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PREDICTION MODEL OF SURFACE ROUGHNESS USING TAGUCHI METHOD

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ABSTRACT
In this modern world of highly growing technology and new advancements in every field is necessary as per Increased demand and accuracy. In this paper, artificial neural network (ANN) and regression analysis were used for the prediction of surface roughness. Regression analysis was also used to build a mathematical model representing the surface roughness as a function of the process parameters. The coefficient of determination was found to be 94.93% and 93.63%, for the best neural network model and regression analysis, respectively, from the comparison of the models with thirteen validation experimental tests.
New materials come with highly advanced properties, to determine the quality of the product there are various factors like Surface Roughness, Material Removal rate. Surface roughness not only enables one to have good surface properties but also reduces the overall manufacturing cost associated, In terms of metrology it gives us a proper tolerance and accuracy which determines the allowances in the different types of fits. These properties are also vital in terms of improved Tensile strength, Fatigue Str ength, corrosion resistance, and temperature-dependent failures (creep). Composites are supermaterials which are having a matrix and reinforcement to improve the qualities of base metal, Al6061 matrix along with SiC (5%) is taken as a composite material. Composite has a very good surface texture, good machinability, and good strength. Stir Casting is one of the best composite fabrication processes which has a mechanical stirrer (Ultrasonic stirrer) that gives mixing up nanoparticles and it comes with a uniform composition. A cylindrical Workpiece of dimensions Diameter (30mm), Length (100mm) is turned on the lathe and it is divided into 9 segments to measure roughness by changing the machining parameters, Speed, depth of cut, feed rate by analyzing various research papers three levels of speed (27.23m/min, 60.21m/min,94.24m/min), feed(.04mm,.12mm,.20mm), depth of cut(.1mm,.2mm,.3mm) are taken. This study focuses on optimizing surface roughness by using the Taguchi method subsequently, 27 readings are taken into consideration to make a regression model, and ANOVA is done which helps us to predict the Roughness without doing any experimental work. The optimal parameters obtained are Speed=94.24m/min ,Depth of cut= 0.1mm , feed = 0.0795 mm

1.INTRODUCTION

Surface unpleasantness is characterized as the more modest recurrence of genuine surfaces comparative with the box. Assuming you take a gander at machined parts, you will see that their surfaces typify a perplexing shape made of a progression of pinnacles and box of differing levels, profundities, and dividing. Surface harshness is a part of surface and assumes a significant part in deciding how an item will communicate with its current circumstance. Unpleasantness is a decent sign of the expected exhibition of a mechanical part, since inconsistencies on a superficial level might frame nucleation destinations for breaks or corrosion.[1]

Metal lattice composites (MMC) having aluminum (Al) in the network stage and silicon carbide particles (SiCp) in the support stage, for example Al – SiCp type MMC, have acquired prevalence in the new past. In this serious age, fabricating ventures endeavor to create unrivaled quality items at sensible costs. This is conceivable by accomplishing higher efficiency while performing machining at an ideal blend of cycle factors. They are low weight and high strength. MMC is viewed as reasonable for an assortment of parts requesting superior execution, particularly in the auto, aviation, military, and clinical applications.[2]
The significance of impartial framework Composites has been Supporting Bet for a long time. The smooth thought process, similar to Aluminum and the in implementation like earthenware material, control the upside of these composite. The most remarkable. The obvious type of NINCS is Aluminum implanted with hard clay specifically. Long fiber MMC have adequate seating attributable to financial and further developed property contrasted and solid alloy.[3]
Sasimuragan.T.and Planikumar K.(2011) examined and determined the machining boundary on surface unpleasantness of half and half Aluminum metal lattice composite (Al6061-SiC203) and the outcome showed that the improvement of cutting velocity profundity of cut and feed rate diminished. the surface harshness. To decrease surface, it is encouraged to apply medium cutting

velocity, low feed rate, and least lower profundity [4]. Deva Siddappa, D. Chandrasekaran, M, and Mandal, A(2012) conveyed the ANN model to anticipate the surface unpleasantness in end processing of Al-SiC MMC in the little arrangement of the trial informational collection. This module supports execution with a typical blunder of 0.31% against 0.53% for the RMS distributed outcome [5].

2.Literature review

This segment includes survey of Al-MMC, Manufacturing, Physical and wear properties, Machining of AMMC and improvement of boundaries, Future extension, and Objective of present work related with it as Composites are Well known for their upgraded properties and attributes

2.1Use of Al-MMC

•Warren et.al (2001), mostly centers around the utilization and different properties of Al MMC. These materials have expanded firmness; wear opposition, weakness strength, coff. Of warm development, these properties are predominantly utilized in aviation vehicles, auto parts, modern parts, coordinated chips, and warm resistors.

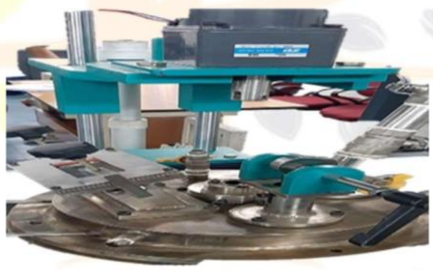
•Rosso et.al (2001), discusses the utilization of earthenware composites for guard purposes, Aeronautics, and the interaction boundaries like exhaustion strength, wear opposition, weight thickness, and coefficient of warm development.

•Shenqing et.al (2003), enlightens us regarding the readiness of al-sic composite and erosion mix projecting and its utilization in the assembling of cylinders of IC motor. It is a decent, upgraded material, it has a decent acknowledgment rate and has a decent remittance. It is another age material utilized by China in mass assembling. It is an industry 4.0 material.

3.Methodology and Experimental setup

3.1Stir casting

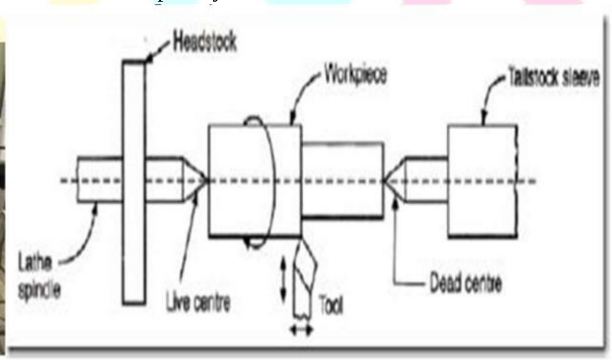
mix projecting is a very précised strategy to manufacture aluminum composites, It has a ultrasonic stirrer which vibrates with an exceptionally high recurrence and surrenders blending to Nano level. Al6061 is taken as lattice and Si-C is taken as support, the weight part is 5%. The workpiece of aspect distance across (30mm), Length (100mm) is create



with an It is an expansion of Friction mix handling, This is an exceptionally fine cycle to make composites excellent mechanical properties, in FSC we utilize a mechanical stirrer and in our lab its ultrasonic one, It vibrates with an extremely high recurrence and we effectively get stirring up to nanoparticle and the strength of composite is extremely huge when contrasted with other cycle

3.2 Conventional Lathe

Machine is one of the most established and known as mother, all things considered, it is extremely straightforward and can be utilized to make tube shaped parts utilizing a solitary point cutting instrument. Machine can perform different activities like Turning, tighten turning, confronting, boring, arranging, penetrating and so forth. In machine Tool is kept fixed and work piece is turned and it is determined utilizing an engine with variable speed yields



Working principle

Working of machine is exceptionally straightforward as it has a hurl where we hold work piece and it is turned with a given speed, there is a device post where we can hold the instrument, and it is kept fixed and apparatus is taken care of to work piece with a given feed rate and profundity of cut, cutting apparatus is taken care of radially or longitudinally to the workpiece, it relies upon kind of activity

3.3 Surface Roughness (Taylor hobson)

The Subtonic 3+ is a mobile, independent for the estimation of surface and is fitting for use in both the studio and lab. Boundaries available for surface assessment are: Ra, Rq, Rz (DIN), Ry and Sm

The boundaries assessments and different elements of the instrument are microchip based. The estimation results are dislodged on a LCD screen and can be result to an intentional printer or one more PC for additional outcomes

The instrument is regularly controlled by a soluble non-battery-powered battery. Whenever liked, a Nickel cadmium battery-powered battery can be utilized and its life differs as per the utilization. This testing machine gives us a variable result with an incredible usefulness and exactness. We can plot the chart of unpleasantness

Figure 11: Surface roughness measuring Instrument

This machine assists us with plotting the chart of unpleasantness and to work out the worth of Ra. It has a pointer with variable result which transduces the simple sign to an exceptionally helpful result. It has a DIP switch, Connector, get holder which have a one of a kind usefulness and use . The goal of this machine is extremely high, with a result rate arranged by 3-4 seconds. Which is viewed as exceptionally quick . the exactness and accuracy of this machine is extremely high and it utilizes multi dimensional approach to order the kind of harshness

4. Measurement of Surface Roughness

Inception and calculation of SR machined work pieces can be carried out by means of difference measurement techniques . These methods can be ranked into the following types

. Direct measurement method

.compression based techniques

.non- contact method

$$R_a = \frac{1}{L}\int_0^L |Y(x)|dx,$$

where

R_a = the arithmetic average deviation from the mean line

L= the sampling length

Y= the ordinate of the profile curve

Figure6: Mean roughness

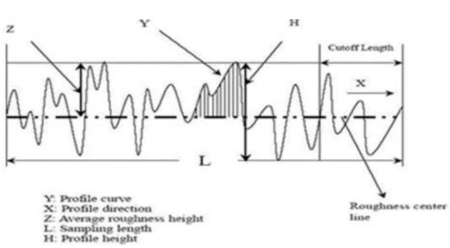


Figure7:Measurement of roughness by Stylus

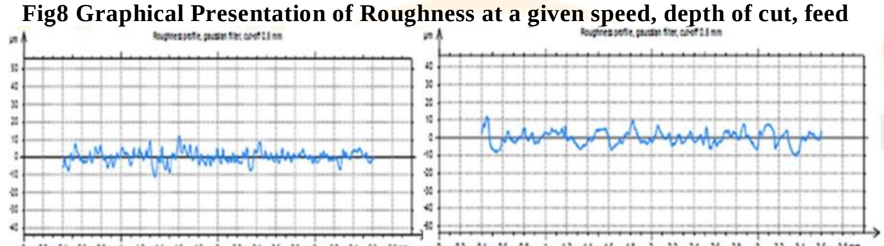
4.1 SURFACE ROUGHNESS VALUE

TABLE1: SURFACE ROUGHNESS VALUES

S.N.	DIAMETER	RPM	SPEED(m/min)	FEED(mm/rev)	DEPTH OF CUT(mm)	RA
1	30	289	27.27	0.04	.1	1.49
2	30	289	27.27	0.04	.2	1.83
3	30	289	27.27	0.04	.3	2.61
4	30	289	27.27	0.2	.1	2.41
5	30	289	27.27	0.2	.2	2.18
6	30	289	27.27	0.2	.2	2.17
7	30	289	27.27	0.12	.1	3.62
8	30	289	27.27	0.12	.2	3.19
9	30	289	27.27	0.12	.3	3.23
10	30	639	60.21	0.04	.1	1.62
11	30	639	60.21	0.04	.2	1.7
12	30	639	60.21	0.04	.3	1.70
13	30	639	60.21	0.2	.1	1.42
14	30	639	60.21	0.2	.2	1.67
15	30	639	60.21	0.2	.3	1.65
16	30	639	60.21	0.12	.1	1.83
17	30	639	60.21	.12	.2	1.42
18	30	639	60.21	.12	.3	1.86
19	30	1000	94.24	0.04	.1	1.34
20	30	1000	94.24	0.04	.2	1.65
21	30	1000	94.24	0.04	.3	1.93
22	30	1000	94.24	0.2	.1	1.02
23	30	1000	94.24	.2	.2	1.23
24	30	1000	94.24	0.2	.3	1.32
25	30	1000	94.24	0.12	.1	1.44
26	30	1000	94.24	0.12	.2	1.17
27	30	1000	94.24	.12	.3	1.30

ANALYSIS OF DATA

Fig8 Graphical Presentation of Roughness at a given speed, depth of cut, feed



5. Regression Analysis

S.N	Log S	Log d	Log f	Log Ra
1	3.30432	-2.3026	-3.2188	0.239017
2	3.30432	-1.6094	-3.2188	0.277632
3	3.30432	-1.2040	-3.2188	0.412110
4	3.30432	-2.3026	-1.6094	0.500775
5	3.30432	-1.6094	-1.6094	0.542324
6	3.30432	-1.2040	-1.6094	0.609766
7	3.30432	-2.3026	-2.1202	0.712950
8	3.30432	-1.6094	-2.1202	0.746688
9	3.30432	-1.2040	-2.1202	0.819780
10	4.09784	-2.3026	-3.2188	-0.139262
11	4.09784	-1.6094	-3.2188	-0.051293
12	4.09784	-1.2040	-3.2188	-0.020203
13	4.09784	-2.3026	-1.6094	0.113329
14	4.09784	-1.6094	-1.6094	0.215111
15	4.09784	-1.2040	-1.6094	0.254642

16	4.09784	-2.3026	-2.1202	0.292670
17	4.09784	-1.6094	-2.1202	0.357675
18	3.30432	-2.3026	-3.2188	0.4488580
19	3.30432	-1.6094	-3.2188	-0.385662
20	3.30432	-1.2040	-3.2188	0.261365
21	3.30432	-2.3026	-1.6094	-0.198451
22	3.30432	-1.6094	-1.6094	-0.116534
23	3.30432	-1.2040	-1.6094	-0.030459
24	3.30432	-2.3026	-2.1202	0.104360
25	3.30432	-1.6094	-2.1202	0.139762
26	3.30432	-1.2040	-2.1202	0.148420
27	4.09784	-2.3026	-3.2188	0.207014

6.ANOVA

TABLE 3 ANALYSIS OF VARIANCE WITH DIFFERENT SPEED FEED DEPTH OF CUT

Analysis of Variance						
Source	DF	Adj SS	Adj MS	F-Value	P-Value	Contribution%
Speed	2	15.5547	7.7774	56.01	0.000	80.69
Feed	2	0.5735	0.2868	2.07	0.153	2.975
Depth of cut	2	0.3696	0.1848	1.33	0.287	1.917
Error	20	2.7774	0.1389			14.40
Total	26	19.2752				

SS-Sum of Squares,D.F. Degrees of freedom ,M.S.-Mean Square,C-contribution
This table illustrate the contribution of cutting parameters (Speeddepth of cutfeed rate) on the dependent function i.e. Surface roughness

Table 4 Experimental results for S/N ratio by Taguchi method

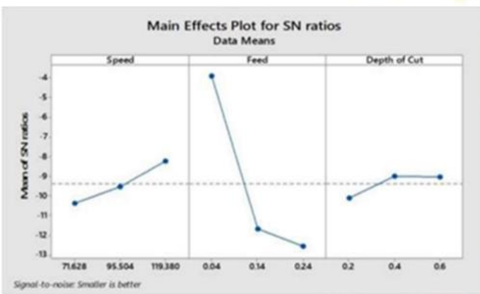
S.N	DIAMETER	RPM	SPEED(mm)	FEED(mm/rev)	DOC(mm)	Ra(m)	S/N ratio	Mean
1	30	289	27.23	0.04	.1	1.49	-4.6599	1.710
2	30	289	27.23	0.04	.2	1.83	-6.1121	2.365
3	30	289	27.23	0.04	.3	2.61	-13.8039	4.900
4	30	289	27.23	0.2	.1	2.41	-13.2435	5.880
5	30	289	27.23	0.2	.2	2.81	-15.3875	5.880
6	30	289	27.23	0.2	.2	2.17	-11.7811	2.6325
7	30	289	27.23	0.12	.1	3.62	-3.2274	1.450
8	30	289	27.23	0.12	.2	3.19	-6.2487	2.654
9	30	289	27.23	0.12	.3	3.23	-9.9937	3.160
10	30	639	60.21	0.04	.1	1.62	-11.6985	2.3647
11	30	639	60.21	0.04	.2	1.7	-13.7327	4.860
12	30	639	60.21	0.04	.3	1.70	-9.3647	9.952
13	30	639	60.21	0.2	.1	1.72	-5.8007	1.950
14	30	639	60.21	0.2	.2	1.41	-8.6971	2.365
15	30	639	60.21	0.2	.3	1.62	-13.9620	4.990
16	30	639	60.21	0.12	.1	1.83	-9.3245	2.952
17	30	639	60.21	0.12	.2	1.43	-12.8096	4.370
18	30	639	60.21	0.12	.3	1.86	-6.5624	3.652
19	30	1000	94.2	0.04	.1	1.34	-3.6369	1.520
20	30	1000	94.2	0.04	.2	1.65	-5.2488	3.324
21	30	1000	94.2	0.04	.3	1.93	-12.7298	4.330

22	30	1000	94.2	0.2	.1	1.02	-6.5478	6.632
23	30	1000	94.2	0.2	.2	1.23	-13.6248	4.800
24	30	1000	94.2	0.2	.3	1.32	_16.6987	9.325
25	30	1000	94.2	0.12	.1	1.44	-0.2915	0.967
26	30	1000	94.2	0.12	.2	1.17	-23.451	4.365
27	30	1000	94.2	0.12	.3	1.30	-15.1327	5.710

Taguchi suggests the use of the loss function to compute the performance characteristic from the expected value. The significance of the loss function is further altered into a signal-to noise (S/N) ratio η; usually, there are three types of the perform Table 8: Standardization of data characteristic in the assessment of the S/N ratio, that is, the lower-the-better, the higher-the-better, and the nominal- the-better

7.GRAPH FROM THE TAGUCHI

Signal-to-Noise: In the Taguchi method, the term 'signal' represents the necessary value (mean) for the o/p characteristic and the term 'noise' represents the undesirable value (S.D.) for the output characteristic. Therefore, the S:N ratio is the ratio of the mean to the S.D. Taguchi uses the S:N ratio to measure the quality characteristic deviating from the desired value



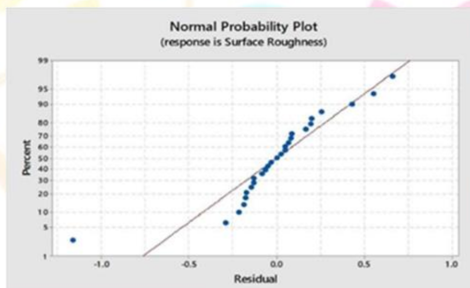


Fig9 Mean effective plot for SN ratio **fig10 normal probability plot response is surface roughness**

Fig. Above figure shows the response is surface roughness normal probability plot within the residual and percent ,the blue dotted shows the percentage probability of residual at different stage ,minimum at (-.25) residual and maximum probability at 30 to 75 percent of expected value

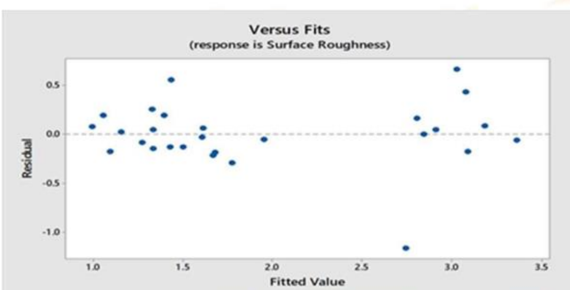


Fig11 (response is surface roughness versus fits versus residual

Above figure shows the residual values found out in discrete pattern but main values of residual are found at mean value of 0.0 residual of different fitted values. The size of the stud residual should be independent of its predicted value. In other words, the vertical spread of the stud residuals should be approximately the same for each bowler. In this case the plot looks good. The spread from top is not out of line with his competitors, despite their protestations about the highest score

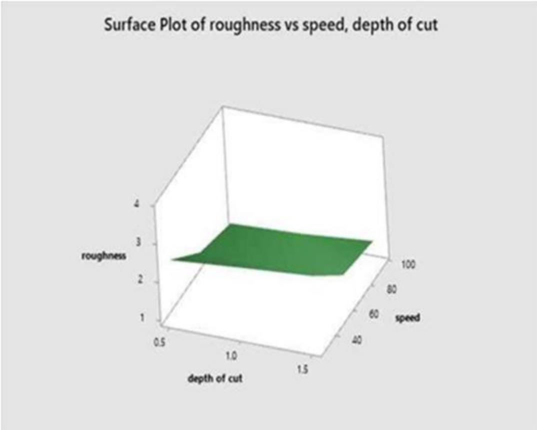


Fig12 : 3Dinteraction plot of roughness vs speed , depth of cut

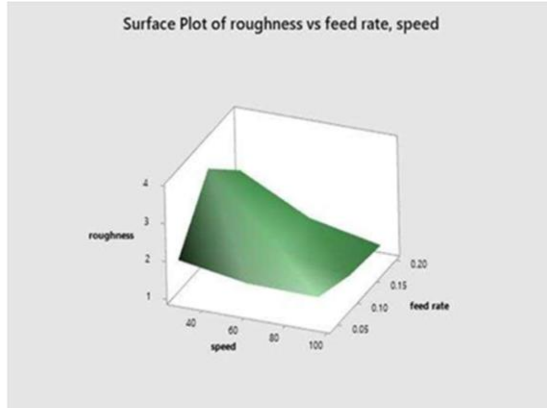


Fig 13: 3D interaction plot of roughness vs speed , feed rate

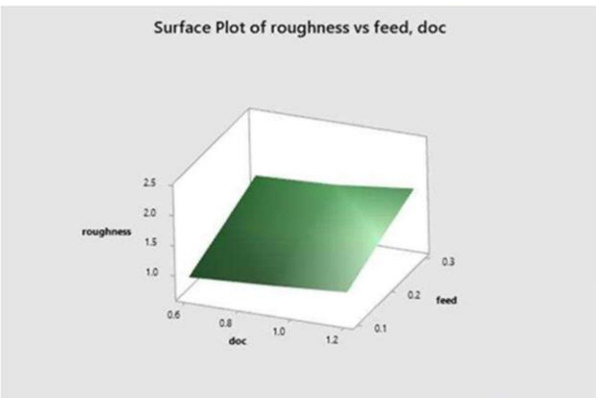


Fig 14: 3D interaction plot of roughness vs doc , feed rate

Table 5 Analysis of Variances

Analysis of Variance						
Source	DF	Adj SS	Adj MS	F-Value	P-Value	Contribution%
Speed	2	15.5547	7.7774	56.01	0.000	80.69
Feed	2	0.5735	0.2868	2.07	0.153	2.975
Depth of cut	2	0.3696	0.1848	1.33	0.287	1.917
Error	20	2.7774	0.1389			14.40
Total	26	19.2752				

Error 23 0.132299 0.005752
Total 26 0.840231
Regression Equation
Log Ra = 1.728 - 0.7061 Log S + 0.1645 Log F - 0.123 Log D
Ra = 52.12 S(-0.7061)F(0.1645)D(-0.123)

Speed(m/min)	Feed rate (mm/rev)	Depth of cut (mm)	Calculate Ra(mm)	%error
27.27	0.04	.1	1.49	15.33
27.27	0.04	.2	1.83	12.16
27.27	0.04	.3	2.61	-27.36
27.27	0.2	.1	2.41	-11.67
27.27	0.2	.2	2.81	-6.67
27.27	0.2	.2	2.17	9.55
27.27	0.12	.1	3.62	44.67
27.27	0.12	.2	3.19	-16.97

27.27	0.12	.3	3.23	34.33
60.21	0.04	.1	1.62	7.21
60.21	0.04	.2	1.7	-4.97
60.21	0.04	.3	1.70	-9.97
60.21	0.2	.1	1.72	12.67
60.21	0.2	.2	1.41	-2.97
60.21	0.2	.3	1.62	3.97
60.21	0.12	.1	1.83	7.35
60.21	0.12	.2	1.43	-9.64
60.21	0.12	.3	1.86	43.45
94.24	0.04	.1	1.34	34.21
94.24	0.04	.2	1.65	-16.23
94.24	0.04	.3	1.93	19.82
94.24	0.2	.1	1.02	13.11
94.24	0.2	.2	1.23	-5.65
94.24	0.2	.3	1.32	-6.64
94.24	0.12	.1	1.44	1.35
94.24	0.12	.2	1.17	-19.62
94.24	0.12	.3	1.30	32.25

From the table above, experimental values and theoretical values are very close to each other. Percentage error is minimum at machining parameter i.e. speed=94.24m/min, feed=.12mm/rev, depth of cut=.1 mm. This concludes the validity of model as experimental results are very close to the theoretical values

8. CONCLUSION

1.Roughness is minimum at high speed 94.24/min , So at high speed , Surface finish is better
2.Optimum feed rate corresponding to minimum roughness is .12mm.
3.Depth of cut for optimum roughness is .1mm .
4.Optimum cutting parameters are Speed=94.24m/min ,Depth of cut=.1mm , feed =.0795 mm

10. FUTURE SCOPE

1. This work can be carried out to find MRR, Residual stress etc.
2. Various other methods can be used to fabricate MMC
3. In current research three levels in the factors of combinations in the Design of the experiment. These levels can be changed in this research by taking different machines and tools for the different material and tool combinations.
4. Different modeling techniques can be used to predict the effect of machining parameters.
5. Nonlinear regression model may be used and different DOE with more number of values for more accuracy

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