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An Experimental Investigation of GFRP Surface Property and Process Parameter on CNC Milling Machine

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ABSTRACT: Production and manufacturing process deals with conversion of raw materials inputs to finished products as per required dimensions specifications and efficiently using recent technology. The metal cutting essential try for high metal removing rate and best product quality the major problem in achieving high productivity and best quality is short life span of tool. To enhance the tool life many new materials are developed so as to meet the market demand and competitive price. For this there should be proper control over various cost involved in machining named as material cost, labour cost and tooling cost. The material cost can be controlled by using special material which meet all required properties with reduced price. The present work is focused on the influence of cutting speed, feed rate and depth of cut on the delamination damage and surface roughness on Glass Fiber Reinforced Polymeric composite material (GFRP) during end milling. Taguchi design method is employed to investigate the machining characteristics of GFRP. In this work, experiments have to be carried out as per the Taguchi experimental design and an L9 orthogonal array was used to study the influence of various combinations of process parameters on surface quality. Analysis of variance (ANOVA) test is to be conducted to determine the significance of each process parameter on Milling. This work is useful in selecting optimum values of various process parameters that would not only minimize the thrust force and torque but also reduce the delamination and improve the quality of surface machined area.

KEYWORDS: CNC Machine, Milling machine, Filament winding.

I. INTRODUCTION

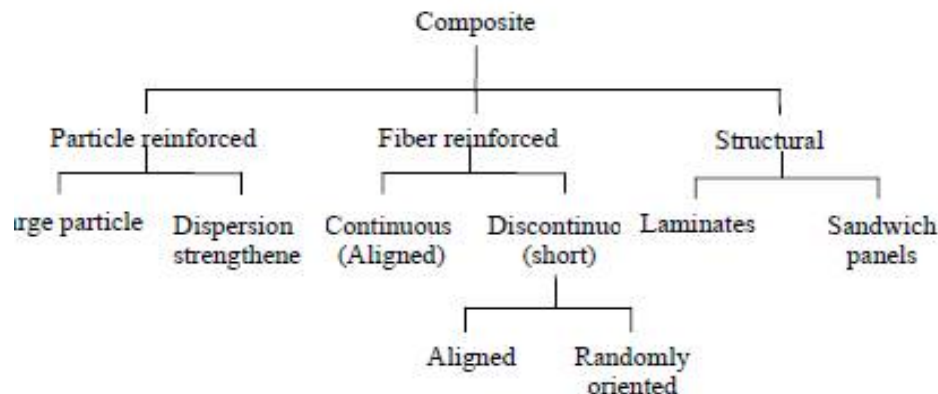
In recent years, fibre reinforced plastics (FRPs) are continuously replacing traditional engineering materials because of their superior advantage over other engineering materials. The advantages include high strength to weight ratio, high fracture toughness, and excellent corrosion and thermal resistance. The glass fibre reinforced plastic (GFRP) composites are being extensively used in various fields like Aerospace, Automobile, Chemical industries, Off shore power plants, Refinery, Oil and Gas, Pulp and paper, Waste and waste water etc.,. The application field of FRP composites, expands the opportunity of machining such as cutting off, drilling, milling, turning etc, has increased for its fabrication. However, the users of FRP have faced difficulties to machine it, because knowledge and experience acquired for conventional materials cannot be applied to such new materials, of which machinability is completely different from that of conventional materials. Generally, composite materials are engineered materials and are made from two or more constituent materials with significantly different physical and chemical properties. The two types of constituent phases are matrix and reinforcement. Generally, most materials, especially brittle ones, exhibit an important characteristic that a small-diameter shape is much stronger than the bulk material.

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I. CLASSIFICATION OF COMPOSITES



PARTICLE REINFORCED COMPOSITES

Large particle and dispersion-strengthened composites are the two sub classifications of particle-reinforced composites. The distinction between these is based upon reinforcement or strengthening mechanism. The term “large” is used to indicate that particle-matrix interactions cannot be treated on the atomic or molecular level. For most of these composites, the particle phase is harder and stiffer than the matrix.

FIBER REINFORCED COMPOSITES

A composite is a structural material which consists of combining two or more constituents. The constituents are combined at a macroscopic level and are not soluble in each other. One constituent phase is called the reinforcing phase and the one in which it is embedded is called the matrix.

STRUCTURAL COMPOSITES

A structural composite is normally composed of homogeneous composite materials, the properties of which depend not only on the properties of the constituent materials but also on the geometrical design of the various structural elements.

II. LITERATURE REVIEW

Reddy Sreenivasulu[1] et.al were presented work is focused on the influence of cutting speed, feed rate and depth of cut on the delamination damage and surface roughness on Glass Fiber Reinforced Polymeric composite material (GFRP) during end milling. Taguchi design method is employed to investigate the machining characteristics of GFRP. From the results of ANOVA, it is concluded that cutting speed and depth of cut are the most significant factors affecting the responses, their contribution in an order of 26.84% and 40.44% respectively. Confirmatory experiments show that 5.052µm for surface roughness and 1.682 delamination damage to validate the used approach after conducting with optimal setting of process parameters. Finally, artificial neural network has been applied to compare the predicted values with the experimental values, the deviations are found in the range of 3.7%, it shows good agreement between the predictive model results and the experimental measurements. B.V.Kavad[2] et.al were investigated in order to maintain the integrity of the material and obtain the necessary accuracy in drilling of GFRP. This paper attempts to review the influence of machining parameter on the delamination damage of GFRP during drilling. In conventional machining feed rate, tool material and cutting speed are the most influential factor on the delamination hence machining at higher speed, harder tool material and lower feed rate have lesser delamination of the GFRP. Vibration assisted drilling and Ultrasonic assisted drilling have lesser thrust and hence lesser delamination compared to conventional drilling, which indicates that both vibration assisted drilling and Ultrasonic assisted drilling are more appropriate for drilling of GFRP. M.A. Amran[3] et.al were carried out the effects of drilling parameter such as spindle speed, feed rate and drill diameter on the surface roughness and surface texture of drilled hole by applying RSM. There are three factors (spindle speed, feed rate and drill diameter) under investigation, therefore, by applying RSM there will be 20 experimental observations. The minimum surface roughness measured for the hole was 1.06 µm at

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Special Issue 8, May 2016

combination of 2000 rpm spindle speed, 78 mm/min feed rate and 2.5 mm drill diameter. While the maximum surface roughness of 2.59 μ m was measured at the combination of 250 rpm spindle speed, 153 mm/min feed rate and 3.5 mm drill diameter. One factor plot analysis found that the most significant parameter was spindle speed followed by drill diameter and feed rate. Thus, surface roughness decreased when increasing the spindle speed, feed rate and drill diameter. There were interactions between all the parameter of spindle speed, feed rate and drill diameter in drilling process under investigation. Harsh Y Valera[4] were presented an experimental study of power consumption and roughness characteristics of surface generated in turning operation of EN-31 alloy steel with TiN+Al₂O₃+TiCN coated tungsten carbide tool under different cutting parameters. The study shows the influences of three cutting parameters like spindle speed, depth of cut and feed rate affecting surface roughness as well as power consumption while turning operation of EN-31 alloy steel.

III. METHODOLOGY

CONCEPT OF TAGUCHI APPROACH:

Basically experimental design methods are too complex and not easy to use. Furthermore, a large number of experiments have to be carried out when the number of the process parameters increases, to solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with a small number of experiments only. The experimental results are then transformed into a signal- to - noise (S/N) ratio to measure the quality characteristics deviating from the desired values. Usually, there are three categories of quality characteristics in the analysis of the S/N ratio, i.e., the-lower-better, the-higher-better, and the-nominal-better. The S/N ratio for each level of process parameter is compared based on the S/N analysis. Regardless of the category of the quality characteristic, a greater S/N ratio corresponds to better quality characteristics.

Therefore a method of calculating the Signal-To-Noise ratio we had gone for quality characteristic. They are

- Smaller-The-Better,
- Larger-The-Better,
- Nominal is Best.

LEVELS	PROCESS PARAMETER		
	SPEED	FEED	DOC
1	1000	0.02	0.25
2	1250	0.04	0.50
3	1500	0.06	0.75

TRIAL NO.	DESIGNATION	SPEED	FEED	DOC
1	A ₁ B ₁ C ₁	1000	0.02	0.25
2	A ₁ B ₂ C ₂	1000	0.04	0.50
3	A ₁ B ₃ C ₃	1000	0.06	0.75
4	A ₂ B ₁ C ₂	1250	0.02	0.50
5	A ₂ B ₂ C ₃	1250	0.04	0.75
6	A ₂ B ₃ C ₁	1250	0.06	0.25
7	A ₃ B ₁ C ₃	1500	0.02	0.75
8	A ₃ B ₂ C ₁	1500	0.04	0.25
9	A ₃ B ₃ C ₂	1500	0.06	0.50

Taguchi L9 Orthogonal array DOE

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, May 2016

EXPERIMENTAL DATA:

TRIAL NO.	DESIGNATION	SPEED	FEED	DEPTH OF CUT	MTTIME SEC	MRR	R _a
1	A ₁ B ₁ C ₁	1000	0.02	0.25	254	10.97721	1.079
2	A ₁ B ₂ C ₂	1000	0.04	0.50	144	2.429912	1.409
3	A ₁ B ₃ C ₃	1000	0.06	0.75	71	33.34084	1.488
4	A ₂ B ₁ C ₂	1250	0.02	0.50	222	11.02242	1.986
5	A ₂ B ₂ C ₃	1250	0.04	0.75	118	24.77477	2.176
6	A ₂ B ₃ C ₁	1250	0.06	0.25	75	31.39372	1.819
7	A ₃ B ₁ C ₃	1500	0.02	0.75	191	10.85158	3.389
8	A ₃ B ₂ C ₁	1500	0.04	0.25	112	23.77741	2.982
9	A ₃ B ₃ C ₂	1500	0.06	0.50	78	30.6308	1.651

Machining time, material removal rate and surface roughness

SURFACE ROUGHNESSES (ANALYSIS OF RESULT)

TRIAL NO.	DESIGNATION	SPEED	FEED	DEPTH	R _a	S/N
1	A ₁ B ₁ C ₁	1000	0.02	0.25	1.079	-0.660429
2	A ₁ B ₂ C ₂	1000	0.04	0.50	1.409	-2.97822
3	A ₁ B ₃ C ₃	1000	0.06	0.75	1.488	-3.45206
4	A ₂ B ₁ C ₂	1250	0.02	0.50	1.986	-5.95958
5	A ₂ B ₂ C ₃	1250	0.04	0.75	2.176	-6.75318
6	A ₂ B ₃ C ₁	1250	0.06	0.25	1.819	-5.19665
7	A ₃ B ₁ C ₃	1500	0.02	0.75	3.389	-10.6014
8	A ₃ B ₂ C ₁	1500	0.04	0.25	2.982	-9.49015
9	A ₃ B ₃ C ₂	1500	0.06	0.50	1.651	-4.35494

Surface roughness and s/n ratios values for the experiments

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, May 2016

ROUGHNESS RESPONSE FOR EACH LEVEL OF THE PROCESS PARAMETER

Response Table for Signal to Noise Ratios

LEVEL	SPEED	FEED	DOC
1	-2.364	-5.740	-5.116
2	-5.970	-6.407	-4.431
3	-8.149	-4.335	-6.936
DELTA	5.785	2.073	2.505
RANK	1	3	2

Response Table for Means

LEVEL	SPEED	FEED	DOC
1	1.325	2.151	1.960
2	1.994	1.994	1.682
3	2.674	1.653	2.351
DELTA	1.349	0.536	0.669
RANK	1	3	2

FACTOR	TYPE	LEVELS	VALUES
SPEED	FIXED	3	1000,1250,1500
FEED	FIXED	3	0.02,0.04,0.06
DOC	FIXED	3	0.25,0.50,0.75

R_a versus speed, feed, doc

ANALYSIS OF VARIANCE (ANOVA)

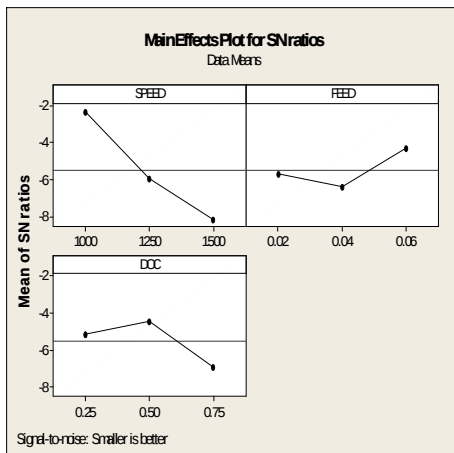
SOURCE	DF	SEQ SS	ADJ SS	ADJ MS	F	P	%
SPEED	2	2.7284	2.7284	1.3642	4.58	0.179	60
FEED	2	0.5377	0.5377	0.2689	0.90	0.525	12
DOC	2	0.6777	0.6777	0.3389	1.14	0.468	15
ERROR	2	0.5951	0.5951	0.2976			13
TOTAL	8	4.5390					100

Analysis of Variance for Ra, using Adjusted SS for Tests

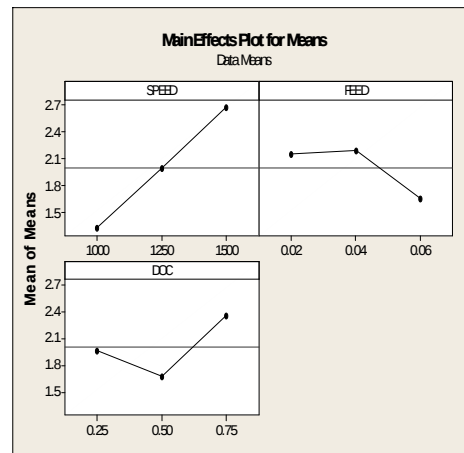
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, May 2016



Main Effects Plot for SN ratios



Main Effects Plot for Means

MACHINING TIME (ANALYSIS OF RESULT)

TRIAL NO.	DESIGNATION	SPEED	FEED	DOC	MT SEC	S/N
1	A ₁ B ₁ C ₁	1000	0.02	0.25	254	-48.0967
2	A ₁ B ₂ C ₂	1000	0.04	0.50	144	-43.1672
3	A ₁ B ₃ C ₃	1000	0.06	0.75	71	-37.0252
4	A ₂ B ₁ C ₂	1250	0.02	0.50	222	-46.9271
5	A ₂ B ₂ C ₃	1250	0.04	0.75	118	-41.4376
6	A ₂ B ₃ C ₁	1250	0.06	0.25	75	-37.5012
7	A ₃ B ₁ C ₃	1500	0.02	0.75	191	-45.6207
8	A ₃ B ₂ C ₁	1500	0.04	0.25	112	-40.9844
9	A ₃ B ₃ C ₂	1500	0.06	0.50	78	-37.8419

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, May 2016

MACHINING TIME FOR EACH LEVEL OF THE PROCESS PARAMETER Taguchi Analysis: MT versus SPEED, FEED, DOC

LEVEL	SPEED	FEED	DOC
1	-42.76	-46.88	-42.19
2	-41.96	-41.86	-42.65
3	-41.48	-37.46	-41.36
DELTA	1.28	9.43	1.28
RANK	3	1	2

LEVEL	SPEED	FEED	DOC
1	156.33	222.33	147.00
2	138.33	124.67	148.00
3	127.00	74.67	126.67
DELTA	29.33	147.67	21.33
RANK	2	1	3

Response Table for Signal to Noise Ratios

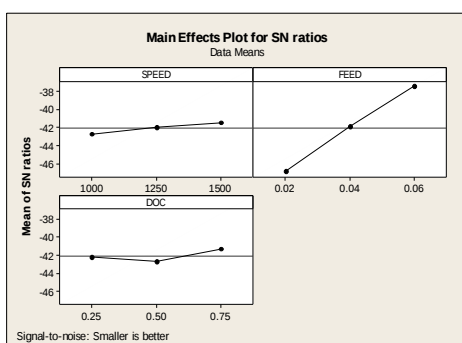
Response Table for Means

FACTOR	TYPE	LEVELS	VALUES
SPEED	FIXED	3	1000,1250,1500
FEED	FIXED	3	0.02,0.04,0.06
DOC	FIXED	3	0.25,0.50,0.75

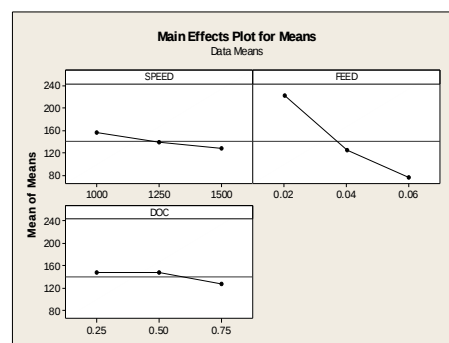
MT versus speed, feed, doc

ANALYSIS OF VARIANCE (ANOVA)

SOURCE	DF	SEQ SS	ADJ SS	ADJ MS	F	P	%
SPEED	2	1312.9	1312.9	656.4	3.24	0.236	3
FEED	2	33844.2	33844.2	16922.1	83.45	0.012	92
DOC	2	869.2	869.6	434.8	2.14	0.318	2
ERROR	2	405.6	405.6	202.8			3
TOTAL	8	36432.2					100



Main Effects Plot for SN ratios



Main Effects Plot for Means

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, May 2016

MRR (ANALYSIS OF RESULT)

LEVEL	SPEED	FEED	DOC
1	-18.15	-19.22	-18.91
2	-16.77	-18.12	-17.17
3	-14.53	-12.10	-13.37
DELTA	3.62	7.12	5.54
RANK	3	1	2

Ratio response table for means

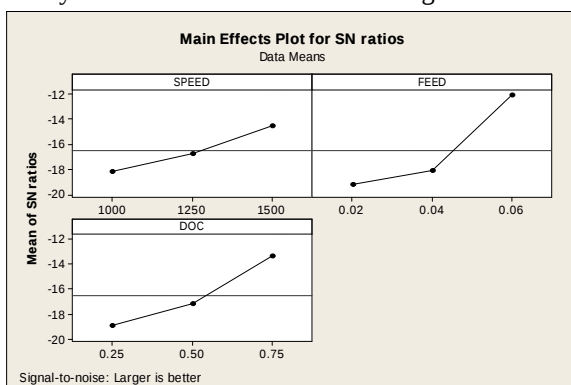
LEVEL	SPEED	FEED	DOC
1	0.1472	0.07067	0.15333
2	0.14300	0.12133	0.11067
3	0.13367	0.21433	0.14233
DELTA	0.01333	0.14367	0.04267
RANK	3	1	2

Response table for signal to noise

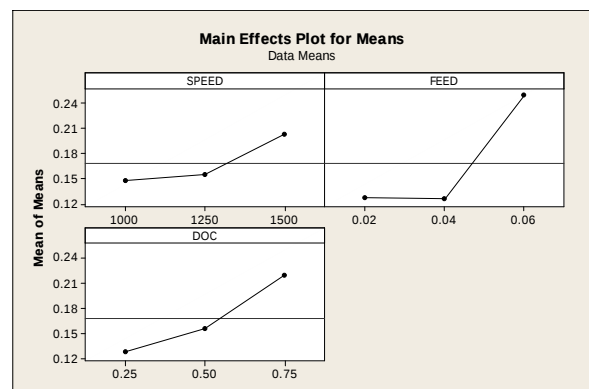
ANALYSIS OF VARIANCE (ANOVA)

SOURCE	D F	SEQ SS	ADJ SS	ADJ MS	F	P	%
SPEED	2	0.0053096	0.0053096	0.0026548	3.72	0.212	10
FEED	2	0.0300969	0.0300969	0.0150484	21.09	0.045	60
DOC	2	0.0131136	0.0131136	0.0065568	9.19	0.098	26
ERROR	2	0.0014269	0.0014269	0.0007134			4
TOTAL	8	0.0499469					100

Analysis of variance results for the roughness



Main Effects Plot for SN ratios



Main Effects Plot for Means

IV. CONCLUSION

OPTIMAL CONTROL FACTOR

1. Surface Roughness-A1(Speed -1000)B3(Feed -0.06)C2(DOC-0.50)

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, May 2016

2. Machining Timing-A3(Speed-2000)B1(Feed 0.02)C2(DOC -0.25)
3. Material Removal Rate- A3(Speed-2000)B1(Feed 0.05)C1(DOC 0.5)

PERCENTAGE OF CONTRIBUTION OF PROCESS PARAMETER

1. Surface Roughness- speed 60%
2. Machining Timing- Feed 72%
3. Material Removal –DOC-Rate-DOC- 46%

REFERENCES

- 1.Reddy Sreenivasulu Optimization of Surface Roughness and Delamination Damage of GFRP Composite Material in End Milling using Taguchi Design Method and Artificial Neural Network,ReddySreenivasulu Procedia Engineering 64 (2013) 785 – 794.
2. B.V.Kavada, A.B.Pandeya, M.V.Tadavia, H.C.JakhariaA Review Paper on Effects of Drilling on Glass Fiber Reinforced Plastic2nd International Conference on Innovations in Automation and Mechatronics Engineering, ICIAME 2014.
3. Harsh Y Valeraa, Sanket N Bhavsara Experimental Investigation of Surface Roughness and Power Consumption in Turning Operation of EN 31 Alloy Steel Procedia Technology 14 (2014) 528 – 534.
4. Surinder Kumar¹; Meenu Gupta²; P.S. Satsangi³ and H.K. Sardana⁴ Modeling and analysis for surface roughness and material removal rate in machining of UD-GFRP using PCD tool International Journal of Engineering, Science and Technology Vol. 3, No. 8, 2011, pp. 248-270.
5. ASM Handbook - Vol.16, Machining, 9th Edition, 1989, ASM International.
6. Trent E.M., Metal Cutting, Butterworths-Heinmann, 2000.