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An Experimental Study to Minimize the Surface Roughness in K10 End Milling of Natural Fibers Refinforced Composites

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Abstract:
Fibre Re-inforced Plastic (FRP), belongs to chemical compound matrix stuff, wide utilized in a range of applications viz craft, robots and machine tools .Machining of natural fiberstrengthened Plastic composite is a vital activity within the integration of those advanced materials into engineering application. Machining damage due to disproportionate cutting parameter may result in rejection of the composite components at the last stage of their production cycle. Surface roughness's being prime requirement and are indicator of surface quality for machined part by the customer. This study applied modeling and simulation techniques to optimize parameters for minimum surface roughness in finish edge of NFRP. With group of experimental machining information the mathematical model has been formulated with the use of Response Surface Methodology (RSM). The best model was thought-about for formulating the equation, were obtained with simulated annealing (SA).

Keywords:*Natural Fibre Reinforced Plastic (NFRP), Surface Roughness, Mathematical Model, End Milling*

I INTRODUCTION

Natural fibre strengthened chemical compound composites have raised interests among scientists and engineers in recent past due to their environmental friendly nature .It is slowly and partly replacing materials like glass , carbonfibres etc as fibre reinforced composites [1-2]. The fibers have high specific strength, modulus , eco friendly and easy available in some countries.

Dilli et al [3] studied the finish of NFRP with thetarget of evaluating the cutting parameters and their effect on delamination and surface values..Using ANOVA and MRA a relationship between this was obtained.Ketan et al [4] studied drilling of GFRP in determining surface delamination by finding the significant process parameters using Taguchi OA.Manickam et al[5] studied vinyl ester composites and optimized the mechanical using gray based Taguchi.Model was developed using RSM technique and it was found that model was good enough in predicting the properties. Shubham et al [6] experimented drilling of GFRP using Taguchi technique using L9 OA with spindle speed and absolutely drilled materials were predominate factors. Dilli et al [7] conducted a study on turning of pineleaf-FRP with RSM techniques .From the analysis of variance ,analysis the factors were determined for analysis of average surface roughness.

Nageswara Rao et al [8] studied on machinability of hemp FRC during milling .The optimization of parameters was obtained through regression model and the ANOVA was postulated to work out the influence of the parameters.

Chandrabakty eta al [9] experimented in drilling of on ramie woven fiber composites in drilling

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using Taguchi Technique. Optimum parameters were obtained using ANOVA technique using factors speed and feed with various drill bit sizes were used.

There square measuremany literatures on modeling and simulation of surface roughness in machining of composite [10,11].Among the different predictive modelling and simulation technique use ,Response surface Methodology (RSM) and Simulated Annealingis most robust.SA was additionally thought-about in improvement of machining conditions for minimum surface roughness [12] and wire discharge machining has additionally been extensively employed in machining of semiconducting materials [13,14]

Despite the various capabilities of Simulated Annealing the application of it in optimization of machining parameters for natural fibers have been given less attention by researchers.

II EXPERIMENTAL DETAILS

2.1 Material and processes

It had beenfound cotton and jute fibre reinforce plastics plays an awfullyvery important role within the field of engineering region. Cotton and jute fibre reinforced plastic composite were fabricated using per the table 1given below. Fig 1 shows the application of resin during the fabrication of first layer in jute and cotton.

Table 1 Composition of cotton and jute FRP composite

Sl.No	Material	Type
1	Matrix	Epoxy-EP306,Araldite,DIGBA
2	Hardener	HY-151
3	Reinforcement	Cotton And Jute Fibre

Figure 1. Application of resin in first layer of Jute and Cotton

A CNC vertical centre with most speed of 4500 revolutions per minute was used for mill with TiN and TiAlN Coated K10 finish mills and Solid uncoated K10 finish mills were used for machining. The surface roughness was evaluated employing a Hand surface instrument with cut-off length being 0.8mm.

2.2 Plan of experiment

RSM for 3 factors at three levels ,used for the implementation of the set up of experiment. The Box- Behnken style was designated as shown in Table 2, which had fifteen rows with the desired columns. Table 3, shows the factors and levels designated for machining.

Table 2 Box-behnken design For making

Factor	Replication	Base runs	Total runs	Base block	Total block	Center point
3	1	15	15	1	1	3

slot on the plate the following tools are used

- Tool-1: Titanium Namite
- Tool-2: Titanium Aluminium Nitrate

Table 3 Factors with corresponding levels in box-behnken design

Levels	Speed (m/min)	Feed (mm/min)	Depth of cut (mm)
-1	100	50	1
0	700	350	2
1	1300	650	3

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Corresponding values are tabulated in Minitab and according to each row of the Box-Behnken Design, the experiment was conducted.

2.3 Surface Roughness Measurements

Manufacturers needmanagement processes for producing a consistent and reliable product. When exactitude surface engineering is needed, surface mensuration is a key a part of maintaining management over the method, by observance the output to visualize that the methodisn't outside the limit. Figure 2 shows the surf applied, used for activity.

Fig. 2.Surf coder machine

Surface roughness may be a calculation of average roughness of a linear surface expressed as (Ra). Figure 3,measureRa for jute.

Fig. 3. Measurement of surface roughness(Ra) value

2.4 SA Optimization Process

SA rulecould be atechnique, which is customized from method| of gradual cooling of metals done throughoutsciencetemperingprocess. The likelihood of being at the energy state of E is set by the Ludwig Boltzmann distribution as shown in Figure 4(18).

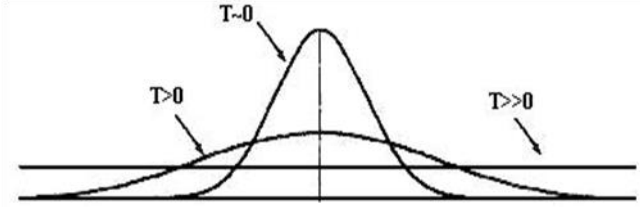

Figure 4. Distribution of probability for three different temperatures

$$\boldsymbol{Pr}\ \mathbf{(E)} = \frac{1}{Z(T)} \times \boldsymbol{exp}\ \left(-\frac{E}{KB.T}\right) \qquad (1)$$

Where Z (T) is standardization issue and relies on the temperature T. The parameter computer memory unit is physicist constant and therefore the exponential term is Boltzmann constant

There aren’t any specific techniquesoutlinedwithin thereservesrule to randomise the inputs. The precise nature through thatit's done typically depends upon the matter being solved.

III RESULT AND DISCUSSIONS

The Table 4 and 5 show the result of surface roughness obtained for cotton with Ti- N Coated tool and Ti-AlN Coated tool.

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Table 4 RSM table of Ra values of cotton using titanium namite coated end mill

stdorder	Runorder	Speed (m/min)	Feed (mm/min)	DOC (mm)	Ra (µm)
10	1	-1	1	0	3.3052
12	2	0	-1	-1	2.8056
8	3	-1	0	-1	4.0212
9	4	0	0	0	3.3112
3	5	0	1	1	3.4648
14	6	1	0	1	2.2146
4	7	-1	0	1	3.0648
15	8	0	1	-1	3.9052
2	9	0	0	0	3.2692
5	10	-1	-1	0	3.8212
11	11	0	-1	1	3.5252
1	12	1	1	0	2.8242
13	13	1	0	-1	3.6032
6	14	0	0	0	3.4512
7	15	1	-1	0	3.6648

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Table 5 RSM table of Ra values of cotton using titanium aluminium nitride coated end mill

Stdorder	Runorder	Speed (m/min)	Feed (mm/min)	DOC (mm)	Ra (µm)
10	1	-1	1	0	3.3630
12	2	0	-1	-1	3.0382
8	3	-1	0	-1	3.9410
9	4	0	0	0	3.0784
3	5	0	1	1	3.3268
14	6	1	0	1	3.2410
4	7	-1	0	1	2.9122
15	8	0	1	-1	3.2410
2	9	0	0	0	3.4070
5	10	-1	-1	0	3.9012
11	11	0	-1	1	3.4672
1	12	1	1	0	2.9766
13	13	1	0	-1	3.2410
6	14	0	0	0	3.5458
7	15	1	-1	0	3.5701

Table 6 and 7 shows the result of surface roughness obtained for jute with Ti- N Coated tool and Ti-AlN Coated tool.

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Table 6 RSM table of Ra values of jute using titanium namite coated end mill

Stdorder	Runorder	Speed (m/min)	Feed (mm/min)	DOC (mm)	Ra (µm)
10	1	-1	1	0	5.1518
12	2	0	-1	-1	5.7596
8	3	-1	0	-1	5.5750
9	4	0	0	0	5.5596
3	5	0	1	1	5.3596
14	6	1	0	1	5.9628
4	7	-1	0	1	5.2902
15	8	0	1	-1	5.6918
2	9	0	0	0	5.6322
5	10	-1	-1	0	5.5496
11	11	0	-1	1	5.3782
1	12	1	1	0	5.5830
13	13	1	0	-1	5.3148
6	14	0	0	0	5.5702
7	15	1	-1	0	5.5236

Table 7 RSM table of Ra values of jute using titanium aluminium nitride coated end mill

Stdorder	Runorder	Speed (m/min)	Feed (mm/min)	DOC (mm)	Ra (µm)
10	1	-1	1	0	5.1670
12	2	0	-1	-1	5.6480
8	3	-1	0	-1	5.6426
9	4	0	0	0	5.5734
3	5	0	1	1	5.4710
14	6	1	0	1	5.8950
4	7	-1	0	1	5.2232
15	8	0	1	-1	5.6086
2	9	0	0	0	5.6098
5	10	-1	-1	0	5.5334
11	11	0	-1	1	5.4612
1	12	1	1	0	5.5992
13	13	1	0	-1	5.4216
6	14	0	0	0	5.5986
7	15	1	-1	0	5.4682

ANOVA was conducted once conducting experiments to make outwhether or notvariations in surface roughness between numerous runs ar statistically vital. Equation (2) & (3) was obtained from the ANOVAs results for experimental knowledge generated throughoutfinishmill of cotton and equation (4) and (5) for jute. The developed second order mathematical model given in equation (1).

Regression Equation for Response Surface Analysis is given in eqn (2) (Cotton using Titanium Nitride Coated End Mill)

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$Ra= 3.234+0.000474\times A+0.000942\times B+0.1995\times C-3.32E\text{-}07\times A\times A+4.42E\text{-}07\times B\times B+0.001672\times C\times C+1.048E\text{-}07\times A\times B-1.8E\text{-}04\times A\times C-9.68E\text{-}04\times B\times B$ (2)

Regression Equation for Response Surface Analysis is given in eqn (3) (Cotton using Aluminium Titanium Nitride Coated End Mill)

$Ra= 3.732-14.52E\text{-}04\times A+5.38E\text{-}04B+0.2079\times C-0.0972\times C\times C -4.28E\text{-}04\times A\times C-4.52E\text{-}04\times B\times C$ (3)

Regression Equation for Response Surface Analysis is given in eqn (4) (Jute using Titanium Nitride Coated End Mill)

$Ra= 6.6432-5.68E\text{-}04\times A-10.26E\text{-}04\times B-1.4584\times C+0.3405\times C\times C+6.9E\text{-}07\times A\times B+7.78E\text{-}04\times A\times C$ (4)

Regression Equation for Response Surface Analysis is given in eqn (5) (Jute using Titanium Nitride Coated End Mill)

$Ra= 6.2067-5.16E\text{-}04\times A-9.08E\text{-}05\times B-0.8451\times C-2.14E\text{-}07\times A\times A+6.9E\text{-}07\times A\times B+7.44E\text{-}04\times A\times C$ (5)

Fig 5&6 shows the contour plot obtained for Cotton and jute fiber reinforced Composites

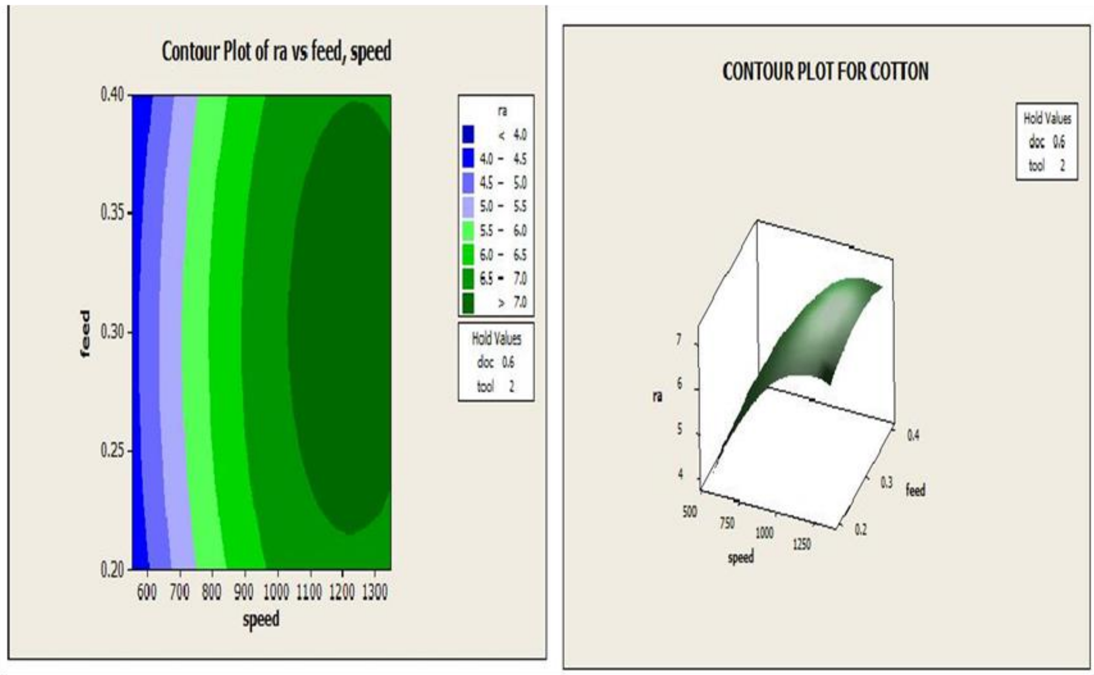

Figure 5. Contour Plot for Cotton Plate

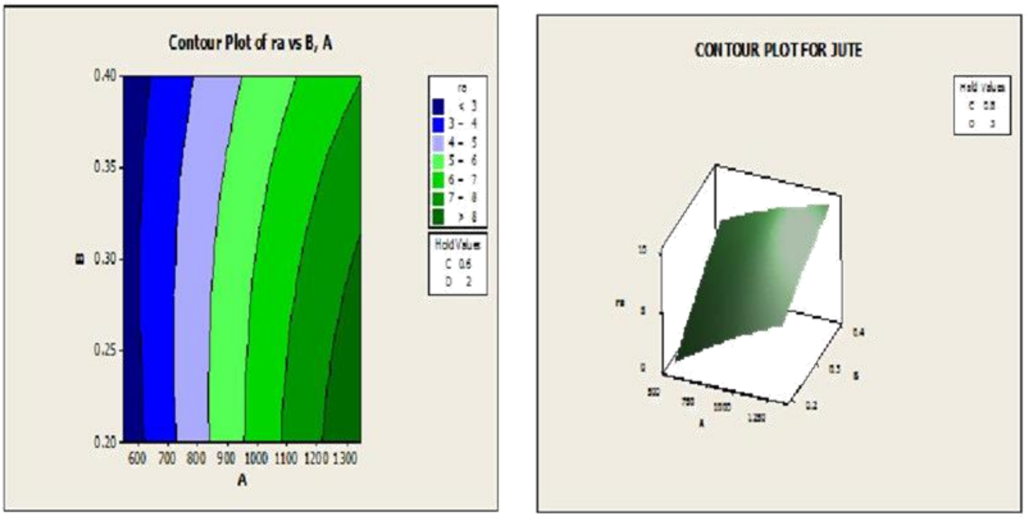

Figure 6. Contour Plot for Jute Plate

In order to obtain equation for the optimization,Eq. (2) - (5) were used as the fitness function of the solution. From table3the preset for solution are given as below:

$100 \leq X1 \leq 1300$ (6a)

$50 \leq X2 \leq 650$ (6b)

$1 \leq X3 \leq 3$ (6c)

The process parameters for Raminimum waschosen to be the initial points for the SA solution and are given below:

X1 = 700 (7a)

X2 = 350 (7b)

X3 = 2 (7c)

Criteria incorporated in the SA algorithm for optimisation are listed in Table 8.

Table 8: Parameter values for inputs.

Parameters	Setting value
Re-annealing interval	100°C
Initial temperature	100°C

By using the fitness performdeveloped in combining weight. (2) to (5), the restrictions of method parameters developed in Eqs. (6a)-(6c), the initial points developed in Eqs. (7a)–(7c), and therefore the parameters given in Table 6, the Matlab improvementtool cabinet are next applied to search out the minimum values of Ra at the optimum points. The optimized values given in Figure 7 and 8. The optimal solution is obtained at the 8804th iteration of the SA algorithm for cotton and at the 5519th iteration of the SA algorithm for jute respectively. The obtained results are compared with the experimental value as shown in Table 9 &10.

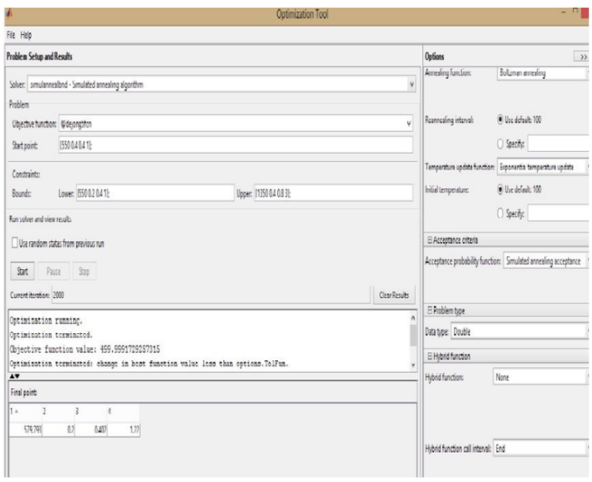

Figure 7. Results of the Optimization Toolbox

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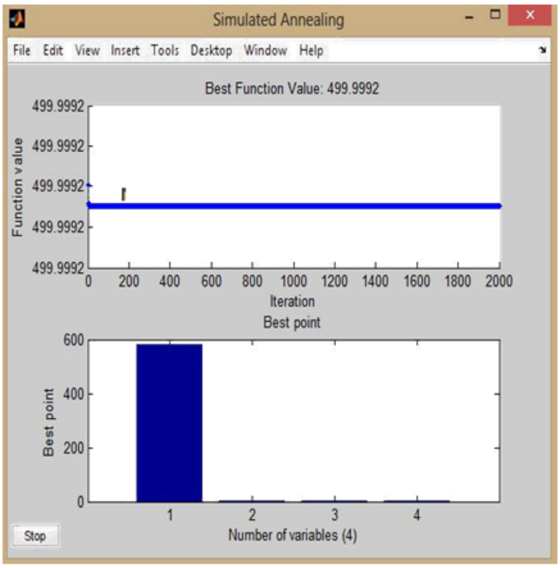

Figure 8. Results of the Mat lab Optimization Toolbox

Table 9 Comparison between the optimal cutting condition results for COTTON

Technique	**Cutting speed (m/min)**	**Feed (mm/min)**	**Depth of cut(mm)**	**Tool material**	**Surface roughness (Ra)**
Experimental	1300	350	3	Titanium nitrate (coated)	2.2146
S A	889	340	3	Titanium nitrate (coated)	1.6931

Table 10 Comparison between the optimal cutting condition results for JUTE

Technique	**Cutting speed(mm/min)**	**Feed (mm/min)**	**Depth of cut(mm)**	**Tool material**	**Surface roughness (Ra)**
Experimental	100	50	1	Titanium nitrate (coated)	5.1518
S A	602	312	1.5	Titanium nitrate (coated)	4.9634

3.1 Cotton Plate

From Figure 6, it is found that the curve steeply decreases and increases with increase in speed and depth of cut. When feed increases, curve steeply increases and then decreases. The curve steeply increases and then decreases as the speed increases. When an increase in the feed and depth of cut occurs, the curve slightly increases. After that the feed curve decreases, the depth of cut curve slightly increases. The speed and feed curves increase as the speed and feed increase until a certain point. Then both curves decline. The curve starts to increase when the depth of cut increase. After a certain point the curve steeply increases. From Table 4 and Table 5 , it is for Titanium Namite tool, cutting velocity plays a major role in machining. It is also found that when feed is greater than 25, it shows that it is physically and statistically significant for Titanium Aluminium Nitrate tool.

3.2 Jute Plate

From Figure 7, it is found that the speed and feed curves increase as the speed and feed increase until a certain point. Then both start to fall. With increase in depth of cut ,the curve steeply decreases and then starts increasing. The curve almost increases straight as the speed increases. When the feed increases,the curve slightly increases and then increases. The depth of cut-graph changes as speed graph changes. When speed increases the curve starts to increasing steeply and then slightly. When feed increases the curve decreases and then starts to increase. When the depth of cut increase, the curve increases and then decreases. From the Table 6 and Table 7, it is observed that in Titanium Namite tool cutting velocity contributes more in machining than other two parameters. In machining process cutting velocity has more contribution when considering the Titanium Aluminium Nitrate tool.

III CONCLUSION

It was found that Simulated tempering (SA) may be effectively incorporate for estimating the minimum Ra values as compared to the experimental. It has also been found that with 889 mm/min for cutting speed, 340 mm/min for feed, 3 mm depth of cut and Titanium Nitride Coated as tool material the best *Ra* value obtained was 1.6931microns for Cotton. As such, the results indicate the possibility of obtaining minimum Ra in milling NFRPusing technique of RSM-SA.

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