ISSN: 2456-043X

International Journal of Engineering Science and Generic Research (IJESAR)
Available Online at www.ijesar.in
Volume 2; Issue 3; May-June-2016; Page No. 01-06

STUDY OF CUTTING PARAMETERS DURING TURNING OF MMC (STEEL) USING RSM

[1] Sudhanshu Shukla, [2] Abhishek Singh Jatav

[1] M. Tech student of Manufacturing & Industrial Engineering, Suresh Gyan Vihar University, Jaipur

[2]Faculty of mechanical Engineering, Suresh Gyan Vihar University, Jaipur

Abstract

This paper presents the influence of process parameters like cutting speed, feed and depth of cut on surface roughness (Ra) in turning MMC (metal matrix composites) using uncoated tungsten carbide insert under dry environment. The experiments have been conducted based on RSM. Abrasion and adhesion are observed to be the principal wear mechanism from images of tool tip. No premature tool failure by chipping and fracturing was observed and machining was steady using carbide insert. Built-up-edge formation is noticed at low and higher cutting speed and at high feed combination and consequently surface quality affected adversely. The optimal parametric combinations for surface roughness are used according to manually. Mathematical models for surface roughness are found to be statistically significant.

Keywords: SURFACE ROUGHNESS, RSM, ANOVA, TURNING OPERATION, MMC

Introduction

Surface finish is the method of measuring the quality of a Product. It paragraph reveals the importance of surface excellence and cutting forces in machining. The surface finish of the machined work piece is greatly influenced by various factors such as cutting tool properties, machining parameters, work piece properties and cutting phenomenon. Machining parameters such as feed, speed and depth of cut play a crucial role during machining. These have a major effect on the size of production, cost of production and rate of production hence their care full selection is of utmost significance. The selected machining parameters should yield desired quality on the machined surface while utilizing the machining resources such as machine tool and cutting tool to the fullest extent possible, consistent with the constraints on these resources. So it can be achieved by establish empirical relationship between machining condition and surface roughness indicators using design of experiments (DOE). The proposed work will be employed for investigating the effect of turning parameters on surface roughness in turning of METAL MATRIX COMPOSITE stainless steel. An attempt has also been made to optimize the turning parameters for minimum surface roughness using response surface methodology.

EXPERIMENTAL DETAILS

Experimental setup

Traditionally the selection of machining parameters is carried out manually based on the information contained in research papers. Manual selection of machining parameters reflects the problem of variability in experience and judgment among the planners. In addition to this, the induction of cost intensive NC machines onto the shop floor, stresses more emphasis on the effective utilization of these resources using the optimal machining parameters. Present industries make use both of the conventional and the NC machines on the shop floor.

Figure 1: CNC lathe used for the turning purpose

Corresponding author: Sudhanshu Shukla

Hence it becomes necessary to go for automated methods for selection of the optimal machining parameters that suits the demands of the present day industries. Computer aided procedures have been found reliable for their fastness, accuracy and consistency in the automated selection of machining parameters compared to their manual counterparts. The methodology can be implemented by empirical modeling of performance as a function of machining conditions using a proper design of experiments (DOE). This all components make the system manipulated by a cutting head positioning device or robot handling system which is responsible to execute a nozzle motion along the predetermined path. A water catcher is placed at the bottom work material to collect the abrasive particles and water.

MATERIAL SPECIFICATION

A composite material is a material consisting of two or more physically and/or chemically distinct phases. The composite generally has superior characteristics than those of each of the individual components. Usually the reinforcing component is distributed in the continuous or matrix component. When the matrix is a metal, the composite is termed a metal-matrix composite (MMC). A metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal. The other material may be a different metal or another material, such as a ceramic or organic compound. When at least three materials are present, it is called a hybrid composite. An MMC is complementary to cermets.

Chemical Composition of MMC Metal

DESIGN OF EXPERIMENT

Design of Experiment is a powerful approach to improve product design or to improve process performance where it should be used to reduce cycle time required to develop new product or the processes. Design experiment is a test or series of test where changes are made in the input parameters of a process for concluding and identifying changes in the output response corresponding to input parameters. A number of experiments required, mainly depends on design of experiment. Thus, it is important to have a well designed scheme of the experiment, so that number of experiments required can be minimized. In this research, the design suggested by RSM based on face centered design (FCD) has been implemented to analyze the effect of independent process parameters on surface roughness indicators.

Table-1 shows independent process parameters and their levels in machining of metal matrix composite.

Table 1: Chemical Composition of MMC Metal

Alloy Element	wt %
B4C	2
Mg	1
Si	0.6
Cu	0.25
Fe	0.2
Cr	0.17
Zn	0.09
Ti	0.01
Mn	0.01
Al	Bal.

Table 2: Process parameters and their levels for the turning of metal matrix composite (Steel)

Factors	Symbol	Levels		
		-1	0	+1
Cutting speed (m/min)	A	100	175	250
Feed (mm/rev)	B	0.10	0.25	0.40
Depth of cut (mm)	C	0.10	0.25	0.40

The complete design layouts for experiments on material matrix composite steel are summarized in table 2. The design layout table shows total 20 experimental combinations of cutting speed, feed and depth of cut. The twenty set of experiments constitute 2^2 factorial points, six centre points and six star points.

Table 2: Experimental design layout for the turning of material matrix composite steel

		Factor 1	Factor 2	Factor 3	Response 1
Std	Run	A:Cutting Speed	B:Feed	C: Depth of Cut	Ra
		m/min	mm/rev	Mm	Microns
1	1	100	0.1	0.1	1.26
3	2	100	0.4	0.1	1.93
4	3	250	0.4	0.1	1.606
15	4	175	0.25	0.25	1.712
16	5	175	0.25	0.25	1.692
10	6	250	0.25	0.25	1.52
11	7	175	0.1	0.25	1.17
6	8	250	0.1	0.4	1.16
7	9	100	0.4	0.4	2.643
20	10	175	0.25	0.25	1.662
14	11	175	0.25	0.4	1.82
8	12	250	0.4	0.4	2.268
19	13	175	0.25	0.25	1.712
12	14	175	0.4	0.25	2.021
2	15	250	0.1	0.1	1.06
13	16	175	0.25	0.1	1.48
17	17	175	0.25	0.25	1.727
18	18	175	0.25	0.25	1.694
9	19	100	0.25	0.25	1.932
5	20	100	0.1	0.4	1.401

ANALYSIS FOR AVERAGE SURFACE ROUGHNESS (R_a)

After the examination of Fit Summary, output revealed that the quadratic model is statistically significant for average surface roughness and therefore it will be used for further analysis.

ANOVA analysis for R_a

The ANOVA is commonly used to perform test for significance of the regression model, test for significance on individual model coefficients and test for lack-of-fit of model. This analysis was carried out for a significance level of α = 0.05, i.e. for a confidence level of 95%. The ANOVA test for response surface quadratic model for average surface roughness is summarized.

It shows that the value of "Prob. > *F*" for model is 0.0001 which is less than 0.05, that indicates the model is significant, which is desirable as it indicates that the terms in the model have a significant effect on the response.

For the Insignificant value we use backward elimination for getting best model and eliminating the not significant term or improver the R-Squared value. by which we can improve our model table 3, Shows the reduced ANOVA Table having the R-squared value 0.9939 and adequate precision value more than 4 that is 66.74.

Table 3: Reduced ANOVA table for quadratic model (response: average surface roughness, R_a)

Source	Sum of		Mean	F	p-value	
	Squares	DOF	Square	Value	Prob > F	
Model	2.762376	7	0.394625	279.9539	< 0.0001	
A-Cutting Speed	0.24087	1	0.24087	170.8777	< 0.0001	
B-Feed	1.950989	1	1.950989	1384.066	< 0.0001	
C- Depth of Cut	0.382594	1	0.382594	271.4186	< 0.0001	
AB	0.008321	1	0.008321	5.902708	0.0318	
BC	0.160745	1	0.160745	114.035	< 0.0001	
A^2	0.009527	1	0.009527	6.758345	0.0232	
B^2	0.018453	1	0.018453	13.09075	0.0035	
Residual	0.016915	12	0.00141			
Lack of Fit	0.014354	7	0.002051	4.003846	0.0730	
Pure Error	0.002561	5	0.000512			
Cor Total	2.779291	19				
Std. Dev.	0.037545		R-Squared		0.993914	
Mean	1.6735		Adj R-Squared		0.990364	
C.V. %	2.243486		Pred R-Squared		0.980546	
PRESS	0.054068		Adeq Precision		66.74984	

Final mathematical model for R_a

The final regression model for average surface roughness in terms of coded factors is shown as follows:

$Ra = +1.68 - 0.16 * A + 0.44 * B + .20 * C - 0.032 * A * B + 0.14 * B * C + 0.055 * A^2 - 0.076 * B^2$ While, the regression model for average surface roughness in terms of actual factors is

$Ra = + 1.33861 - 4.74767E-003 * \text{Cutting Speed} + 3.55883 * \text{Feed} - 0.27100 * \text{Depth of Cut} - 2.86667E-003 * \text{Cutting Speed} * \text{Feed} + 6.30000 * \text{Feed} * \text{Depth of Cut} + 9.70000E-006 * \text{Cutting Speed}^2 - 3.37500 * \text{Feed}^2$

The normal probability plot of the residuals is shown in Fig.4.1. The normal probability plot indicates whether the residuals follow a normal distribution or not, if the residuals follow a normal distribution majority of points will follow a straight line except some moderate scatter even with normal data. The figure displays that the residuals generally fall on a straight line implying that the errors are distributed normally.

RESULT AND DISCUSSION

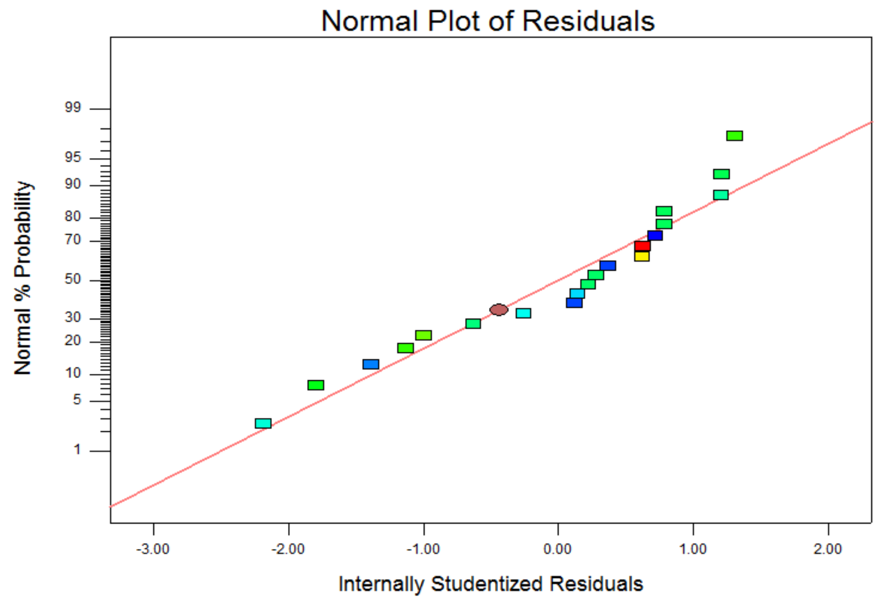

Figure 1: Normal probability of the residuals plot for average surface roughness.

It tests the assumption of constant variance. The plot should be a random scatter. The figure 4.2 shows that there is no obvious pattern and it shows unusual structure. This implies that there is no reason to suspect any violation of the independence or constant variance assumption.

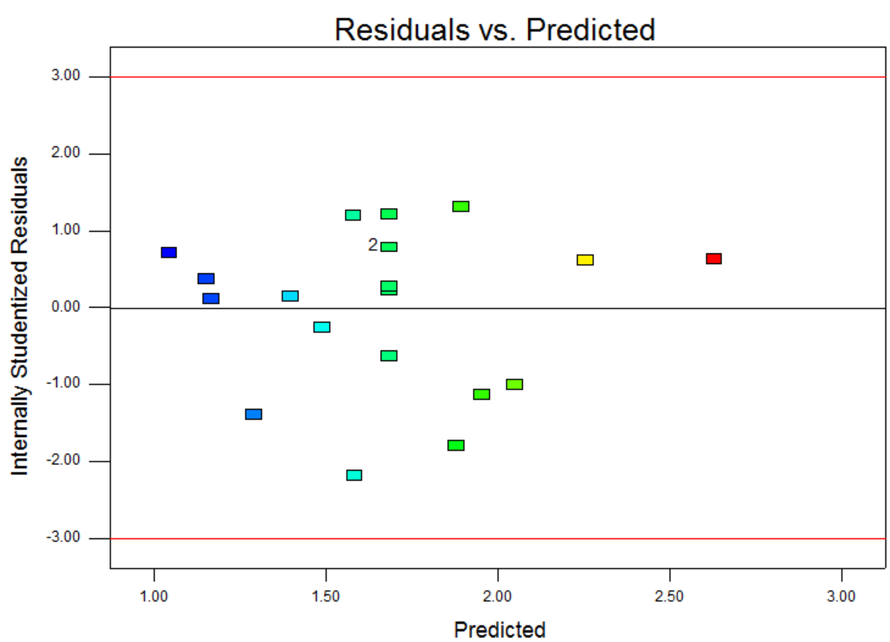

Figure 2: Residuals versus the Predicted response plot for average surface roughness.

CONCLUSION

Three numeric factors response surface methodology based on the Face centered design technique has been used for the development of mathematical models to predict average surface roughness.

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

- ❖ Out of three parameters, feed seems to be the most significant and influential machining parameter that affect the average surface roughness (R_a)
- ❖ The depth of cut has significant for both the average surface roughness for the MMC steel.
- ❖ The mathematical models developed clearly show that surface roughness increases with increasing the feed but decreases with increasing the cutting speed.
- ❖ The results of ANOVA and the confirmation runs verify that the developed mathematical models for surface roughness parameters shows excellent fit and provide predicted values of surface roughness that are close to the experimental values, with a 95 per cent confidence level.
- ❖ The percentage error between the predicted and experimental values of the response factor during the confirmation experiments are within 5 per cent.
- ❖ The model can be used for direct evaluation of Ra under various combinations of machining parameters during turning of MMC steel.
- ❖ The minimum average surface roughness Ra (1.059 microns) have been obtained at cutting speed 249.86 m/ min , feed 0.10 mm/rev and depth of cut .10 mm have been obtained at cutting speed 249.85 m/ min , feed 0.40 mm/rev and depth of cut 0.40 mm.

REFERENCES

1. V. Massardier, R.Fougeres, P.Merle, 1995, Comparison between the experimental and theoretical behavior of aluminium based metal matrix composites reinforced with performs of α alumina platelets, Journal of Material and Science and Engineering , Vol. 203 pp. 93- 104.
2. Choudhury I.A. , Baradie M.A., 1997, Surface roughness prediction in the turning of high strength steel by factorial design of experiment Journal of Material Processing Technology, Vol.67 pp.55-67.
3. Davim, J.Paulo. (2001). A note on the determination of optimal cutting conditions for surface finish obtained in turning using design of experiments, Journal of Material Processing Technology, vol. 116, pp.305-308.
4. Ghani, J.A. Choudhury, I.A. Hassan, H.H. (2003). Application of Taguchi method in the optimization of end milling parameters. Journal of Materials Processing Technology, 145, 84-92.
5. N. S. Reddy and P. Vengateshwararao, (2005), Selection of optimum tool geometry and cutting Conditions using a surface roughness prediction model for end milling, International Journal of Advanced Manufacturing Technology, 26 1202-1210.
6. A. Pramanik, L. C. Zhang and J. A. Arsecularatne, (2006), Prediction of cutting force in machining of metal matrix composites, International Journal of Machine Tools and Manufacture, 46 1795-1803.
7. K. Palanikumar, (2007), modeling and analysis for surface roughness in milling glassfiber reinforced plastics using response surface methodology, Materials Design, 28 2611-2618.
8. J. Z. Zhang and J. C. Chen, Tool condition monitoring In an end milling operation based on the vibration signal collected through a micro controller – based data acquisition system, International Journal of Advanced Manufacturing Technology, 39 (2008) 118-128.