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Application of Taugchi method for Optimization of Dry Sliding wear Process Parameters in Improving the Wear of Al6061+4%B_4C+4%CU based Composite

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***Abstract:** The process parameters can be improved by using Taugchi's method which is a statistical method of optimization and it also improve the product quality that is manufactured. The main aim of the current research is to apply Taughci method of optimization and ANOVA in the optimization of dry sliding wear process parameters of Al6061- 4% B_4C & 4% Cu based composite. In current analysis three factors mainly selected for wear optimization and they are loads, sliding speed, sliding distance and effect of these parameters are studies and the optimum value of each factor is find out by using the method of optimization. To study the wear behavior of composite orthogonal array (L_9), Signal to nose ratio analysis of variance are used. The experiment is carried out by using suitable orthogonal array (L_9). Experiments are performed on a pin on disc machine according to the selected orthogonal array. The optimum value of the parameters obtained graphically and confirmation of experiments are carried out. Smaller is the better approach used for selection of optimum parameters finally scanning of wearied surfaces under Scanning Electron Microscope and shows the uniform distribution of metal matrix in AMCs.*

***Keyword:** Stir casting, AMCs, Taugchi Method, Orthogonal Array, ANOVA, Dry Sliding Wear, S/N Ratio, Pin on Disc.*

I. INTRODUCTION

Metal matrix composite mainly consists of two phase one of them is known as metal matrix phase and other is known as reinforcement phase. The strength and hardness of metal matrix composite are high when compared with base metal at a reduced weight. Al6061- 4% B_4C & 4% Cu based composite fabricated by stir casting method which is very simple and cost involved in stir casting is not high. Due to good toughness and good tribological properties metal matrix composite are used in automotive and aerospace industry and there uses increases day by day.

N. NATARANJAN studied the wear behavior of AMCs uses sliding speed and load are mainly two process parameters and found that as the metal matrix composite manufactured by stir casting and Taugchi method applied then as the load increases the wear decrease, with an increase in sliding distance wear increases. The effect of load and temperature considered by Straffelini et al. that when the temperature increases above 1500°c and when load also increases both parameters increase the load. **K.S. Sridhar Raja** investigates the wear rate behavior as a function of load and sliding distance of al356 reinforced with boron carbide and he found that when load increases the also increase but when reinforcement is done above 9% then with increases in load and sliding distance wear rate decreases considerably**. TR Hemant kumar** studied the wear behavior of AL-Cu-Mg alloy and found that on the addition of cu mg in al alloy the wear resistance increased and he successfully optimizes the wear parameters on a pin on disc machine and shows the effect of sliding distance, load, sliding velocity and all result graphically**. Veerbhadarappa** develop the composite by stir casting method and varied the percentage of Sic in MMC after performed test on Pin on Disc machine and study the effect of these variation on wear properties and found that on increase the % of Sic in AMCs the wear decreases but it has minimum value when sic % has around 6% and when increase the value beyond 6% the wear again increased. He also studied the effect of normal pressure and sliding distance ant found that on increasing the normal pressure wear decreased and when sliding distance increased wear also increases. **A DHINAKAR** investigates the dry sliding wear properties of Mg group composite and performed Gray analysis and ANOVA confirms the experiment.

II. TAUGCHI METHOD

Taugchi method is a statistical method of optimization. It is developed by Taugchi and Konishi. Initially, it had developed for improving the quality of manufactured goods but now a days it is widely used different other fields such as Engineering, Biotechnology. To obtain the better result the parameters which are to be optimized should be selected carefully and bifurcating them into control and noise factors. Taugchi method involves identification of proper control factors to obtain the optimum result of the process. Design of experiment is one of the important and powerful statistical techniques through which the effect of multiple variables simultaneously can be studied and it uses a series of steps that must follow in a certain sequence for the experiment to obtain an improved understanding of process parameters. All designed experiments need a certain number of combinations of factors and levels that are to be tested in order to obtain the result of those conditions. Taguchi method based on the assignment of factors in the orthogonal array to find out those test condition. DOE process includes mainly three phases they are 1. Planning phase,2. Conducting phase 3.The analyzing phase. Experimental result analysis uses S/N ratio in order to obtain best process design. Nominal the best, larger the better, smaller the better is the three categories of performance characteristics to analyze the S/N ratio.
Smaller is the better is mainly uses by a researcher in order to study the dry sliding wear behavior of composite.

Taugchi method mainly involves 8 steps and they are given blow:

1. Identification of the main function and its effects
2. Identification of noise factors, testing condition, and quality characteristics.
3. Identification of objective function which is to be optimized.
4. Identification of control factors and their levels.
5. Selection of orthogonal array and construction of array.
6. Perform the matrix experiments.
7. Study the data, obtain the optimum control factor levels and their performance.
8. Perform the verification experiment.

III. MATERIAL USED AND FABRICATION METHOD

In the present research aluminum which available commercially, boron carbide (size of particle 100mesh), and Cu with 4% of both. Stir casting used for casting of cylindrical specimens. A different test is performed on specimens after machining of the object in correct dimensions and mechanical properties are obtained.

ALUMINIUM 6061

Table 1: Typical composition of aluminum alloy 6061

Component	Amount % weight
Aluminum	Balance
Magnesium	0.8-1.2
Silicon	0.4-0.8
Iron	Max 0.7
Cu	0.15-0.40
Zinc	Max0.25
Titanium	Max 0.15
Manganese	Max 0.15
Chromium	0.04-0.35

BORON CARBIDE

Boron carbide powder (see figure 1) is mainly produced by reacting carbon with B2O3 in an electric arc furnace, through carbo thermal reduction or by gas phase reactions. For commercial use, B4C powders usually need to be milled and purified to remove metallic impurities.

Table 2: Typical properties of boron carbide

Density (g.cm-3)	2.52
Melting point	2445
Hardness(Knoop 100g) (kg.mm^{-2})	2980-3580
Fracture Toughness(MPa.m$^{-1/2}$)	2.9-3.7
Young Modulus	450-470
Electrical conductivity	140
Thermal conductivity	30-42

COPPER POWDER

CU possesses very good mechanical properties so it can be used for various applications and AMC's also.pure Cu is very soft and very difficult to machine so widely used for alloying and MMC's.

Table 3: Properties of Cu

Density (g.cm-3)	8.89
Modulus of Elasticity GPa	100-150
Tensile strength MPa	220-345
Coefficient of thermal Expansion	17
Thermal conductivity	300

STIR CASTING

Al 6061 select as base metal matrix and 4% B_4C (size of the particle is 100 meshes) and 4% Cu powder used as the reinforced material. Stir casting used as the fabrication method of metal matrix composite. This method of fabrication is very fast ant the cost involved in it very low and a uniform mixing obtained. In this method, Al 6061 heated in a muffle furnace and the temp is 750°C and it is controlled by a temperature controller and at this temperature 4% B_4C (size of the particle is 100 mesh) and 4% Cu powder mixed in melted base metal. To obtain the correct mixing the stirrr rotated in the crucible for about 20 min. at speed 300 rpm. After 20 min. the stirr stopped and molten metal which is a mixture of AMCs is poured in a graphite mould and allow solidifying.

IV. TESTING OF SPECIMENS

To obtain dry sliding wear of Al6061- 4% B_4C & 4% Cu based composite wear test was performed on a pin on disc machine. Pin material is AMC's composite whose wear is to be finding out and Steel grade EN 32 use as disc material. Disc rotated as per rpm set in the planning phase and the pin is held stationary and the load is applied through lever mechanism. Wear test were performed according to the orthogonal array. Wear rate of the specimens is the function of applied load, sliding distance, sliding velocity. The test procedures are given below:

Initially, pin is fixed in the clamp and then require rpm is set on friction and wear monitoring test rig attached to pin on disc machine and to achieve a correct value of sliding distance the time set on a timer and all setting done on no loading condition and then load is applied through lever mechanism. After that machine is started according to set rpm and time after the completion of a time machine. of is stopped. The final weight of specimen is noted on weighing machine. The difference between initial weight and final weight gives the weight loose which is measure wear.

V. RESULT AND OPTIMIZATION OF WEAR BY TAUGHCI'S METHOD

Identification of the main function:

Optimization of dry sliding wear of Al6061- 4% B_4C & 4% Cu based composite done on pin-on-disc type friction and wear monitoring test rig**.**

1. Identification of test condition:

Work material: Al6061+ 4% B_4C & 4% Cu.

Machine used: Pin-on-disc type friction and wear monitoring testing.

Counter body material: It is the surface against which pin rotated and it is made of steel grade EN 32.

2. Objective function:

'Smaller is Better' approach is selected and S/N ratio is calculated. The formula used for calculation of S/N ratio is given below:

Signal to noise ratio = -10 x$(\log \frac{1}{n}\sum_{i=1}^{n} {y_i}^2)$

n= no. of observation, y= wear rate (mm^3/m)

3. Selection of control factor and their levels

A meeting with the group of people and following the guidelines are given in operator manual provided by the manufacture of pin-on-disc type friction and wear monitoring test rig is called Brain Storming.

Table4: Shows the Control Factor and Their Levels

Control factors	levels		
	1	2	3
Load (N)	15	30	45
Sliding Velocity (m/s)	2	2.5	3
Sliding Distance (m)	600	1200	1800

4. Orthogonal array:

The l_9 orthogonal array used for conducting the experiments in best possible way. The degree of freedom is given below:

DOF: 1 for mean value

8= (2*4), two each remaining factors

Total DOF=9

Table 5: Shows the Orthogonal Array for Conducting the Experiments

Experiment no.	levels		
	1	2	3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	3
5	2	2	1
6	2	3	2
7	3	1	2
8	3	2	3
9	3	3	1

Table 6: Shows the Wear Rate of Specimens According To Experiments Conduct On Pin On Disc Machine

Experiments no.	S/N Ratio Wear rate
1	59.5424
2	61.7010
3	56.7804
4	54.3866
5	53.1888
6	54.9771
7	51.1785
8	52.8352
9	49.2621

VI. OPTIMIZATION OF WEAR AND SELECTION OF OPTIMUM PARAMETERS

1. S/N ratio of individual control factors are given below:

$S_{L1} = (S/N_{1+} S/N_{2+} S/N_3)$, $S_{L1} = (S/N_{4+} S/N_{5+} S/N_6)$, $S_{L1} = (S/N_{7+} S/N_{8+} S/N_9)$,

$S_{V1} = (S/N_{1+} S/N_{4+} S/N_7)$, $S_{V2} = (S/N_{2+} S/N_{5+} S/N_8)$, $S_{V3} = (S/N_{3+} S/N_{6+} S/N_9)$,

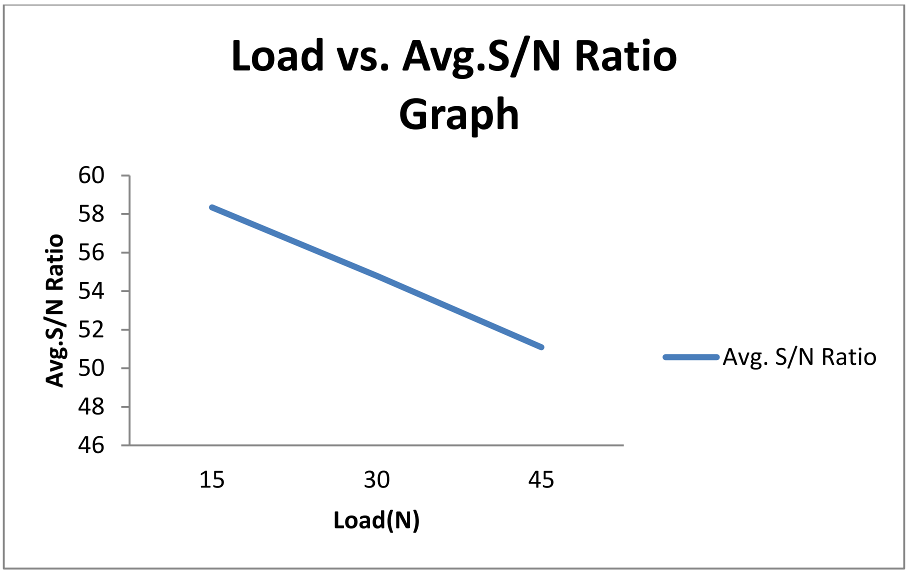
$S_{D1} = (S/N_{1+} S/N_{5+} S/N_9)$, $S_{D2} = (S/N_{2+} S/N_{6+} S/N_7)$, $S_{D3} = (S/N_{3+} S/N_{4+} S/N_8)$

S/N_k represents the S/N ratio corresponding to k^{th} experiments.

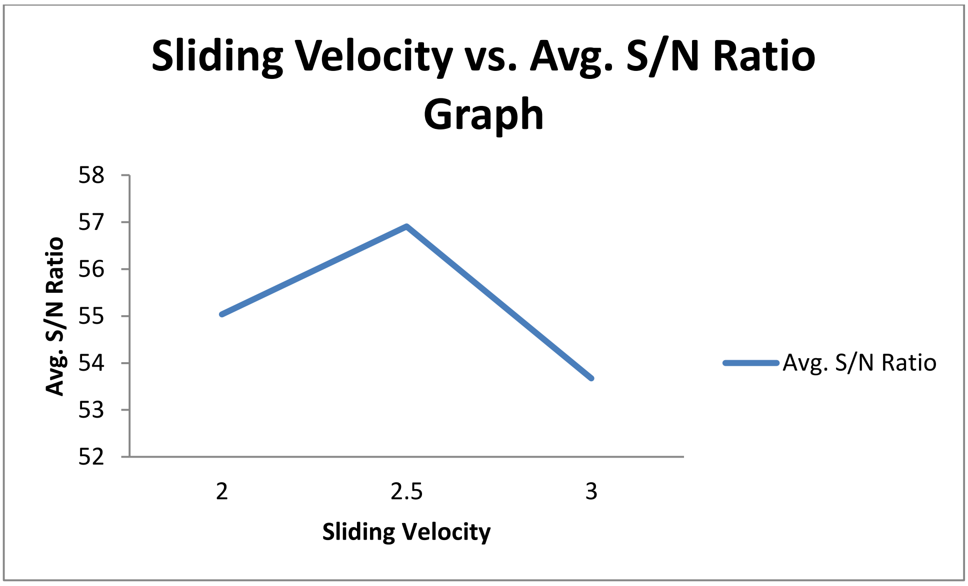
Average S/N ratio can be easily calculated and Table 7: shows the average S/N for each factor

Levels	Load	Sliding Velocity	Sliding Distance
	Avg. S/N ratio	Avg. S/N ratio	Avg. S/N ratio
1	58.3413	55.0358	52.8991
2	54.7865	56.9083	55.9522
3	51.0919	53.6732	54.6674

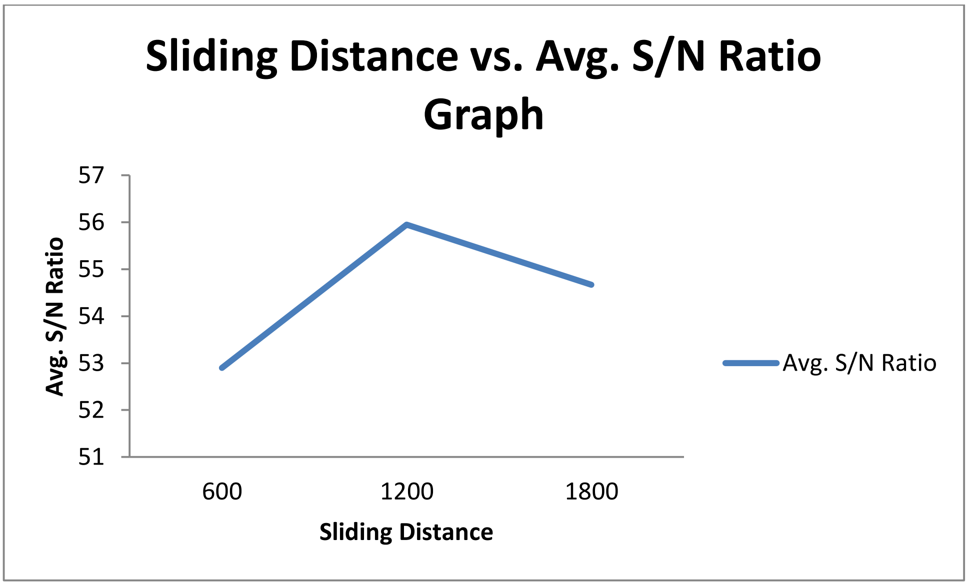
THE GRAPHICAL REPRESENTATION OF THE ABOVE VALUES OF S/N RATIOS IS GIVEN BELOW:



1. **LOAD VS. AVG. S/N RATIO GRAPH**



2. **SLIDING VELOCITY VS. AVG. S/N RATIO GRAPH**



SLIDING DISTANCE VS. AVG. S/N RATIO GRAPH.

From the above graph, we can conclude the optimum value of the parameters and their levels. The optimum values of the parameters are given below:

Selected parameters	Optimum values
Load	45N
Sliding velocity	3 m/sec
Sliding distance	600 meters

VII. ANALYSIS OF VARIANCE AND CONFERMATION OF EXPERIMENTS

Response magnitude in the percentage of each factor in the orthogonal array can be easily evaluated with help of Analysis of variance. Analysis of variance involves a statistical method on the variation of group causes. We can relate this technique with the design of experiments. ANOVA total sum of square is equal to the sum of the square of deviations and the error component. In ANOVA we construct a table and valve of F (test statics) is calculated and compare this valve with $F_{tab.}$

If the value of $F_{cal} < F_{tab.}$ then the null hypothesis is selected and its variation can be attributed to chance. If the opposite of the earlier condition occurs, this will lead rejection of the hypothesis.

Table 8: SHOWS THE ANOVA TABLE

Source of variation	Degree of freedom	Sum of squares	Mean square	F_{cal}	F_{tab}	P value
treatments	2	3.7259	1.86295	0.4575	5.48	0.234
Error	6	24.5162	4.086			
Total	8					

From the above ANOVA table, it is concluded that $F_{cal} < F_{tab.}$ so above hypothesis are selected and experiments have some common causes of variation this also validates the above Taugchi's method optimize the parameters successfully.

TABLE 9: THE % CONTRIBUTION OF EACH FACTOR IN DRY SLIDING WEAR

Parameters	% Contribution in dry sliding wear
Load	72.46
Sliding velocity	19.29
Sliding distance	7.23
Error	1.02

From the above table, we can conclude that load is the parameter which affects the dry sliding wear of a composite. Sliding distance and sliding velocity also affect the dry sliding wear but very less than load affects.

CONLUSION

- Stir casting method successfully apply for fabrication of composite and it has very low cost and it produced the uniform mixing and homogenous microstructure.
- Experiments are carried out according to the orthogonal array on a pin on disc machine with selected parameters.
- Taugchi's method provides the optimum values of wear rate of a composite with help of experiments.
- Wear rate mainly depends upon load, sliding distance, sliding velocity but in current research load is the main factor which contributes the wear and has higher % of dry sliding wear rate contribution.
- As the load increased the wear rate of AMCs decreased and has an optimum value at 45N.
- As sliding speed increased the wear rate also decreased but when sliding distance increased the wear is also increased slowly.
- ANOVA successfully applies which gives the validation of experiments and confirmation of experiments is also carried out.
- The developed AMCs have a good tensile strength, high hardness, low weight and good impact energy.

It can be used for high speed application in which parts are subjected a very high degree of dry sliding wear such as automotive industry and aerospace industries in pistons, bearings, brake rotor, cylinder heads etc.

REFERECNSE

1. D. Huda, M.A. El Baradie, and M.S.J. Hashmi, Journal of Materials Processing Technology 37 (1993), 513-528.
2. Y. Sahin, and S. Murphy, "The effect of sliding speed and microstructure on the dry wear properties of metal matrix composites", Wear 214 (1998), 98-106.
3. Shyam Kumar Karna, Ran Vijay Singh, Rajeshwar Sahai , Application of Taugchi method in process Optimization, Proceedings of the National Conference on Trends and Advances in Mechanical Engineering, YMCA University of Science & Technology, Faridabad, Haryana, Oct 19-20, 2012.
4. S Madhusudan, M M M Sarcar, NRM Bhargva & K Sunil Ratna Kumar "Fabrication & deformation of Al-Cu composite metallic materials", Journal of Engineering & Material Science vol 19, 2012 pp 175-178.
5. Saikeerthi.S.P., Vijyaramnath.B, Elanchezhian.C " Experimental Evaluation of Mechanical properties of Al6061-B_4C-Sic composite", International journal of Engineering Research volume no.3 (2014) pp 70-73.
6. R.N. Rao , and S Das , "Effect of sliding distance on wear and friction behavior of as cast and heat treated Al-Sic_p composite, Material, and Design, 32 (5), 2011, 3051-3058.
7. Feng Qiu, Xiang Jao, Jian Tang , Yu Yang Gao, Shi li shu " Microstructure and Tensile properties of Al- Cu matrix composite reinforced with Nano sized silicon carbide particles fabricated by semisolid Stirring process'.
8. Taugchi G. Konishi S, Taugchi's Methods, orthogonal array and linear graphs tools for quality American supplier institute, American supplier institute.
9. Earnest Doebelin, Engineering Experimentation, Tata McGraw Hill Publication.
10. A Dhinakar, T. Panneer Salvam, S. Raghuraman "International journal of advance in material science Engineering vol.3.
11. Gourav Agarwall, Amar Patnaik , Rajesh kumar Sharma " Parametric optimization of the three bodies Abrasive wear behavior of Sic chopped glass fiber reinforced epoxy composite International journal of Composite material (2013), 32-38.
12. G. Straffelini, M. Pellizzari, A. Molinary, Influence of load and temperature on the dry sliding behaviour of Al-based metal matrix composites against friction material, Wear. 256 (2004) 754–763.
13. Veerabhadrappa Algur, Lakshmana Naik Tk "DRY SLIDING WEAR BEHAVIOUR OF ALUMINIUM ALLOY REINFORCED WITH SIC METAL MATRIX.
14. COMPOSITES USING TAGUCHI METHOD" Int. J. Mech. Eng. & Rob. Res. Vol. 3, No. 4, October 2014.
15. TR Hemant Kumar, RK SWAMI "An experimental investigation on wear parameters on metal matrix composites using Taguchi's technique" IJEMS VOL. 10 August 2013 pp329-333.
16. N. NATARAJAN, S. Vijyarangan, Rajendra R. " Wear behaviour of A356/25SiCp aluminium matrix composites sliding against automobile friction material" Int. J. Mech. Eng. & Rob. Res. Vol. 5, No. 5, October 2006.
17. K S Sridhar Raja, V K Bupesh Raja, F Aaro Rinold and L.S Abhilash4
18. "Effect of Steel slag on Wear Characterization of Aluminium Composite Using Taguchi Technique"IOP Conference Series: Materials Science and Engineering vol. 197 no. 1.

