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Model Equation for Machining Parameters for Al/SiC_p based on Material Removal Rate by Using Tungsten Carbide Tool

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Abstract:

Today's scenario is to produce quality products with optimum resources. This is possible with sophisticated automations and new materials usage in machining process. Time management is very important in manufacturing industry. This research concentrates on study and analysis of material removal rate for Al/SiC_p material in turning operation with tungsten carbide tool. In this work input machining parameters are spindle speed, feed and depth of cut and output is material removal rate. By various conditions of input parameters in machining Al/SiC_p with coolant sheral B and tungsten Carbide tool output parameter material removal rate (MRR) is calculated. From the practical values regression equation is generated by using MINITAB 17 software . At confidence level 95% verification of machining process is done by ANOVA. In this paper improved mathematical model is developed for material removal rate (MRT) with in the selected range of machining conditions.

Keywords: Material Removal Rate (MRT), Turning Process, Al/Sic_p , Full Factorial Design, Analysis Of Variance (ANOVA), tungsten Carbide tool MINITAB-17.

1 Introduction

Now a days industries are is are looking to manufacture the product in low cost with high quality in short period. Automated and flexible manufacturing systems are implemented for that purpose along with computerized numerical control (CNC) machines that are capable of achieving high quality with low processing time for products.. Turning of material is one of the most common method to get the finished machined parts. Turning is the removal of material from the work piece by rotating work piece against the tool. Turning reduce the diameter of the work piece, usually to a specified dimension and to produce a smooth finish on the metal.

Literature Review:

Aluminium alloys are widely used non ferrous materials in engineering applications because of their attractive properties such as high strength to weight ratio, good ductility, good malleability, corrosion resistance ,and low weight but wear resistance is less [1]. Aluminum based particulate reinforced metal matrix composites came into existence due to their high performance properties to use the materials in aerospace, automobile, chemical and transportation industries because of their high strength, more elastic modulus and more wear resistance over regular base alloys. The material removal rate (MRT) is an important factor in turning operation and high MRT is always desirable to reduce the cost of product and to minimize the machining time for the machine as well as for operator . The material removal rate (MRT) is defined in turning operations is the volume of material removed t per unit time and it is expressed as mm^3/min. The effects of machining parameters on MRT in turning process were widely investigated by many researchers previously. In this paper the effect of important cutting parameters on MRT for Al/SiC_p was found with Tungsten Carbide tool. As Al/SiC_p is one of the most widely used composite material in automotive and aerospace industry and studying on it will be useful for many industries Many research papers are present on

MRT of Al alloys to know the effect of various cutting parameters but very few paper on. Al/SiC_p Al/SiC_p with tungsten Carbide tool . Performance characteristics by using Taguchi method for optimization of the parameters. They found that feed rate and cutting speed are great influence on MRT.[2]. Empirical equation to predict material removal rate in terms of spindle speed, feed rate and depth of cut using multiple regressions modeling method for. AlMgSiCu work piece material and tool is carbide inserted cutting tool. For material removal rate, confirmation experiments are found that in an average percentage error observed to be 3.35, which has the satisfactory performance to the prediction equation.[3] Jitendra J. Thakkar et al. carried out the experiment investigation on Ss410 round bars and using ANOVA they observed that the maximum volume of material removed can be achieved when machining was done at high depth of cut and high feed rate. Depth of cut was found to be the main significant parameter for MRT.[4] It is observed that cutting fluid[5] using also effect the MRT and reduces the tool wear. Al Composite material**[**6**]**The Aluminum Silicon-Carbide Al/SiC_p material has a unique set of material properties that are suited to high performance applications. Al/SiC_p has a high thermal conductivity . It is light weight, which is appropriate for portable designs and other low weight sensitive applications. Its composition is in table 1

Tungsten carbide tool[7]Sintered or cemented carbide materials are produced to improve their performance and to extend their range of applications. These are prepared from powder metallurgy technique. It Properties like high red hardness (about 1000^0C), high wear resistance, high modulus of rigidity , low thermal expansions and high thermal conductivity. Material removal rate.MRT defined as the volume of material removed per unit time It units are mm^3/min,(or)in^3/min. There will be a two methods to find out the material removal rate .that is 1.Based on weight 2.Based on formula. Based on formula: In this method the work piece dimensions are measured and it is product of average diameter of work piece before machining and after machining multiplied by inverse of feed ,depth of cut speed and constant value 3.14 and it is in eq-1 we get MRT value .MINI TAB Software MINI TAB is a software is used to get the initial model and refined model based on experimental values obtained . It is used to determine the coefficients of mathematical values based on the response surface regression model.

Table-1 chemical composition of Al5083 matrix composite

ELEMENT	Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Al
%PERCENT	0.4	0.4	0.1	0.40-0.1	4.0-4.9	0.25	0.15	0.005-0.25	Balance

2. Experiment Methodology:

1. Selection of tool in this is Tungsten carbide tool and work piece is Aluminum Silicon-Carbide
2. Selection for number of experiments is based on full factorial method considering three levels and three parameters.
3. While Performing Machining operations on CNC Machine sheralB used as coolant.
4. Calculating material removal rate based on formula and values are noted.
5. Verifying the data obtained from the formula after machining conditions with ANOVA software .
6. Getting the predicted mean valves based on regression equation which is developed and checking with practical values for validity.
7. Improving the obtained model equation by neglecting insignificant factors based on P valves.
8. Finally generated model equation is used to get predicted values

Machining process

The machining was carried out using a CNC XLTURN machine having maximum spindle speed of 3000rpm, and tool changer has maximum no. of eight tools and with 1HP spindle horse power. The machine has 2-axis movement along X, Z directions. CNC programs can be written in a FANUC software. The present work piece material used was Al/SiC_P with the dimensions 70mm length and 25mm diameter cylindrical rods tungsten Carbide tool as tool . In this three level and three parameters are selected for machining the work piece. material removal rate is calculated for 27 machining operations according to full factorial method. Values are tabulated in table 2.

In table 2 speed is coded as SP , feed is coded as FD, depth of cut as DC.

3. Results And Analysis

The Material removal rate is calculated by using the formula

MRT= (3.14) **($D_{average}$) (d) (1/f) (N),** mm³/min.------- eq-1

The material removal rate values are shown in the below.

Table-2

	Coded Values			Un coded Values			Material removal rate (mm³/min)	
Sl. No	(SP) (rpm)	(FD) (mm/min)	(DC)(mm)	Speed (rpm)	Feed (rev/mm)	Depth of cut (mm)	Actual values	Predicted values
1	1	1	1	600	50	0.2	188.11	177.807
2	1	1	2	600	50	0.3	281.61	284.073
3	1	1	3	600	50	0.4	374.72	389.479
4	1	2	1	600	60	0.2	156.76	150.634
5	1	2	2	600	60	0.3	234.67	230.241
6	1	2	3	600	60	0.4	312.27	308.988
7	1	3	1	600	70	0.2	134.37	150.705
8	1	3	2	600	70	0.3	201.15	203.653
9	1	3	3	1200	70	0.4	267.66	255.74
10	2	1	1	1200	50	0.2	376.23	277.656
11	2	1	2	1200	50	0.3	563.22	563.316
12	2	1	3	1200	50	0.4	749.45	748.115
13	2	2	1	1200	60	0.2	313.53	310.27
14	2	2	2	1200	60	0.3	469.35	469.271
15	2	2	3	1200	60	0.4	624.45	627.411
16	2	3	1	1200	70	0.2	268.74	270.129
17	2	3	2	1200	70	0.3	402.3	402.47
18	2	3	3	1200	70	0.4	535.32	533.951
19	3	1	1	1800	50	0.2	564.35	577.319
20	3	1	2	1800	50	0.3	844.83	842.371
21	3	1	3	1800	50	0.4	1124.18	1106.56
22	3	2	1	1800	60	0.2	468.41	469.721
23	3	2	2	1800	60	0.3	704.03	708.114
24	3	2	3	1800	60	0.4	936.83	945.648
25	3	3	1	1800	70	0.2	403.11	389.367
26	3	3	2	1800	70	0.3	603.45	601.101
27	3	3	3	1800	70	0.4	802.99	811.975

3.1 Regression Analysis For MRT: Regression coefficients are calculated using MINITAB 17 software and are presented in tables as below.

Response surface Regression valves: MRT versus SP,FD,DC**.**

Table-3 Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	9	1701341	189038	1894.80	0.000
Linear	3	1596654	532218	5334.63	0.000
speed	1	1027633	1027633	10300.37	0.000
feed	1	116421	116421	1166.93	0.000
doc	1	452600	452600	4536.59	0.000
Square	3	1114	371	3.72	0.032
speed*speed	1	0	0	0.00	0.982
feed*feed	1	1113	1113	11.16	0.004
doc*doc	1	1	1	0.01	0.917
2-Way Interaction	3	103573	34524	346.05	0.000
speed*feed	1	19405	19405	194.50	0.000
speed*doc	1	75640	75640	758.17	0.000
feed*doc	1	8529	8529	85.48	0.000
Error	17	1696	100		
Total	26	1703037			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
9.98832	99.90%	99.85%	99.61%

Regression Equation for MRR in Uncoded Units:

MRT = -2 + 0.4040 speed - 8.35 feed + 1623 doc - 0.000000 speed*speed
+ 0.1362 feed*feed - 43 doc*doc - 0.006702 speed*feed + 1.3232 speed*doc - 26.66 feed*doc-----eq---2

3.2 Checking the accuracy of the developed model.

The value of 'P' in the table 5 is less than 0.005 which shows that the model is adequately significant at 95% confidence level, which exhibits that the terms in the model have a significant effect on the response. The cutting speed is most dominant effect on material removal rate. Followed by depth of cut, and feed. This is known fact that increasing cutting speed will increase material removal rate. The 'MRT' is primarily a function of cutting speed. The general regression equation generated is eq-2 1. In table 3 the' p ' values of speed*speed and doc* doc is greater than 0.05this shows the unaffected combination so by eliminating this values the improved model can be developed as below.

3.3 Improving the Regression Equation:

Improved Response Surface Regression: MRT versus speed, feed, doc

Table4:

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	7	1701340	243049	2720.92	0.000
Linear	3	1596654	532218	5958.15	0.000
speed	1	1027633	1027633	11504.30	0.000
feed	1	116421	116421	1303.33	0.000
doc	1	452600	452600	5066.83	0.000
Square	1	1113	1113	12.46	0.002
feed*feed	1	1113	1113	12.46	0.002
2-Way Interaction	3	103573	34524	386.50	0.000
speed*feed	1	19405	19405	217.23	0.000
speed*doc	1	75640	75640	846.78	0.000
feed*doc	1	8529	8529	95.48	0.000
Error	19	1697	89		
Total	26	1703037			

Model Summary

S	R-sq	R-sq(adj)	Rsq(pred)
9.45124	99.90%	99.86%	99.66%

Regression Equation in Uncoded Units

MRT = 2 + 0.4034 speed - 8.35 feed + 1597 doc + 0.1362 feed*feed - 0.006702 speed*feed

+ 1.3232 speed*doc - 26.66 feed*doc ----eq-3

From table- 4 gives is the improved model of material removal rate as the ‘p’ values are totally less than 0.05.this exhibits confidence level upto 99%. The general regression equation is generated for improved model is eq--3

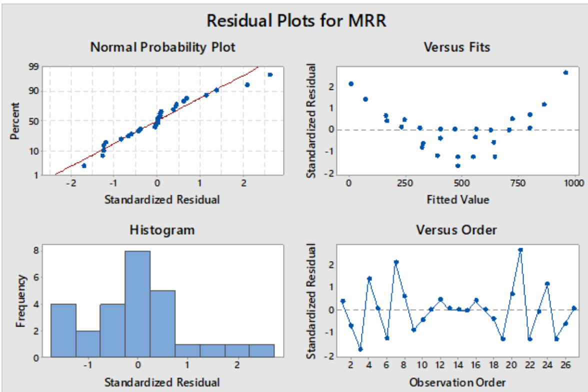
Equation for Prediction values of MRT :

MRT = -2 + 0.4040 speed - 8.35 feed + 1623 doc - 0.000000 speed*speed + 0.1362 feed*feed - 43 doc*doc - 0.006702 speed*feed + 1.3232 speed*doc - 26.66 feed*doc---3

The regression equation is generated to get the the predicted values for the MRT is eq --3

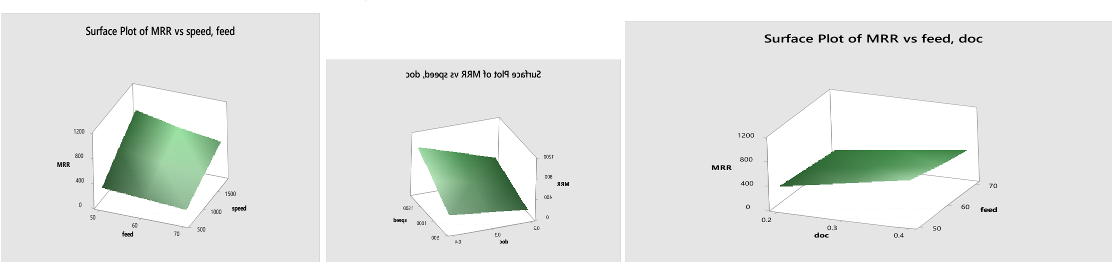
3.4 Analysis of MRR plots:

Scatter plots are drawn for actual and predicted values for precision turning and is presented in graph-1. It is observed that predicted values are fairly closed to the actual values.



Graph-1

Graph-2



Graph -3 effect of MRT on machining parameters

Scope of the future work: The work still can be continued by changing work piece and tool material with various input conditions and out parameters

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CONCLUSIONS:

Empirical mathematical model is developed for material removal rate within the range of the turning parameters selected..The experimental and predicted values are nearer to each other, which shows the accuracy of the experiment is good. .From the main effect plots, it is clear that the given input parameters has a significant effect on material removal rate in this experimental range with prominent one speed second is depth of cut followed by feed.

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