"Investigation of Tribological characteristics of Al 7068+ B_4C+Gr Hybrid Composite for Defence application"

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ABSTRACT

Aluminium Composites are nowadays used in various fields of aerospace, marine automotive industries, Defence since their higher strength, stiffness Selection of suitable armor materials for Defence applications is very crucial with respect to increasing mobility of the systems as well as maintaining safety. So, determining the material with the lowest possible areal density that resists the predefined threat successfully is required in armor design studies The present investigation aims to establish the Tribological characteristics of Al 7068 reinforced with Boron carbide (B_4C) & Graphite (Gr) Hybrid composites , Made by stir casting process & studied using a pin-on- disc apparatus under dry sliding condition. Analysis of variance is used to evaluate effect of the various parameters on both wear loss and coefficient of friction in order to suggest most suitable material for Defence Application

Keyword: - *AL 7068, Boron carbide,Graphite, Dry sliding wear, Taguchi.*

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1. INTRODUCTION

The aluminium and its alloys have many application in the design as light weight,,low density, higher strength, high energy absorption capability, , good thermal conductivity & corrosion resistance. Technical developments today are mainly leads for low maintenance or maintenance free machines, plants and equipment. To fulfil all these requirements aluminium alloy and their hybrid composites are most promising one. The need for high-strength and low weight materials in the Defence and ordinance, industries starts extensive research and development of aluminium alloy and their hybrid composites. Particulate reinforced Hybrid composites leads in both mechanical and physical properties with increasing tribological characteristics and stir casting processing is one of the methods for manufacturing these materials.

2. LITERATURE REVIEW

Harunmindivan et al [1] studied the reciprocal sliding wear behavior of B_4C particulate reinforced aluminumalloy composite and authors reported that wear resistance of composite increases by increasing the B_4C content upto 10 weight % toptan investigated reciprocal dry sliding wear behavior by B_4Creinforced aluminum alloy matrix composites and author conducted that COF and wear rates was increased as volume fraction and distance increased, COF and wear rates decreased as velocity increased and COF decreased and wear rates increased as load increased and also he concluded that the volume fraction is the most important factor for COF, while load is the most important factor for wear rates investigated tribological behavior of aluminium/ B_4C composite under dry sliding motion[5]. and they observed that in tribological results of LM14 aluminium alloy matrix reinforced with 5% of B_4C particles fabricated through stir casting route wear rate and coefficient of friction has a direct relation with the load , whereas inverse with the sliding speed and distance. And load was the major factor (47.4%) in determining the wear rate followed by distance and sliding velocity whereas distance affects the coefficient of friction to a large extent (44.1%) followed by load and sliding velocity

Canakci et al. [2] Investigated Abrasive wear behaviour of B_4C particle reinforced Al2024 MMCs and authors observed that the abrasive wear properties of the 2024 Al alloy were considerably improved by the addition of B4C particles, and the abrasive wear resistance of the composites was found to be much higher than that of the unreinforced 2024 Al alloy. The harder B_4C particles provide the major contribution for the abrasive wear resistance. The abrasive wear resistance of the composites is increased with increasing B_4C particle content and size.

Suresha and Sridhar[3] have investigated the dry sliding wear behaviour of Al matrix composites reinforced with Gr and SiC particulate up to 10%. Parametric studies indicate that the wear of hybrid composites has a tendency to increase beyond % reinforcement of 7.5% and compare to the Al-Gr and Al-SiC composites, these hybrid composites exhibit better wear Characteristics

Uthayakumar et al. [4] have studied the dry sliding wear behaviour of aluminium reinforced with 5% SiC and 5% B_4C hybrid composite using a pin on disc tribometer. The experimental results show that the hybrid composites retain the wear resistance properties up to 60 N load and sliding speed ranges 1–4 m/s

S.C. Vettivel et al. [5] studied the experimental investigation on mechanical behavior, modelling and optimization of wear parameters of B_4C and graphite reinforced aluminiun hybrid composites. Authors revealed that the high hardness and good % of elongation obtained in the AA 7075 hybrid composite compared to the AA 6061 alloy and its hybrid composite.

3. OBJECTIVE

Defence material should possess a combination of properties such as superior wear resistance, low coefficient of friction, high temperature strength, compatibility, conformability, , fatigue strength, cavitations resistance No single material satisfies all the requirements of a good Defence material.. In spite of having several high temperature properties of Boron carbide (B_4C) ceramic particles, Al–B_4C-Gr composites have rarely been explored for ordinance application Hybrid Composites like Al7068-B_4C-Gr have not been studied in detail so far. Therefore present research in Aluminum-based composite is aimed to develop Defence material with improved tribological and mechanical properties. Proposed material would offer superior wear resistance and low coefficient of friction

4. MATERIAL & METHODOLOGY

AL 7068-

It was Developed in the mid 1990's, higher strength for ordnance applications Al 7068 alloy provides the highest mechanical strength of all aluminium alloys and matching that of certain steels , as in table I

Table 1 Chemical composition of Al 7068

Cu	Mg	Si	Fe	Mn
1.6-2.4	2.2-3.0	0.12	0.15	0.10
Cr	Zn	Zr	Ti	Al
0.05	7.30-8.30	0.05-0.15	0.1	Balance

Mechanical Properties-

1. Yield Strength (Mpa) : 590
2. Tensile Strength (Mpa) : 641
3. Elongation (%) : 6-8
4. Brinell Hardness(BHN) : 160-190
5. Modulus of Elasticity (Gpa) : 73.1

Reinforcement Particles (B_4C Powder & Graphite)-

For this study, B_4C particles with average size of 75 µm were used as the reinforcing particles with variation of 3% ,6% .It is one of the hardest known materials, after cubic boron nitride and diamond also graphite powder is added as solid lubricant with constant 1%.

Wear test samples-

Al 7068 alloy cylindrical Pins with Pure alloy , 3% B_4C , 6% B_4C variations & constant 1%Gr are manufactured by stir casting process. Test pins specimen are machined into diameter 10 mm and length 25 mm .

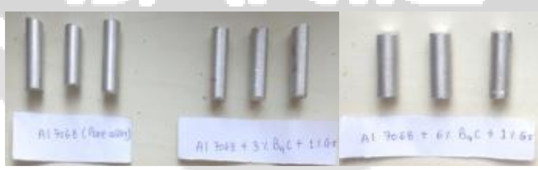

Fig 1) Wear test samples

Taguchi technique-

Taguchi method is an efficient problem solving tool, which can improve the performance of the product, process, design and system. In order to observe the influencing process parameters in wear, three process parameters namely applied load, sliding velocity and temperature each at three levels were considered as listed in Table 1. A three level L9 orthogonal array with nine experimental runs was selected. For Defence application three temperature conditions as Room temperature(taken as 27°C) , 50 °C and 100°C. Wear characteristics was with the concept of the "smaller the better".

Table 2) three level L9 orthogonal array conditions

Parameters	Level 1	Level 2	Level 3
Load (N)	10	20	30
Sliding Velocity(m/s)	1	2	3
Pin Material	PureAl-7068	Al 7068+3% B_4C+ 1%Gr	Al 7068+6% B_4C+ 1%Gr
Temperature(°C)	Room Temperature(27)	50	100

Table 3) Wear test samples.

Test sample	% REINFORCEMENT
Pure Al-7068	0
Al 7068+3% B_4C+ 1%Gr	3
Al 7068+6% B_4C+ 1%Gr	6

5. EXPERIMENTAL SETUP AND RESPONSE -

Fig 2) Pin on disc apparatus.

Dry sliding test was conducted on pin on disc apparatus with constant sliding distance 1000m, Disc track diameter 100mm.The disc is made up of steel (EN31)is used.A threelevel L9 orthogonal array with Four parameter is selected Before starting of experiment surface of pins is polished by emery paper. WINDCOM software which is usedas data acquisition system for pin on disc monitoring From that wear loss & Coefficient of friction of material with various parameters is Recorded with various Reponses

Table 4) L9 orthogonal array conditions and wear loss responses

Set	Load(N)	Sliding Velocity(m/s)	Reinforcement(%)	Temperature (°C)	Wearlossmicron
1	10	1	0	27	35.68
2	10	2	3	50	32.29
3	10	3	6	100	28.74
4	20	1	3	100	48.85
5	20	2	6	27	40.02
6	20	3	0	50	46.34
7	30	1	6	50	50.37
8	30	2	0	100	57.89
9	30	3	3	27	51.86

Table 5) L9 orthogonal array conditions and Coefficient of friction responses

SR NO	Load(N)	Sliding Velocity(m/s)	Reinforcement(%)	Temperature (°C)	COF
1	10	1	0	27	0.372
2	10	2	3	50	0.337
3	10	3	6	100	0.313
4	20	1	3	100	0.386
5	20	2	6	27	0.374
6	20	3	0	50	0.402
7	30	1	6	50	0.426
8	30	2	0	100	0.451
9	30	3	3	27	0.434

6 . RESULTS AND DISCUSSION

Analysis of variance (ANOVA) is used to analyze the Experiment by means of statistical approached with MINITAB 17 software also Regression equation is obtained to correlate response Regression equation for wear rate and coefficient of friction is obtained to correlate them with various parameters

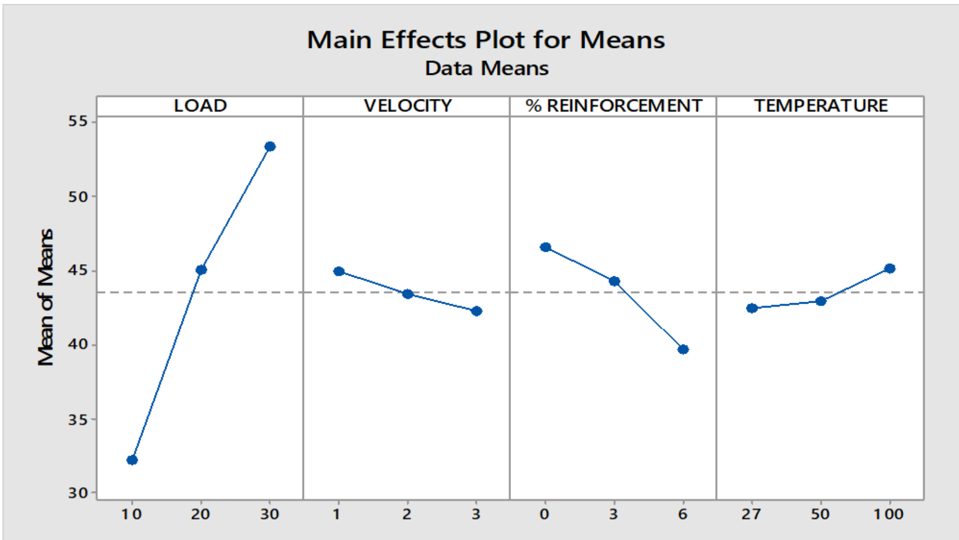

Chart 1) Main effect plot for means of wear

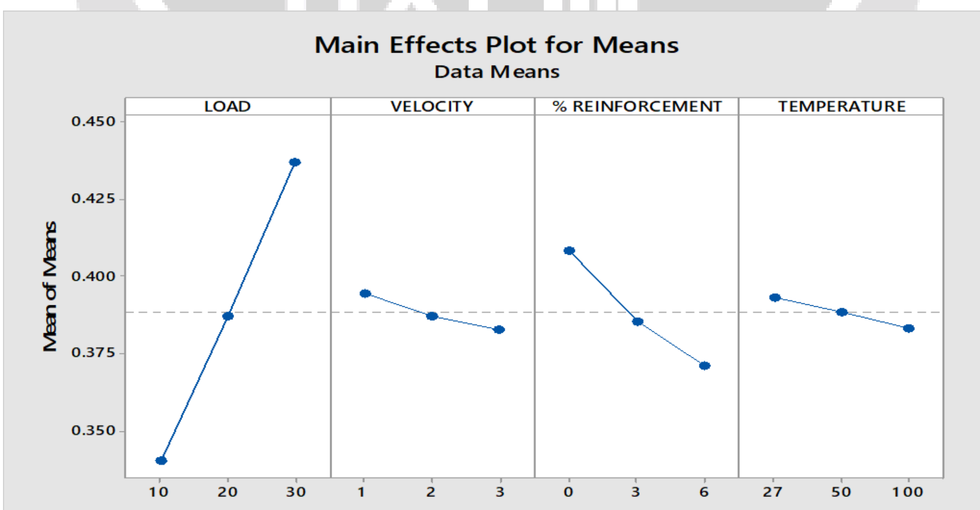

Chart 2) Main effect plot for means of Coefficient of friction

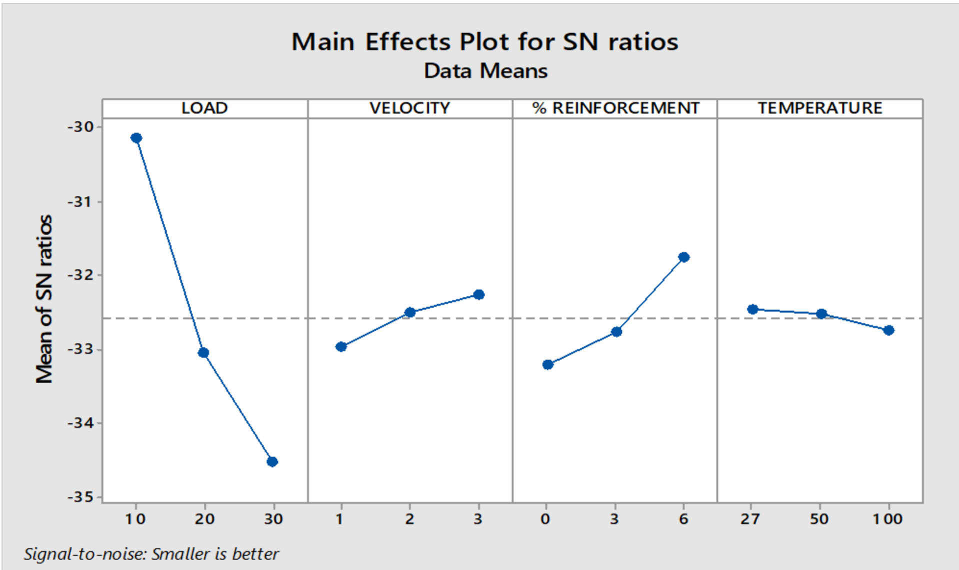

Chart 3) Main effect plot for SN ratio of wear

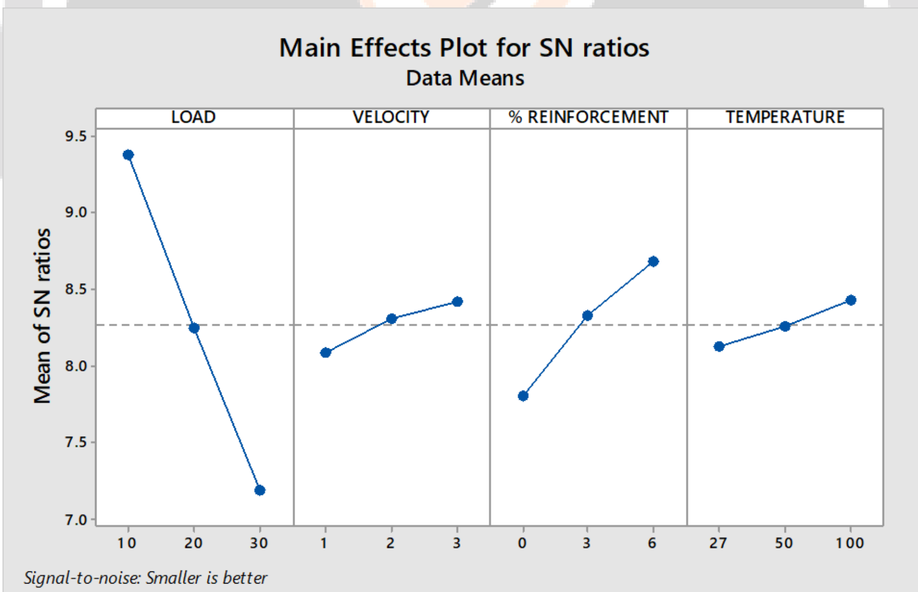

Chart 4) Main effect plot for SN ratio of Coefficient of friction

Table 6) Analysis of variance for results for SN ratio of wear

Source	DF	Seq. SS	Contribution	Adj. SS	Adj. MS	F-Value	P-Value
Regression	4	764.30	95.41%	764.30	191.074	57.45	0.001
Load	1	670.14	66.37%	670.14	670.138	201.49	0.023
Velocity	1	10.56	2.61%	10.56	10.56	3.18	0.149
% Reinforcement	1	71.67	24.09%	71.67	71.968	21.64	0.010
Temperature	1	11.63	2.34%	11.63	11.63	3.50	0.135
Error	4	13.30	4.59%	13.30	3.326		
Total	8	777.60	100.00%				

Table7) Analysis of variance for results for SN ratio Coefficient of friction

Source	DF	Seq. SS	Contribution	Adj. SS	Adj.MS	F-Value	P-Value
Regression	4	0.016358	92.37%	0.016358	0.00409	344.09	0.029
Load	1	0.013920	62.43%	0.013920	0.0139	1171.20	0.014
Velocity	1	0.000204	4.29%	0.000204	0.0002	17.18	0.005
% Reinforcement	1	0.000143	22.46%	0.000143	0.00209	175.90	0.000
Temperature	1	0.000048	3.19%	0.000048	0.000143	12.07	0.025
Error	4	0.016406	7.63%	0.016406	0.00001		
Total	8	0.016406	100.00%				

Table 8) Response Table for SN Ratio For Wear

Level	Load	Velocity	% Reinf.	Temp.
1	-30.13	-32.96	-33.21	-32.46
2	-33.05	-32.49	-32.75	-32.51
3	-34.53	-32.26	-31.75	-32.73
Delta	4.40	0.69	1.45	0.27
Rank	1	3	2	4

Table 9) Response Table for SN Ratio For Coefficient of friction

Level	Load	Velocity	% Reinf.	Temp.
1	9.375	8.090	7.807	8.127
2	8.242	.8.302	8.322	8.258
3	7.193	8.418	8.681	8.425
Delta	2.182	0.329	0.874	0.297
Rank	1	3	2	4

Regression Equation-

WEAR LOSS = 26.34 + 1.0568 Load - 1.327 Velocity - 1.154 % Reinforcement + 0.0373 Temperature

COF = 0.33006 + 0.004817 Load - 0.00583 Velocity - 0.006222 % Reinforcement - 0.000131 Temperature

7 . CONCLUSION

The main goal of these work is to investigate improved Tribological characteristics of Al 7068 hybrid composite with B_4C & Gr material for Defence application. Following conclusion are drawn from analysis-

1) Load and % reinforcement in base al alloy has most significant effect on wear loss &Coefficient of friction.

2) As load increases wear& Coefficient of friction increases, effect of Temperature and velocity has moderate effect
3) But as % reinforcement of B4C& Gr increase both wear loss &Coefficient of friction decreases significantly

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