

To Study the Surface Properties of GFRP in USM by using Taguchi Methodology

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Abstract

USM has become an important and cost-effective method of machining extremely tough and brittle materials. It is widely used in the process of drilling and machining on sections of complex geometry and intricate shapes. The work piece material selected in this experiment is GLASS FIBRE REINFORCED PLASTIC (GFRP) taking into account its wide usage in industrial applications. In today's world GFRP contributes to almost one third of the world's production and consumption for industrial purposes. This material is not used for traditional machining due to chipping or fracturing. Many similar problems can be successfully solved using ultrasonic technologies. The input variable parameters are type of tool material, frequency, amplitude, concentration in usm. Taguchi method is applied to create an L'18 orthogonal array of input variables using the Design of Experiments (DOE). The effect of the variable parameters mentioned above upon machining characteristics such as Material Removal Rate (MRR), Surface Roughness (SR) and Tool Wear Rate (TWR) studied and investigated. The tool material is titanium (ASTM-1) and carbide (k20). All the calculations are made with the help of MINITAB 16 software. Most influence factor for MRR is observed as amplitude with 67.27% contribution. For SR amplitude with contribution of 33.3% and TWR is observed as frequency with 44.4% contribution plays an important role.

Keywords: USM Machine, MRR, Surface Roughness, TWR, Tool Material (Titanium, Carbide), Taguchi Methodology

I. INTRODUCTION

USM IS cost-effective method of machining extremely tough and brittle materials. It is effective in 0.1mm micro drilling. Its applications make it effective in drilling and machining on sections of complex geometry and intricate shapes. Abrasive powders used in current experiments are silicon carbide and boron carbide. Since there are so many conducting abrasive powders in market like tungsten carbide, tantalum carbide, boron nitride etc. and not much work has been done on these abrasive particles. So there is large scope for further work on these abrasive particles.

Table -1:
Factors and their levels of interest

Factors	Factors designation	Level 1	Level 2	Level 3
Tool material	A	Titanium	carbide	
Frequency	B	19	22	25
Amplitude	C	15	30	50
Conc.	D	30	35	40

Table -2:
Degrees of freedom

Factors	A	B	C	D	E	D × E	Total
Degree of freedom	2	2	2	1	2	4	13

II. TAGUCHI METHOD AND DESIGNS OF EXPERIMENT

The designs that are being provided by Taguchi Method are very simple and give a systematic approach for optimization. The input factors are selected which are problem dependent and these are entered in Taguchi design. Taguchi is beneficial method as it conducts balanced experimental combination. The efficiency provided by it is one of its main advantages as multiple factors

are considered at once. The optimal parameters can be identified with fewer experimental resources than traditional approach. It allows looking into variation caused by control factors and noise factors while Noise factors are ignored in traditional methods.

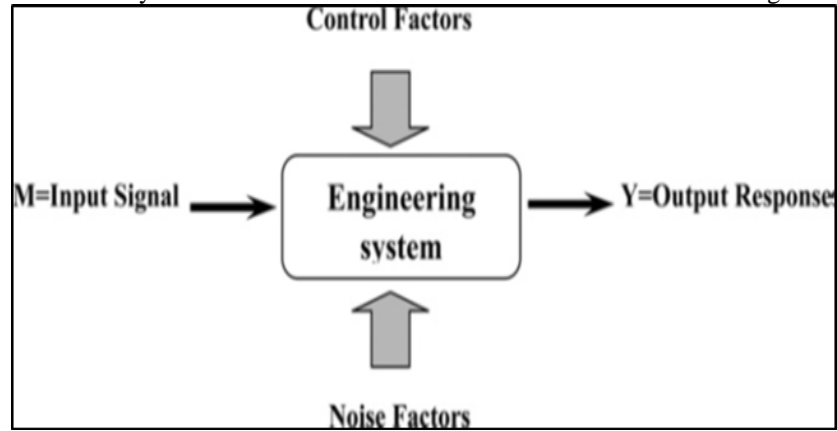


Fig. 1: Taguchi Method and Designs of Experiment

A. Taguchi Procedure:

- 1) System Design
 - 2) Parameter Design
 - 3) Tolerance Design
- System Design adds conceptual level involve creativity and innovation.
 - Parameter Design allows the parameters to be chosen so as to minimize the effects on performance arising from variation in main factors, environment and cumulative damage.
 - Tolerance design successfully completed parameter design and provides an understanding of the effect that the various parameters have on performance, resources can be focused on reducing and controlling variation.

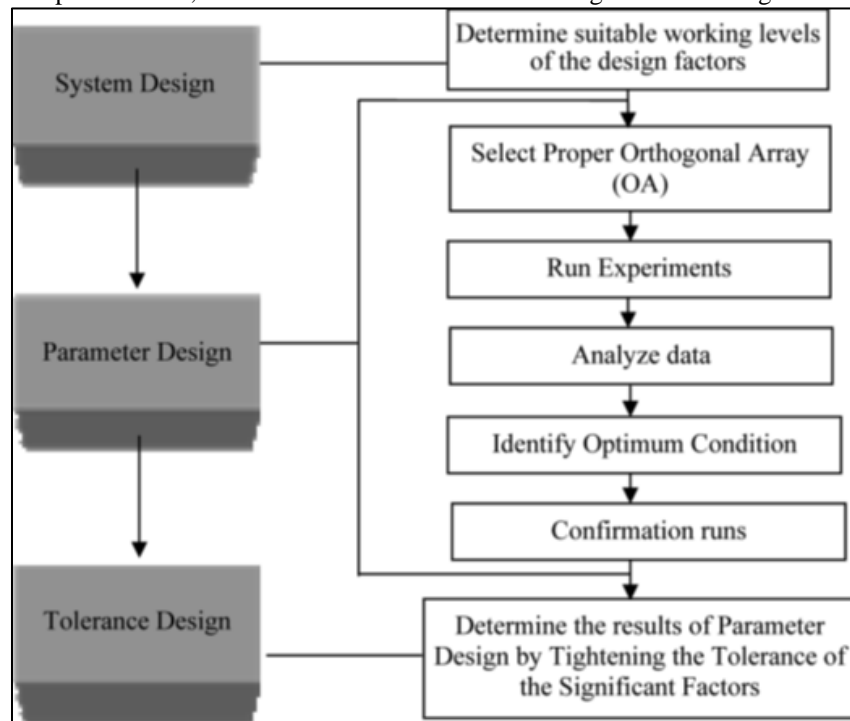


Fig. 2: Taguchi design procedure

III. EXPERIMENTAL SET UP

The USM machine is used for machining glass fiber reinforced plastic (GFRP). The objective of the present work is to find out main effect of cutting speed, feed rate, drill diameters, work piece material, drill material and interaction effect between drill material and cutting speed on MRR, Surface roughness, Hole diameter error, and burr height. Microstructure analysis of work piece material also did. Taguchi methodology is used in this experiment. The L18 design of experiment is taken to find the optimal designs. The various results for MRR, SR, TWR are shown in table as below:

Table -3:
Results for MRR

Experiment No:	Tool material	Frequency (KHz)	Amplitude (micro-meter)	Conc. (%)	MRR (mm ³ /min)	S/N Ratio	Mean
1	Ti	19	15	30	1.97	5.88	1.97
2	Ti	19	30	35	3.69	11.34	3.69
3	Ti	19	50	40	7.81	17.85	7.81
4	Ti	22	15	30	1.67	4.45	1.67
5	Ti	22	30	35	4.09	12.23	4.09
6	Ti	22	50	40	9.21	19.28	9.21
7	Ti	25	15	30	1.97	5.88	1.97
8	Ti	25	30	35	6.01	15.57	6.01
9	Ti	25	50	40	7.17	17.11	7.17
10	Ca	19	15	30	2.58	4.98	2.58
11	Ca	19	30	35	2.38	4.8	2.38
12	Ca	19	50	40	5.08	11.56	5.08
13	Ca	22	15	30	2.03	4.76	2.03
14	Ca	22	30	35	3.55	6.35	3.55
15	Ca	22	50	40	3.89	11	3.89
16	Ca	25	15	30	2.98	11.79	2.98
17	Ca	25	30	35	3.33	8.65	3.33
18	Ca	25	50	40	8.98	9.76	8.98

Table -4:
Results for surface roughness

Experiment No:	Tool material	Frequency (KHz)	Amplitude (micro-meter)	Conc. (%)	Surface roughness	S/N Ratio	Mean Surface roughness
1	Ti	19	15	30	0.69	3.223018	0.69
2	Ti	19	30	35	0.71	2.974833	0.71
3	Ti	19	50	40	1.06	-0.50612	1.06
4	Ti	22	15	30	0.79	2.047458	0.79
5	Ti	22	30	35	0.69	0.537443	0.69
6	Ti	22	50	40	0.71	-0.66848	0.71
7	Ti	25	15	30	1.06	2.615366	1.06
8	Ti	25	30	35	0.79	0.175478	0.79
9	Ti	25	50	40	0.94	0.175478	0.94
10	Ca	19	15	30	0.69	-0.172	0.69
11	Ca	19	30	35	0.71	3.223018	0.71
12	Ca	19	50	40	1.06	3.098039	1.06
13	Ca	22	15	30	0.79	1.310031	0.79
14	Ca	22	30	35	0.94	1.514414	0.94
15	Ca	22	50	40	0.69	2.383728	0.69
16	Ca	25	15	30	0.71	0.91515	0.71
17	Ca	25	30	35	1.06	-0.172	1.06
18	Ca	25	50	40	.87	1.209	8.87

Table -5:
Results for TWR

Experiment No:	Tool material	Frequency (KHz)	Amplitude (micro-meter)	Conc. (%)	TWR (gm/min)	S/N ratio	TWR mean
1	Ti	19	15	30	.0170	35.39	.0170
2	Ti	19	30	35	.0030	50.45	.0030
3	Ti	19	50	40	.0006	64.43	.0006
4	Ti	22	15	30	.0660	23.60	.0660
5	Ti	22	30	35	.0150	36.47	.0150
6	Ti	22	50	40	.0130	37.72	.0130

7	Ti	25	15	30	.0400	27.95	.0400
8	Ti	25	30	35	.0290	30.75	.0290
9	Ti	25	50	40	.0030	50.45	.0030
10	Ca	19	15	30	.0103	39.74	.0103
11	Ca	19	30	35	.0040	47.95	.0040
12	Ca	19	50	40	.0010	60.00	.0010
13	Ca	22	15	30	.0500	26.02	.0500
14	Ca	22	30	35	.0180	34.89	.0180
15	Ca	22	50	40	.0356	28.97	.0356
16	Ca	25	15	30	.0490	26.19	.0490
17	Ca	25	30	35	.0370	28.63	.0370
18	Ca	25	50	40	.0105	39.57	.0105

IV. RESULTS

A. MRR:

The effect of parameters i.e. tool material, frequency, amplitude and conc. were evaluated using ANOVA and factorial design analysis. A confidence interval of 95% has been used for the analysis. Two repetitions for each 18 trails was completed to measure the Signal to Noise ratio (S/N Ratio). ANOVA table shows that tool material with F value 4.25, amplitude with F value 36.08 and concentration 5.74 are the factors that significantly affect the MRR, with % contribution of 2.9%, 67.27 % and 8.61% to MRR. The other factor frequency was found to be insignificant. For S/N ratio frequency, amplitude and concentration are significant to reduce the variation of MRR. So the confidence interval around the MRR is given by 8.52 ± 1.43 mm³/min.

B. Surface Roughness:

The effect of parameters i.e. tool material, frequency, amplitude and conc. were evaluated using ANOVA and factorial design analysis. A confidence interval of 95% has been used for the analysis. Two repetitions for each 18 trails was completed to measure the Signal to Noise ratio (S/N Ratio). In this experiment work surface roughness (Ra) has measured at position center. ANOVA table shows that tool material with F value 26.4, amplitude with F value 26.6 and interaction of A and B with F value 7.7 are the factors that significantly affect the surface roughness with % contribution of 33.1 %, 33.3 % and 7.5 % to surface roughness. The other factor frequency and conc. were found to be insignificant. For S/N ratio tool material, amplitude and interaction were significant to reduce the variation of surface roughness. With 95% confidence interval mean value of surface roughness was found to be 0.8017 ± 0.0667 μ m.

C. Tool Wear Rate:

The effect of parameters i.e. tool material, frequency, amplitude and conc. were evaluated using ANOVA and factorial design analysis on tool wear rate. A confidence interval of 95% has been used for the analysis. Two repetitions for each 18 trails were completed to measure the Signal to Noise ratio (S/N Ratio).

ANOVA table shows that tool material with F value 15.3, amplitude with F value 3.9 and frequency with F value 13.9 are the factors that significantly affect the TWR, with % contribution of 22.9%, 13.4 % and 44.4% to TWR. The other factor conc. and interaction was found to be insignificant. For S/N ratio tool material, frequency and amplitude are significant to reduce the variation of TWR. Thus, the confidence interval around the estimated mean of tool wear rate given by 1.2141 ± 0.1465 μ m

V. CONCLUSION

The present study was carried out to study the effect of input parameters on the MRR and surface roughness and tool wear rate. The following conclusions have been drawn from the study:

- 1) MRR is mainly affected by type of tool material, amplitude and conc.
- 2) Surface roughness is mainly affected by tool material, amplitude and interaction of A and B.
- 3) Tool wear rate are affected by tool material, amplitude and frequency.

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