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Machining parameters Optimization on AL_2O_3+BAMBOO ASH/Al composites by using Taguchi method

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Abstract – **The objective of the paper is to increase the quality of machining and to produce by using Taguchi method. The effects of cutting parameters was studied in turning process done on Al- Al_2O_3 -BAMBOO ASH Matrix composite. The surface roughness of the components and MRR is very important to increase the quality of machining. The direct and interactive effect of process factors on response within the range of examination can be considered with ease from the Taguchi analysis. Taguchi analysis is done for optimizing the process factors such as speed, feed, and depth of cut. The trials have been as per Taguchi's L9 orthogonal array. "Smaller is best" S/N ratio typical is used to determine the means and Analysis of Variance (ANOVA) table is produced to control the numerical association of the factors. The process parameters for completing the desired response can be obtained from the mathematical model. ANOVA table is used to determine the percentage of contribution for significant factors and interactions. The feed is greatest influencing factor and its percentage of contribution is 65% and 41% on surface roughness and MRR respectively. The normal probability plot graph is obtained in the form of straight line so the errors are distributed normally.**

Index Terms – **Surface roughness, MRR, Taguchi, Regression, ANOVA, BAMBOO ASH Matrix**

I. INTRODUCTION

Composite materials are formed by reinforcing two or more materials of varying properties with matrix phase. Composite materials are heterogeneous mixtures of two or more homogeneous phases at macro scale, which have been bonded together. In composites, a set of desirable properties can be obtained. Many in nature happening materials can be observed as composite e.g. bones, wood and others. Manufactured composites are used meanwhile thousands of years, e.g. straw and normal fibers in bricks, laminated woods, etc. Hybrid Composites have possible to auxiliary single reinforced composites due to enhanced properties. Composites are broadly categorized based on the generations. Composite materials are frequently chosen for structural applications because they have desirable combinations of mechanical characteristics. Development of metal matrix composites has become an important area of research interest in Materials Science. Substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness and strength of composite materials. This research deals with evaluation on mechanical properties of Al- Al_2O_3 - BAMBOO ASH composite with desirable working properties. In this, Al-

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Al_2O_3-BAMBOO ASH Matrix Composite is prepared with different proportions, mainly Al_2O_3 (1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9% and 10%), percentage and remaining LM0 Aluminium alloy in the stir casting techniques [9, 10]. The surface roughness testing temperature testing are performed on the specimens to evaluate the mechanical machining properties like surface roughness and temperature the variation of mechanical properties with the increasing percentage of Aluminium Oxide is evaluated and analyzed. In this an attempt has been made to identify the volume percentage of Al_2O_3 to enhance the mechanical property. Microstructure and mechanical properties of extruded Al/ Al_2O_3composites fabricated by stir casting process. The addition of Al_2O_3 particles caused the agglomeration of particles and the hot extrusion resulted in uniform distribution of particles. The hardness, Yield, Ultimate tensile strength increased with increasing stir speed up to 300r/min and by increasing the Al_2O_3 contents. Fabrication and characterization of A359/Al_2O_3 metal matrix composites using electromagnetic stir casting method. The Hardness and the tensile strength of the cast composites increases on increasing the weight fraction of Al_2O_3 and the micro structural observation suggests that the electromagnetic stirring action produces cast MMC with smaller grain size and there is a good particulate matrix interface bonding. Wear resistance of aluminium alloy and its composites reinforced by Al_2O_3 particles [10]. The wear resistance of the composites increased with an increase in the Al_2O_3 particle and also increases with increasing the applied load. The effective wear resistance of the composites dependent on the effective resistance of Al_2O_3 particles to penetration, cutting and grinding by Sic abrasive grit size.

II. Empirical Investigation

In this section a details of case study conducted is presented. This study since these parameters are frequently modified in each process setup. Speed, feed, depth of cut are the parameters chosen for the experiment. The cutting parameters like speed, depth of cut and were calculated. Feed were selected based on machine competences.

TABLE 1 CUTTING PARAMETERS AND LEVELS

Factors	Level 1	Level 2	Level 3
Speed (rpm)	750	1500	2250
Feed rate (mm/rev)	10	15	20
Depth of cut (mm)	0.25	0.5	0.75

III. Design of Experiments

Taguchi method was adopted to optimize the cutting parameter favored. An L9 type DOE was designated for the practicality of performing experiments [1-5]. Turning is very important machining process in which single pint cutting tool removes unwanted material from the surface of a rotating cylindrical work piece. The cutting tool is fed linearly in a direction parallel to the axis of rotation. Turning is carried on a lathe that provides the power to turn the work piece at a given rotational speed and to feed to the cutting tool at specified rate and depth of cut. Therefore, the cutting parameters i.e. cutting speed, feed and depth of cut need to be determined in a turning process. The turning operations are accomplished using a cutting tool, the high forces and temperature during machining create a harsh environment for the cutting tool. So, tool life is essential to assess cutting performance. The purpose of turning operation is to produce low surface roughness of the parts. Surface roughness and Material Removal Rate are important factors to evaluate cutting performance. Proper selection of cutting parameters and tool can produce longer tool life and lower surface roughness and Material Removal Rate. Turning operation is performed on Al_2O_3+BAMBOO ASH/Al Composites. Surface roughness often shortened to roughness, is a component of surface texture. It is calculated by the deviances in the direction of the normal vector of an actual surface from its ideal form. If these deviations are large, the surface is rough, if they are small, the surface is smooth. In surface roughness is naturally dignified to be the high-frequency, short-wavelength element of a sedate surface. But, in practice it is often necessary to know both the amplitude and frequency to ensure that a surface is fit for a purpose. Roughness plays a significant role in defining how an actual object will interact with its environment. In tribology, rough surfaces generally wear more rapidly and have higher friction coefficients than smooth surfaces. Roughness is frequently a good forecaster of the performance of a motorized component, since abnormalities on the surface may form nucleation places for cracks. On the other hand, roughness may stimulate adhesion. Generally speaking, rather than scale specific descriptors, cross-scale descriptors like surface fractality provide more meaningful predictions of mechanical interactions at surfaces including contact stiffness. MRR was also tabulated.

Fig 1 Surface roughness tester

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TABLE 2 TRAILS AND THEIR RESULTS

S.No	Speed (rpm)	Feed rate (mm/rev)	Depth of cut (mm)	SR	MRR
1	1	1	1	2.214	111
2	1	2	2	2.29	98
3	1	3	3	2.52	84
4	2	1	2	2.312	183
5	2	2	3	2.39	170
6	2	3	1	1.79	68
7	3	1	3	2.43	255
8	3	2	1	1.902	153
9	3	3	2	1.955	140

IV. RESULTS AND DISCUSSIONS

a) Determination of the Regression model and Statistical Evaluation

The Regression equation, ANOVA and graph is generated by using Minitab software. The regression equation is give the relationship among Speed, feed, depth of cut, surface roughness and MRR. The equation is given by,

The regression equation is SR = 2.20 - 0.123 A - 0.115 B + 0.239 C

TABLE 3 REGRESSION ANALYSIS FOR SR

Term	Co-efficient	SE co-efficient	T	P
Constant	2.19833	0.083	26.47	0.000
A	-0.12283	0.0233	-5.26	0.040
B	-0.11517	0.0233	-4.94	0.049
C	0.23900	0.0233	10.24	0.000
S = 0.05716	R-Squared= 96.9%		R-Squared (Adj) =95.1%	

The regression equation is MRR = 81.9 + 42.5 A - 42.8 B + 29.5 C

TABLE 4 REGRESSION ANALYSIS FOR MRR

Term	Co-efficient	SE co-efficient	T	P
Constant	81.889	0.4052	202.09	0.000
A	42.500	0.1139	373.28	0.040
B	-42.833	0.1139	376.21	0.049
C	29.500	0.1139	259.10	0.000
S = 0.27889	R-Squared= 97.7%		R-Squared (Adj) =96.6%	

The goodness of fit is clarified by the determination coefficient (R-Sq).In this work, the value of determination coefficient is 0.969, 0.977 which is indicated that 3.1%, 2.3% of the entire discrepancies are not explained by the regression model for surface roughness, MRR respectively. It can be noted that the adjusted determination coefficient is very closer to the

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determination coefficient which means a good relationship between the responses and the experimental results.

b) Taguchi Analysis

This method practices a different set of arrays called orthogonal arrays. These standard arrays instructs the way of accompanying the nominal number of experiments which could give the full information of all the factors that affect the performance parameter. The crux of the orthogonal arrays method lies in indicating the level combinations of the input design variables for each experiment. The experiments were directed and the Surface roughness values were restrained from which the following graphs were drawn by using Minitab software.

TABLE 5. RESPONSE TABLE- SIGNAL TO NOISE RATIOS FOR SR

Level	A	B	C
1	-7.376	-5.848	-7.298
2	-6.635	-6.766	-6.783
3	-6.373	-7.769	-6.303
Delta	1.003	1.921	0.996
Rank	2	1	3

TABLE 6. RESPONSE TABLE - SIGNAL TO NOISE RATIOS FOR MRR

Level	A	B	C
1	-39.74	-44.76	-40.42
2	-42.17	-42.71	-42.67
3	-44.92	-42.71	-43.74
Delta	5.18	5.41	3.32
Rank	2	1	3

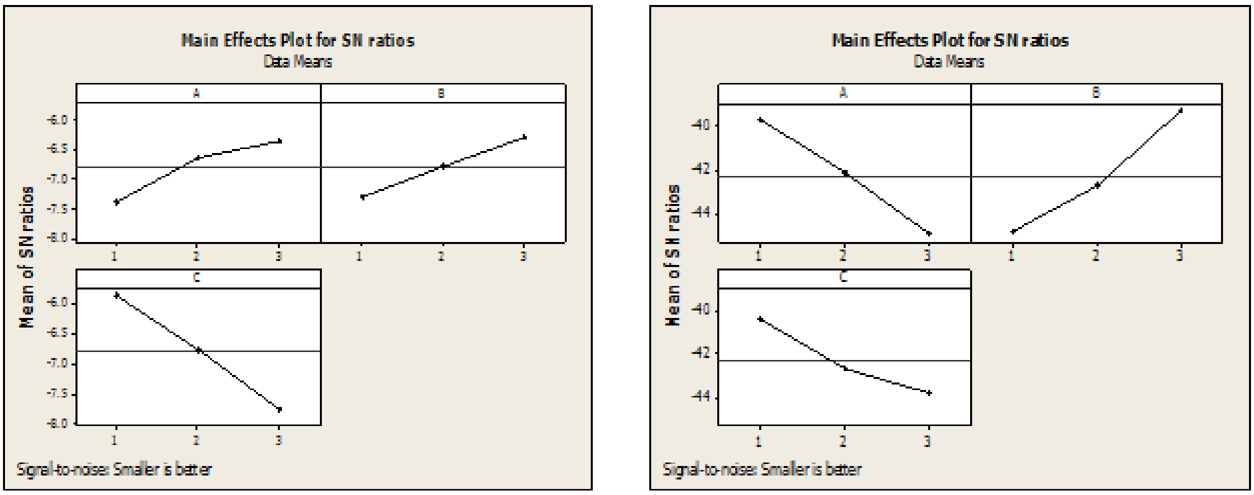

Fig 2: Signal to noise ratio graph for SR and MRR

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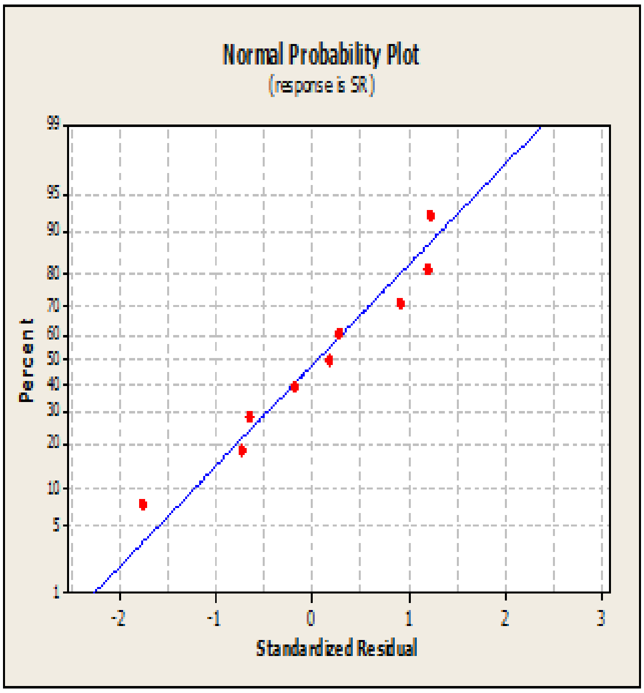
Taguchi analysis is finished as above we acquired signal to noise ratio graph and mean plot graph as shown in the figure 2 and 3. From which a major influencing factor is obtained such as feed rate. The second influencing factor is speed, the third influencing factor is depth of cut whose contribution is very less compared to other influencing factor.

c) Normal Probability plot Graph

The normal probability plot graph for SR and MRR is attained by using the regression equation and the trials values. It is a graphical exemplification for evaluating whether data set is normally disseminated or not. The graph should provide nearly in a line. So the errors are dispersed normally.



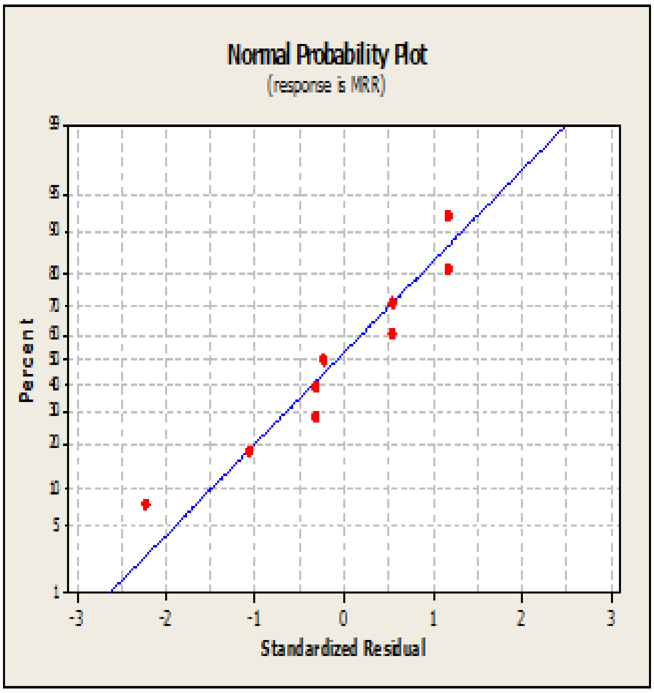


Fig 3 Normal probability plot

d) ANOVA

Analysis of variance (ANOVA) is a collecting of statistical models used to investigate the differences among group means and their accompanying procedures. ANOVA was performed by the Minitab Software which provide the operative values.

TABLE 7. ANOVA TABLE FOR SR

Sources	DOF	SS	MS	F	P	Percentage of Contribution
Speed	2	0.096469	0.048234	10.44	0.087	18.23
Feed	2	0.343694	0.171847	37.18	0.026	64.95
DOC	2	0.079761	0.039880	8.63	0.104	15.07
Error	2	0.009245	0.004622			1.75
Total	8	0.529168				100

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TABLE 8. ANOVA TABLE FOR MRR

Sources	DOF	SS	MS	F	P	Percentage of Contribution
Speed	2	10837.6	5418.8	48769	0.000	40.04
Feed	2	11008.2	5504.1	49537	0.00	40.67
DOC	2	5221.6	2610.8	23497	0.000	19.27
Error	2	0.2	0.1			0.02
Total	8	27067.6				100

e) Confirmation Test

The L9 array are conducted which means 27 experiments are accompanied from which the percentage of error is calculated and tabulated (Table 9) at different conditions such as Speed, feed, depth of cut.

TABLE 9. CONFIRMATION TEST RESULTS

S.No	Speed	Feed rate	Depth of cut	Experimental value of SR	Predicted value of SR	Experimental value of MRR	Predicted value of MRR	% of error of SR	% of error of MRR
1.	750	20	0.75	2.52	2.50	84	81	0.8	3.7
2.	2250	20	0.5	1.955	2.01	140	142	2.8	1.4
3.	1550	15	0.75	2.39	2.42	170	168	1.25	1.2

V. CONCLUSION

In this paper, Taguchi Orthogonal is used to obtain the Surface roughness and MRR in turning operation done on Al- Al_2O_3 -BAMBOO ASH Matrix composite. The following conclusions are done by this experiment,

1. The responses such as and surface roughness and MRR can be computed competently through the linear model established in this experiment. The direct and interactive effect of process factors on response within the range of examination can be considered with ease from the Taguchi and

2. The process parameters for completing the desired response can be obtained from the mathematical model. ANOVA table is used to determine the percentage of contribution for significant factors and interactions. The feed is greatest influencing factor and its percentage of contribution is 65% and 41% on surface roughness and MRR respectively.

3. The speed is contributed about 18%, 40% on surface roughness and MRR respectively. The depth of cut is contributed about 15% and 19% on surface roughness and MRR respectively. The normal probability plot graph is obtained in the form of straight line so the errors are distributed normally.

4. In Regression analysis, the adjusted determination coefficient is very nearer to the determination coefficient so estimation of delamination factor is done by effectually and competently.

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