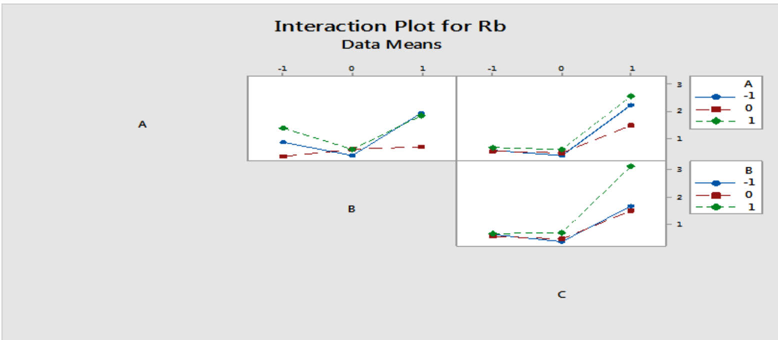

Figure 4: Interaction Plots for Rb (Data Means)

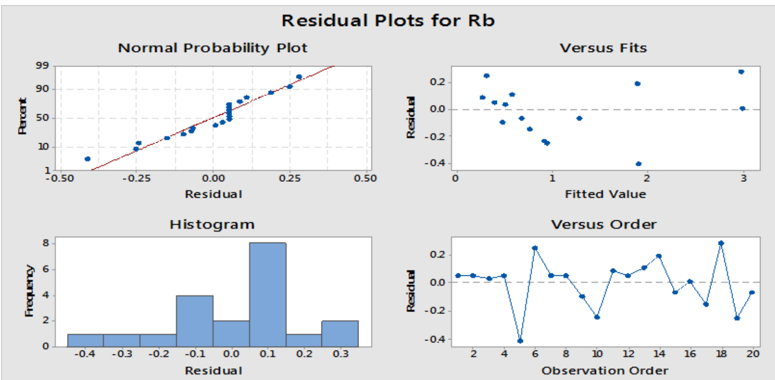

Figure 5: Residual Plots for Rb

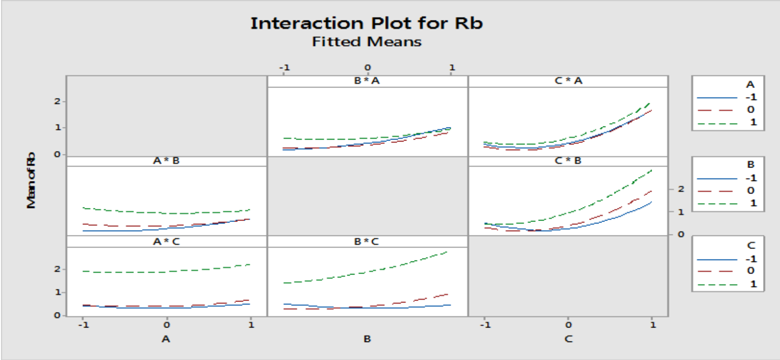

Figure 6: Interaction Plots for Rb

The normal probability plots of the residuals for Rb reveals that the residuals generally fall on a straight line implying that errors are distributed normally. Also in Fig. 5 showing residuals vs order for Rb reveals that they have no obvious pattern and unusual structure. This implies that the models proposed are adequate and there is no reason to suspect any violation of the independence or constant variation assumption. Fig.4 shows the interaction plots of Rb for the parameters.

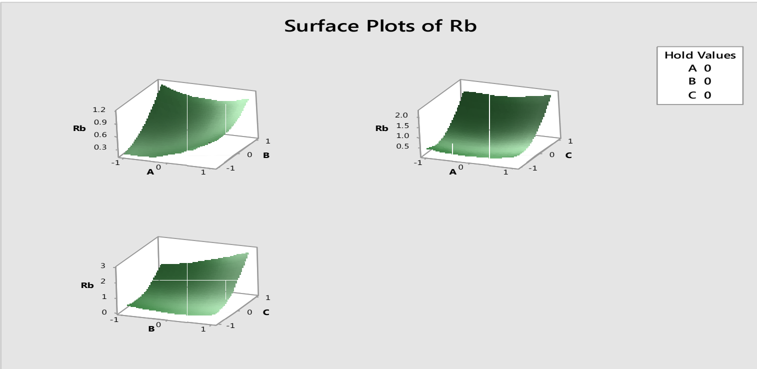

Figure 7: Surface Plots for Rb

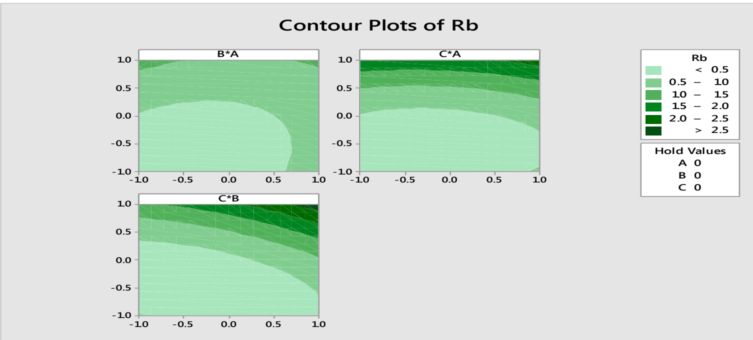

Figure 8: Contour Plots for Rb

The entire 3D surface graph for surface roughness has curvilinear profile in accordance to the quadratic model fitted. Fig-7 shows 3D surface plot graph of the effect of speed and depth of cut on the surface roughness. It has a curve linear shape according to the model fitted. The contour plot for the response, surface roughness is shown in fig-8. The surface roughness increases with increase in feed.

IV. Conclusion

The analysis of the results for surface roughness shows that the tool dia is the most significant factor followed by feed. The optimum value of surface roughness in the given range of parameters as depicted by graphs is 55 mm/min. (feed), 10 mm (tool dia) and 1550 rpm (speed). The Response surface methodology shows significance of all possible combinations of interactions and square terms. 3D surfaces generated by Response surface methodology can help in visualizing the effect of parameters on response in the entire range specified, thus Response surface methodology is a better tool for optimization and can better predict the effect of parameters on response.

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REFERENCES

[1]. IbrahemMaher , M. E. H. Eltaib , Ahmed A. D. Sarhan & R. M. El-Zahry, “Investigation of the effect of machining parameters on the surface quality of machined brass (60/40) in CNC end milling—ANFIS modeling”, Int J Adv Manuf Technol (2014) 74:531–537.

[2]. J.Balaraju, K.Srinivas and K.Siva Prasad, “ Prediction of Surface Finish by end Milling using Factorial Technique” International Journal of Mathematical Sciences, Technology and Humanities 59 (2012) 647 – 653.

[3]. Ranganath M. S., Vipin, Nand Kumar, Rakesh Kumar, “Experimental Analysis of Surface Roughness in CNC Turning of Aluminium Using RSM Techniques”, International Journal of Advanced Research and Innovation,Volume 3, Issue 1, 2015, 45-49.

[4]. Ranganath M. S., Vipin, Nand Kumar, R Srivastava, Surface Finish Monitoring in CNC Turning Using RSM andTaguchi Techniques, International Journal of Emerging Technology and Advanced Engineering Website Volume 4, Issue 9, 2014, 171-179

[5]. Ranganath M. S., Vipin, Harshit, Optimization of Process Parameters in Turning Operation Using Response Surface Methodology: A Review, International Journal of Emerging Technology and Advanced Engineering, Volume 4, Issue 10, 2014, 351-360.

[6]. Ranganath M S, Vipin, Harshit, “Surface Roughness Prediction Model for CNC Turning of EN-8 Steel Using Response Surface Methodology” International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 6, June 2015)

[7]. Ranganath M S, Vipin, Bhupendra Singh, “Experimental Investigation and analysis of Surface Roughness in Drilling Operation using Response Surface Methodology” Vth International Symposium on ‘Fusion of Science & Technology’, New Delhi,India, January 18-22,2016,ISBN: 978-93-84935-64-1.

[8]. Vishal Sardana, Achintya, Ranganath M. S. “Analysis of surface roughness during CNC Turning using Taguchi and Response Surface Methodology” IOSR Journal of Engineering (IOSRJEN) ISSN (e): 2250-3021, ISSN (p): 2278-8719 Vol. 06, Issue 02, 2016 PP 59-70