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Experimental Investigation of Wear Properties of Aluminium LM6 Al_2O_3 Flyash Metal Matrix Composite

Nikhil V. Hiwale[1], Sachin.C. Borse[2]

[1](Department of Mechanical Engineering, DIEMS, Aurangabad
Email: hiwale.nikhil@gmail.com)

[2](Department of Mechanical Engineering, DIEMS, Aurangabad
Email: SACHINBORSE@dietms.org)

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Abstract:

In the existing learn about aluminium alloy LM6 metallic matrix composites (MMCs) containing 4% & 8% Al_2O_3 and 5% fly ash particles have been fabricated by using stir casting method. The checks have been carried out the use of a pin-on-disk friction and put on tester via sliding these pin specimens at a steady velocity of 1.1 m/s (300 r/min) in opposition to a metal counter disk at room temperature one hundred °C, one hundred twenty five °C and a hundred and fifty °C, respectively at a load of 5,10 and 15. The sketch of experiments (DOE) method the usage of Taguchi method has been used in the learn about of put on conduct of MMCs. It was once determined that the composites show off higher put on resistance in contrast to unreinforced alloy up to a load of 15 N. Al2O3 and fly ash particle measurement and its quantity fraction drastically have an effect on the put on and friction homes of composites. With the extend of the reinforcement extent fraction of Al_2O_3, the put on resistance of the composites increases. Key words: Aluminium, Metal Matrix, Wear Properties

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I. INTRODUCTION

New, aluminum rely matrix admixtures (Al Al-MMCs) are universally used in the area of tribology, which have foremost loads in contrast with the monolithic accoutrements due to tough braces. Beaucoup sorts of braces, akin as SiC, TiB2, Al_2O_3, SiCrFe and CrFeC, have been used to manufacture Al¬MMCs. These admixtures can be used in highspeed rotating and recompensing ABC, akin as pistons, connecting rods, force shafts, boscage rotors, and cylinder drags. Chromatic components of the put on movements of MMCs have been delved, and distinctive property of the brace type, brace quantity bit, pass proportion, and specific matrices on put on have been examined. The resistance extended with an extend in the Al_2O_3 atom content material and dimension and abated with an expand in the sliding distance, the put on burden and the abrasive spine size. Also, they plant that the impact of Al_2O_3 snippet dimension on the put on resistance used to be extra good sized than that of the snippet content material (1 1) In severa engineering makes use of the use of aluminium combine is unavoidable due to the fact of its most excellent mechanical, thermal property and it additionally possesse gradual put on resistance property. To extend the put on resistance of the aluminium, and its mix, it is supported with special supports. Supports are typically threads or snips of exceptional frontage and structure as proven in discern wide variety 1. The association of the snips can be slapdash, in utmost instances (Figure 1a), or preferred, in the form of sphere, cubicle or any shut to¬ normal geometrical form. A stringy helps are characterised by using its size and circumference so we distinguish, lengthy (uninterrupted) threads (Numbers 1d and 1e) and quick (sporadic) threads .

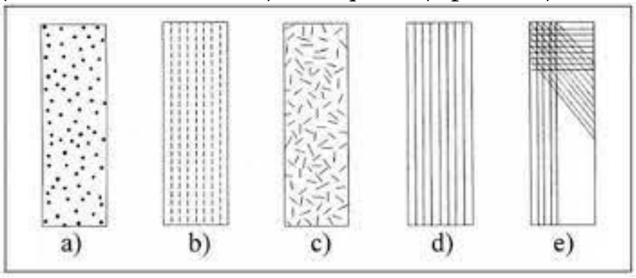

Fig. 1: Shape and Arrangement of Reinforcements in Composite Material [2]

whiskers (Figures 1b and 1c). Arrangement can be, as well, preferred (Figure 1b) and random (Figure 1c), and often the direction of fibers is changed from one layer to another. Among the different reinforcement particulates reinforcement is gaining more attention because of its excellent isotropic property during the fabrication of composite [2].

II. LITERATURE SURVEY

Many researcher have been the usage of Taguchi approach to become aware of the impact of parameters on dry sliding put on conduct of composite. There has been experimental investigation the use of Taguchi and ANOVA to pick out the giant factors, WANG Yi-qi et al. [1] Al_2O_3 fiber and SiC particle hybrid steel matrix composite fabricated with the aid of squeeze casting. When the temperature increases, the SiC does now not beautify the put on resistance. A. Baradeswaran, et al.[3] whilst analyzing on put on on Al_2O_3 composite with various %reinforcement, load, sliding distance. The put on resistance of the composites improved with addition of the Al_2O_3 particle content. The put on charge at 6 wt. p.c Al_2O_3 is solely 1/10th of the put on price for the pure matrix material. T. Hariprasad, et al.[4] performed the test to inspect the impact of B_4C and Al_2O_3 reinforcement upto 12% on exceptional load, sliding distance. For Al_2O_3- B_4C 10% presence acts an brilliant put on resistance. Bharath V. et al.[5] studied the addition stage of Al_2O_3 reinforcement is being diverse from 6 -12wt% in steps of 3wt%. with Al6061 for every composite, minimal weight loss used to be found for (6061Al alloy +12% Al_2O_3). make bigger in hardness of the alloy matrix can be viewed with addition of Al_2O_3 particles. Xiao-song JIANG et al. [6] studied the Al−5%Si−Al_2O_3 steel matrix composites for various load, sliding distance. Results proven that with load increasing, put on loss and coefficient of friction increased. Pardeep Sharma et al. [7] carried parametric learn about of Al6082 alloy composites with various percent of Al_2O_3 from 0-12. Result confirmed that sliding distance is the most influential component and share reinforcement is the aspect which impacts the put on least. Bharat admile [8] studied the dry sliding put on conduct of LM25 aluminium alloy containing Fly ash reinforcement the usage of pin on disc computer with distinctive enter parameters viz, Load, Sliding velocity, sliding distance and weight proportion of reinforcement on put on charge of the composite. Results of the test published that load and sliding pace are most influencing factors. Ravi MISHRA et al. [9] carried out experimental investigation of flyash strengthened aluminium alloy Al6061 composite, percent Wt various from 10,15and 20% with various load, sliding distance. It is located that load and sliding speed are most influential element on wear, that are minimize via enlarge in p.c reinforcement. Ajit Kumar Senapati et al. [10] waste flyash is(two distinctive kind) use in fabrication of aluminium alloy matrix composite, Results printed that there is outstanding effect of reinforcing one of a kind flyash in AMC. Sudarshan et al. [11] aluminium alloy (A356) composites containing 6 and 12 vol. p.c of fly ash particles have been fabricated, with exclusive load. Composites showcase higher put on resistance in contrast to unreinforced alloy up to a load of eighty N. A few tries have been made to fabricate MMC with Al_2O_3 to enlarge the put on resistance traits the usage of low fee reinforcement like bauxite, corumdem, granite, sillimanite. The ever growing demand for low value reinforcement stimulate the activity towords the utilization of flyash with Al_2O_3 which is industrial waste. Al_2O_3 known as a refractory ceramic oxide which is put on and corrosion resistant, used in steel slicing tools.

III. EXPERIMENTAL PROCEDURE

A. Materials Used Eutectic Al–Si alloy LM6 containing 12.2491% Si was once used as a matrix. The chemical compositions of the alloy are given in Table 1 Al_2O_3 and fly ash particle had been used as a reinforcement cloth in this investigation. The chemical compositions of fly ash particle are given in Table 2

Compound	Wt%	Compound	Wt%
Si	12.2491	Fe	0.4353
Ti	0.0672	Ni	0.0264
Co	0.0672	Cu	0.0800
Zn	0.0944	Sn	0.0632
Mn	0.1601	V	0.0146
Cr	0.0199	Al	86.7654
Ca	0.0082		

Table 1: Chemical Composition of Al-Si Alloy [Wt. %]

Designated as Base Alloy

Compound	Wt%	Compound	Wt%
MgO	1.72	CaO	2.82
Al_2O_3	29.65	TiO_2	2.54
SiO_2	51.4	FeO	5.39
K_2O	5.57	CuO	4.56

Table 2: Chemical Composition of flyash

B. Stir Casting

After cleansing Al-Si ingot, it was once reduce to suitable sizes, weighed in requisite portions and was once charged into a vertically aligned pit kind backside poured melting furnace proven in Fig.3. 4% Al_2O_3 +5% fly ash particle had been preheated one by one to 650 o C ± 5 o C earlier than pouring in to the soften of Aluminium-Silicon Alloy. This used to be accomplished to facilitate elimination of any residual moisture as nicely as to enhance wettability. The molten steel used to be stirred with a BN covered stainless metal rotor at velocity of 300-450 rpm. A vortex was once created in the soften due to the fact of stirring the place preheated Al_2O_3 and fly ash particle was once poured centrally in to the vortex. The rotor was once moved down slowly, from pinnacle to backside by means of retaining a clearance of 12mm from the bottom. The rotor used to be then pushed returned slowly to its preliminary position. The pouring temperature of the liquid used to be saved round seven-hundred zero C. Casting used to be made in cylindrical metallic mold of sixteen mm diameter and a hundred mm height. To evaluate the preferred characteristics, two AMCs had been fabricated by means of repeating the identical manner with 8% Al_2O_3 and 5% flyash.

Fig. 2: Stir casting set-up

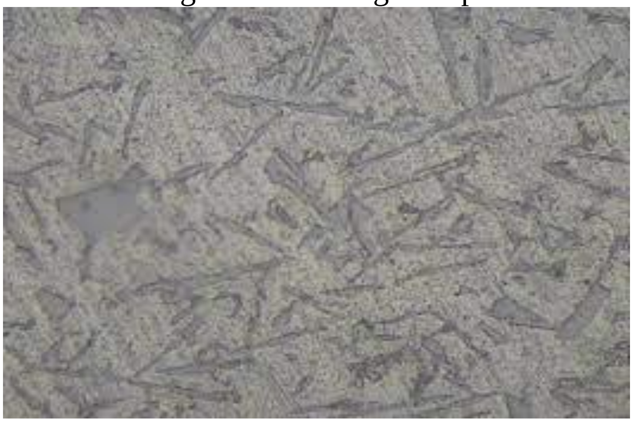

Fig. 3: Microstructure of 4% Al_2O_3 +5% fly ash at Magnification X500

Fig. 4: Microstructure of 4% Al_2O_3 +5% fly ash at Magnification X1000

Compound	Wt%	Compound	Wt%
Cu	0.012	Zn	0.001

Mn	0.0005	Mg	0.0006
Si	11.51	Pb	0.012
Fe	0.19	Sn	0.010

Table 3: Chemical composition of LM6+4%Al_2O_3+5%Flyash

Fig. 5: Microstructure of 8% Al_2O_3 +5% fly ash at Magnification X500

Fig. 6: Microstructure of 8% Al_2O_3 +5% fly ash at Magnification X1000

Compound	Wt%	Compound	Wt%
Cu	0.015	Zn	0.001
Mn	0.0005	Mg	0.0001
Si	11.09	Pb	0.012
Fe	0.21	Sn	0.006

Table 4: Chemical composition of LM6+8%Al_2O_3+5%Flyash

C. Wear Test

A single pin type pin-on-disc test apparatus was used to carry out dry sliding wear characteristics of the composite as per ASTM G99-95 standards. The tests are carried out at the elevated temperature under dry operating conditions. Wear specimen (pin) of size 12 mm diameter and 25 mm length was cut from as cast samples machined and then polished metallographically. A single pan electronic weighing machine with least count of 0.0001g was used to measure the initial weight of the specimen. The cylindrical pin flat ended specimens of size 12 mm diameter and 25 mm length were tested against EN31 steel disc by applying the load. After running through a fixed sliding distance, the specimens were removed, cleaned with acetone, dried and weighed to determine the weight loss due to wear. The difference in the weight measured before and after test gave the sliding wear of the composite specimen and then the wear rate was calculated. The sliding wear rate of the composite was studied as a function of the load, rpm, sliding distance and temperature of the pin. The dry sliding wear tests were carried out at controlled parameter levels. Parameters and levels of parameter are as shown in the table number 5

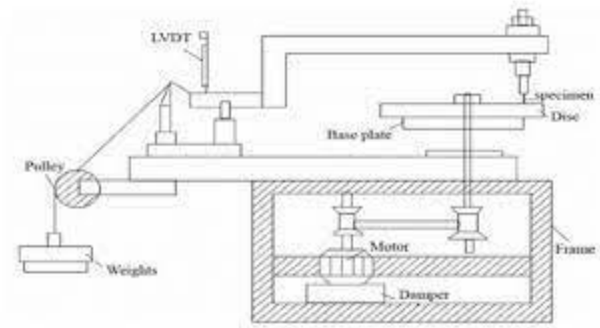

Fig. 7: Schematic Diagram of Pin on Disc Test Rig.

Wear rate of the composites was calculated from equation 1. the ratio of mass loss to sliding distance.

$$W r = \Delta m/L \quad (1)$$

Where,
Wr = Wear Rate
m∆ = m1-m2
L= Sliding Distance

Sr. No.	Parameter	Level1	Level2	Level3
1	Reinforcement	0	4	8
2	Load (N)	5	10	15
3	Sliding Distance (m)	1000	1250	1500
4	Temperature	100	125	150

Table 5: Dry sliding wear test parameter and levels

D. Taguchi Experimental Design

The design of experiments (DOE) approach using Taguchi technique has been successfully used by researchers in the study of wear behavior of MMCs. A major step in the DOE process is the selection of control factors and levels which will provide the desired information. Taguchi creates a standard orthogonal array to accommodate the effect of several parameters on the output parameter and defines the plan of experiment. Four process parameters at three levels led to the total of 9 dry sliding wear tests. The experimental results are analyzed using analysis of variance (ANOVA) to study the influence of parameters on wear rate. A linear regression model is developed to predict the wear rate of the composites. The major aim of the present investigation is to analyze the influence of parameters like load, RPM, Sliding distance and temperature of the pin on dry sliding wear rate of aluminium LM6, Al_2O_3 and flyash metal matrix composites using Taguchi technique.

Sr. No.	Load N	Sliding Distance m	Tempert ure °c	%Reinforcement	Wear rate× 10−7 N/m
1	5	1000	100	0	0.341390
2	5	1250	125	4	0.350040
3	5	1500	150	8	0.369320
4	10	1000	125	8	0.317192
5	10	1250	150	0	0.331594
6	10	1500	100	4	0.349320
7	15	1000	150	4	0.361841
8	15	1250	100	8	0.352431
9	15	1500	125	0	0.372431

Table 6: Experimental Runs and Result

IV. EXPERIMENTAL RESULT

Regression evaluation is carried out in order to discover out the impact of load, rpm, sliding distance and pin temperature on put on charge of aluminum crimson mud composite. Statistical evaluation was once carried out the use of MINITAB sixteen software. The analyzed effects are introduced the use of ANOVA evaluation and suggest results plots. Table 6 indicates the orthogonal array and outcomes bought at some stage in the experimentation. Figure 3show the put on fee ratio most important impact plot for the output overall performance characteristics. From Figure 5 it used to be understood that the superior parameter aggregate for put on price used to be as proven in desk quantity 7.

A. Analysis of Wear Rate

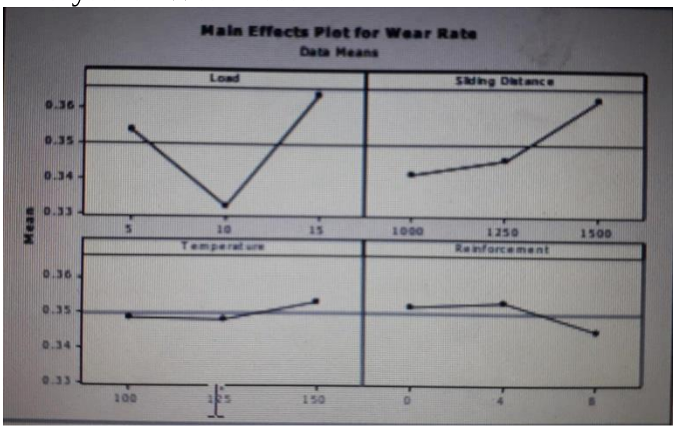

Fig. 8: Main Effect Plot Wear Rate

Sr.No.	Parameter	Optimum level
1	Load	10
2	Sliding Distance	1000
3	Temperature	125
4	Reinforcement	8

Table 7: Optimum Level of Parameters

V. ANOVA FOR WEAR RATE

ANOVA was used to determine the design parameters significantly influencing the wear rate. Table 8 shows the results of ANOVA for wear rate. This analysis was evaluated for a confidence level of 95% that is for significance level 0.05. The last column of the table number 8 shows the percentage of contribution of each parameter on the wear rate, indicating the degree of influence on the result. It can be observed from the results obtained that Load was the most significant parameter having the highest statistical influence (63.22%) on the dry sliding wear rate of composites followed by sliding distance (15.27%) .When the P-value for this model is less than 0.05, then the parameter can be considered as statistically significant. From an analysis of the results obtained in Table 8, it is observed that the effect of load & sliding distance is influencing wear rate of composites.

Source	DF	SS	MS	F Value	P Value	%
Load	2	0.00323 37	0.0016169	102.56	0.000	61.54
Sliding Distance	2	0.00153 35	0.0007668	48.64	0.000	29.18
Temperature	2	0.00009 89	0.0000495	3.14	0.092	1.8
Reinforcement	2	0.00024 63	0.0002463	7.18	0.011	4.68
Error	9	0.00014 19	0.0001419			
Total	17					

Table 8: ANOVA for Wear Rate
DF: degree of freedom, SS: sum of squares,
V: varience, F: test, P: Contribution

A. Model summary

S	R-Sq	R-Sq(adj)	R-Sq(Pre)
0.00397055	97.30	94.90	96.12

Table 9:

B. Regression Equation

Wear Rate= 0.277 + 0.00106 Load + 0.000043 Sliding distance + 0.000093Temperature -0.00088 Reinforcement Analysis of variance (ANOVA) is carried out using MINITAB 16 software to investigate difference in average performance of the factors under test. ANOVA breaks total variation into accountable sources and helps to determine most significant factors in the experiment. The obtained R square value is 97.30%.

VI. CONFIRMATION EXPERIM

A. Predicted Optimum Condition The predicted values of analysis of varience at the optimum levels are calculated by using the relation:

$$n = nm + \sum \quad (nim-nm) \qquad (2)$$

Where,
n = Predicted value after optimization
nm = Total mean value of quality characteristic
nim = Mean value of quality characteristic at optimum level of each parameter
o = Number of main wear parameters thet effect the wear rate. The purpose of this confirmation experiment is to verify the improvement in the quality characteristics.

Parameter	Model Value	Experimental value	Error
Wear Rate	0.32999	0.317192	3.878%

Table 10:

VII. CONCLUSIONS

The use of the Taguchi technique and evaluation of response variables to optimize the dry sliding put on parameters of the Al_2O_3 flyash aluminium based totally steel matrix composite has been mentioned in this paper.
1) Aluminium LM 6 matrix strengthened with 4% Al_2O_3 + 5% flyash and 8% Al_2O_3 + 5% flyash was once effectively organized through stir casting system and the conduct of the composite was investigated the usage of pin-on-disc machine.
2) It is determined that utilized load is observed to be most vast parameter with 61.54% contribution to put on rate. Sliding Distance used to be discovered subsequent considerable parameter with 29.18%

contribution to put on rate.
3) In investigation of Al_2O_3 flyash aluminium primarily based steel matrix composite it is discovered as amplify in reinforcement of Al_2O_3 flyash the put on resistance additionally increase. template used to be supplied through courtesy of Causal Productions (www.causalproductions.com)".

REFERENCES

[1] WANG Yi-qi, SONG Jung-il "Dry sliding wear behavior of Al2O3 fiber and SiC particle reinforced aluminium based MMCs fabricated by squeeze casting method." Journal Elsevair 2010
[2] Puri Ajay j. S.A.Sonawane "Experimental Investigation of Wear Properties of Aluminium LM25 Red Mud Metal Matrix Composite" Vol. 3, 2015
[3] Baradeswaran, A. Elayaperumal "A Statistical Analysis of Optimization of Wear Behaviour of Al-Al2O3 Composites Using Taguchi Technique" Journal Elsevair 2013
[4] T.Hariprashad K. Varatharajan, "Wear Characteristics of B4C and Al2O3 Reinforced with Al 5083 Metal Matrix based Hybrid Composite" Elsevair 2014
[5] Bharat V, Madev Nagaral "Preparation of 6061AlAl2O3 MMC's by Stir Casting and Evaluation of Mechanical and Wear Properties" Elsevair 2014
[6] Xiao-song JIANG, Nai-juan WANG "Friction and wear properties of in-situ synthesized Al2O3 reinforced aluminum composites" Elsevair 2014
[7] Pardeep Sharma, Dinesh Khanduja "Parametric Study of Dry Sliding Wear of Aluminium Metal MatrixComposites by Response Surface Methodology" 2015
[8] Bharat Admile, S. G. Kulkarni "Review on Mechanical & Wear Behavior of Aluminum-FlyAsh Metal Matrix Composite" International Journal 2014
[9] Ravi Mishra, Anilkumar H.C " Tribological Characterisation of Fly Ash Reinforced Aluminium Alloy (Al6061) Composites" International Journal 2011
[10]Ajit Kumar Senapati , Purna Chandra Mishra " Use of Waste Flyash in Fabrication of Aluminium Alloy Matrix Composite" International Journal
[11]Sudarshan , M.K. Surappa "Dry sliding wear of fly ash particle reinforced A356 Al composites" Elsevaier 2008.
[12]. Y. Wan, W. Liu, Q. Xue, (1996) "Effects of diol compounds on the friction and wear of aluminum alloy in a lubricated aluminum-on-steel contact", Wear, 193: 99-104.
[13]. M. D. Bermudez, G. Martınez-Nicolas, F. J. Carrmon, I. Martınez-Mateo, J. A. Rodrıguez, E. J. Herrera, (2001) "Dry and lubricated wear resistance of mechanically-alloyed aluminum-base sintered composites", Wear, 248: 178-186.
[14]. Ravi Mishra, Anilkumar H.C, H. Suresh Hebbar, "Tribological Characterization of Fly Ash Reinforced Aluminium Alloy Composites", International Journal of Engineering Sciences, 2011, Vol.5, pp8-11
[15]. Ashish Srivastava et al., "A Review on Fabrication & Characterization of Hybrid Aluminium Metal Matrix Composite",