International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 08 | Aug 2018 www.irjet.net p-ISSN: 2395-0072

Evaluation of Mechanical and Wear Properties of Aluminium-Al_2O_3 Composite Material

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Abstract-*The MMC have wide application in all engineering field such as automobile and mechanical industry due to their light weight and high strength parameter. In this paper to study of mechanical and wear properties of aluminum alloy and effects of reinforcement material such as short fiber alumina. The composite is fabricated by stir casting method. Adding reinforcing material as 10%, 15%, 20% respectively at same time wear rate reduces and mechanical properties improve. To study wear test and test conduct on pin on disc apparatus as dry sliding condition with ambient temperature for different affecting parameter i.e Normal Load, sliding velocity, sliding distance. And also study of mechanical properties of specimen such as tensile strength, hardness, elongation or chemical composition of material. It was found that tensile strength and hardness increased when alumina is added to 6082 aluminium alloy. Wear rate is decreased when adding alumina to aluminium alloy.*

***Key Words*: Metal Matrix Composite, Wear Test, Pin On Disc, Al_2o_3, Composite Material,**

1. INTRODUCTION

The metal lattice composite [MMC] is by and large a compound, not an unadulterated metal. A metal grid composite is a composite material in which no less than two constituent materials, one being a metal. The other material might be an alternate metal or another material, for example, an earthenware material i.e short fiber alumina . The need of composite materials has expanded, due to the enhanced physical and mechanical properties. A composite material is a material comprising of at least two physically or synthetically unmistakable stages. The composite by and large has great attributes than those of every one of the individual parts. The fortifying segment is circulated in the lattice material. Aluminum grid composites [AMCs] are rising as propel building materials because of their quality, flexibility and sturdiness. The aluminum lattice is getting fortified when it is strengthened with the hard clay particles like Al_2O_3, and B4C and so forth .Aluminum combinations are as yet the subjects of exceptional examinations, as their low thickness gives extra points of interest in a few applications, for example, break rotor, cylinder, break cushion, break liner and so forth. In this examination, a chronicled foundation on the advancement and utilization of metal framework composite for car brake rotor is displayed. The talk likewise incorporates examination of the item life cycle with mix giving a role as a contextual investigation. The authentic audit examination uncovered that continuous advancement of material and preparing strategy have prompt a lighter weight, bring down cost, and higher execution brake rotor because of the better comprehension of the mechanics of metal network composite. It rose up out of the investigation that mix throwing method gives simplicity of task, manageability and most fundamentally exceptionally focused without giving up quality in respect to different systems and all things considered is the most appealing assembling process in the business. These discoveries can be utilized for future plan and make of a productive and successful aluminum grid composite brake rotor for car and different applications. The wear rate of the surface is additionally subject to sliding pace, temperature, warm, mechanical and substance properties of the materials examined. Tainting on material's surface, for example, flotsam and jetsam or particles between the sliding surfaces additionally increment wear rate and harm to the surfaces.

2. LITERATURE REVIEW

W.S. Miller, L. Zhuang, J. Bottema, A.J. Wittebrood, P. to study of application of aluiminium alloy and use of composite material for different application[1]. A.Agbeleye,D.E. Esezobor, S.A. Balogun,J.O. Agunsoye,J. Solis, development of wear properties for aluminium composite for different load condition [2]. A.A. Adebisi, M.A. Maleque use for historical anyalsis of wear properties of break rotor system in automobile or mechanical industry [3]. Puneeth.N, Satheesh.J, G.Anil Kumar effect of Al_2O_3 on tensile and hardness properties of composite.Al_2O_3 partical is, increase propertiesofcomposite[4].K.S.Hanumanth,Ramji*M.Kumar,and A.deals with quality of composition and wear properties breakrotor[5].Vladimi´rToma´sˇek,GabrielaKratosˇova,Rongping Yun,Yanli Fan,Yafei Lu to study effects of alumina [Al_2O_3] as an abrasive on brake friction performance and friction layers of nonmetallic brake friction materials were evaluated.[6]. P. Ramesh, A. Arun Raja, Ajay R. and Abhinav Vishnu.A.R observed that the reinforcement more randomness and diffused inter-metallic spacing than it was seen that alumina particles were deposited on the aluminium matrix [7].

3. PROBLEM STATEMENT

To improvement of properties of automobiles part such as engine and transmission interior part chassis components and body components and this part made by alloy composite

materials and metal for different s type of materials properties. In this project to study automotive break system is responsible for converting kinetics energy into thermal energy which is then dissipated through disc break rotor and other part. Most of the automotive industry use gray cast iron and steel for manufacturer of disc break rotor and break system but it disadvantage its high weight which has impacts on fuel consumption and vehicle emissions and Mechanical properties. Hence in this project break rotor and break made of alloy steel, cast iron replaced by aluminum alloy and reinforcement materials. For this purpose composite will be tested for various combination such as 10%,15%,20% by wt of alumina in aluminum alloy matrix and tested for Mechanical properties such as tensile strength, hardness strengths and wear rate and the result will be compared with existing materials properties .

3.1 Objective

- To conduct wear test on aluminum alloy and Al-Al_2O_3composite materials off different composition at varying load and sliding distance.
- To study mechanical and tribological properties of aluminum and there composite materials for different composition to select best composite materials for break system on basis of mechanical and wear properties.

4. MATERIALS SELECTION

4.1 Aluminum Alloy 6082-

In the present examination, Al-6082 amalgam was picked as the base lattice as it has the incredible erosion obstruction and high quality in 6000 arrangement combinations. As a moderately new amalgam, the higher quality of aluminium compound 6082 has seen it supplant 6061 in numerous applications. The expansion of a lot of manganese controls the grain structure which thusly brings about a more grounded amalgam. The beneath table gives us the concoction arrangement of Al6082 the rest is aluminium.

Table No-1 Chemical Composition of Al-6082 alloy

Element	%
Si	0.7-1.3
Fe	0.5
Cu	0.1
Mn	0.4-1.0
Mg	0.6-1.2
Zn	0.2
Ti	0.1
Cr	0.2
Re	95.43

4.2 Short Fiber Alumina-

Its high quality mechanical properties, warm security, mechanical similarity, concoction similarity, high youthful modulus, great monetary productivity. Its intermittent sorts of fiber or particles give great particular firmness and quality. it has beneficial outcome on the hardness, wear obstruction, weakness opposition and pressure obstruction.

Table No-2 Chemical composition of short fiber alumina

Sr.no	Element	Wt %
1	Al_2O_3	96-97
2	SiO_2	3-4
3	Fe	0.040
4	Cr	0.006
5	Ni	0.014
6	Mg	0.013
7	Na	0.088
8	Ca	0.053
9	Chloride	0.008

5. EXPERIMENTAL WORK

5.1 Fabrication of Composite Material-

The creation of composites materials by utilizing blend throwing is done in materials research center of mechanical designing department at D.V.V.PATIL College Ahmednagar. Its fluid metallurgy method process. Since blend throwing process is efficient, large scale manufacturing and required size and state of composite can be delivered. Its appeared in fig 1 mix throwing process has been utilized to created aluminum and alumina composite material with various example of composite materials.

Table No 3- Composition of aluminium with alumina Composite Materials

Sr.no	Sample	% of alumina
1	Al 6082	0
2	Al 6082+ alumina	10
3	Al 6082+ alumina	15
4	Al 6082+ alumina	20

Synthetic synthesis of aluminum 6082 and Al_2O_3 appeared in tables 1 and 2. An electric heater was utilized as first phase of liquefying the aluminum in the cauldrons at the climatic condition. The softening of aluminum take set at 700c which is accomplished in 1 hours. After accomplishing 700c temperature heater kept on consistent temperature of 700c for 30 minutes. Preheated alumina down to earth included liquid metal through pipe. Alumina particles are preheated to a temperature of 300c at the same time. the support are preheated to enhance the wet capacity, evacuate dampness and furthermore to diminish temperature inclination between liquid metal and fortification. Alumina included 10% 15%,20% by weight in dissolved aluminum amalgam for various synthesis. Also, electrical obstruction heater collected with graphite impeller utilized as blended was utilized for stirrings reason. After alumina augmentations fluid , metal – support blend was mixed for30 minutes .at last composite were poured in preheated metal molds at 700c. lastly take up example.

Fig 1. Sample of Composition

The readied example test was prepared for handling; it is to be machined on machine in the wake of cutting on control hack saw. The example turned on machine to get required measurements and wrapping up. The required measurement of Ø10×30 mm is acquired on machine. Along these lines the example of various organizations prepared for wear test.

Fig 2. Specimen Pin For Wear Test.

For the most part the external race split cushion is comprised of treated steel and low steel, semi metallic material. So partner i.e. break cushion material is likewise chosen as made up of same material. Plate material chose as steel with grade EN8.

Fig 3. En8 Disc

5.2 Wear Test

The readied tests were utilized for tribological test on Wear and grinding screen at PG Laboratory, Department of Mechanical Engineering in Dr.Vitthalrao vikhe patil College of Engineering, Ahmednagar. The stick on circle is a device used to decide Tribological properties of composite materials. The composite material example stick is put on a spoil acting plate which pivoting at a variable RPM. Dry sliding wear test "stick-on-circle" component appeared in fig 4. The composite examples are readied is as indicated by ASTMG99 Slandered. the breadth of the slider plate made up of solidified steel having distance across 165mm and 8mm thickness. The stick test measurements are 10mm width with 30mm stature. The test is directed in dry sliding conditions. The weight has been estimated in a computerized adjust having slightest tally 0.1mg.after each test the plate is cleaned. To direct the wear analyze 3 levels of load and 3 levels of speed are considered. The heap go is taken to be 20 N to 60 N and sliding speed is taken to be 1.03 to 3.14 m/s. Its appeared in tables

Table No 4- Process Parameter Wear Test

Sr.no	Parameter	Value
1	Sliding velocity [m/s]	1.03 to 3.14
2	Normal load [N]	20 to 60
3	Test duration [sec]	750-900
4	Track diameter [mm]	60-140
5	RPM	1000 to 1400

The specimens are prepared according to ASTM E8 standard. The gauge is 62.5 mm long and having diameter of 12.5 mm. the total length of the specimen is 300 mm. the equipment used to test tensile strength is UNIVERSAL TESTING MACHINE [UTM].

5.3 Hardness Test

Hardness is the resistance of materials to localized deformation. A hard material surface resists indentation or scratching and ability to indent or cut material. hardness of the four stir casted sample was tested on Brinell hardness tester. In the Brinell hardness test a hardened steel ball is pressed into the flat surface of test pieces using force 500kgf to 1000kgf. The ball is removed the diameter of resulting indentation is measure using a microscope. Reading on three location are taken and average reading of each sample was considered.

5.4 Density Test

The density is the physical property of the material. The density of the material can be defined has mass per unit volume. It is also a convenient property because it provides a link (or conversion factor) between the mass and the volume of a substance.

Density Test Theoretically: Where, ρ = M / V density in g/cm^3

m= mass in gram

v=volume in cm^3

Density Test Experimentally: The weight of the sample is measured in air. The sample is immersed in water and the weight of the sample is measured. The density of the material is calculated using formula

ρ = Weight of sample of air / Weight of sample of air – Weight of sample water

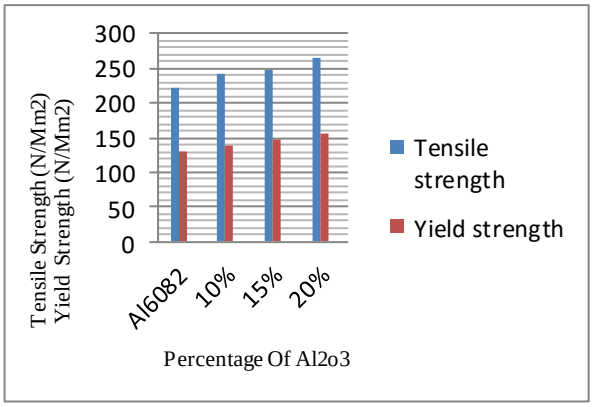
6 RESULTS & DISCUSSIONS

6.1 Tensile test

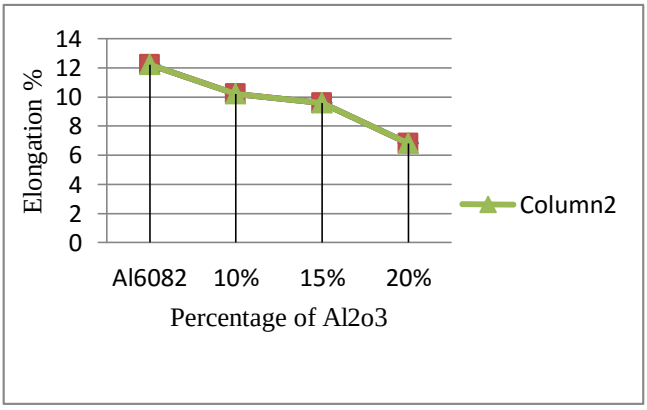
Table show that tensile strength, yield stress and elongation of composite. For Al6082 tensile strength is 220.94 mpa, yield stress 132 mpa, and elongation 12.20 %. For Al6082 + 20% alumina tensile strength is 265Mpa and yield stress is 157.03 Mpa also decreased elongation 6.82%.it is clear that properties of material is increased when adding a reinforcement material and good chemical bonding of both materials.

Table No 5- Shows Result of Tensile Testing

Properties	Al6082	10%	15%	20%
Tensile strength [N/mm^2]	220.94	241.71	248.43	265.41
Yield strength[N/mm^2]	131.26	139.69	148.55	157.04
Elongation %	12.20	10.20	9.60	6.82



Graph1. Shows Variation of Strength of Composite



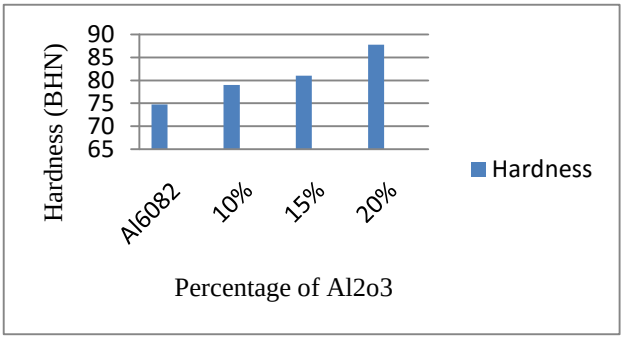
Graph 2. Variation of Elongation of Composite

6.2 Hardness test

Table show hardness of the composite among the different specimen.Al6082 with 20%alumina has the highest hardness 87.66 BHN. for sample Al6082 with 10% hardness is 81.01 BHN and sample Al6082 with 15% hardness is 79BHN. The hardness between second and third sample increased only 2%. But sample four is increased hardness 7% as compared to both sample.

Table No-6 Hardness of the Composite Specimen

Properties	Al6082	10%	15%	20%
Hardness[BHN]	74.77	79	81	87.67



Graph 3: Shows Variation of Hardness And Composite

6.3 Chemical Composition Test

Table7 show chemical composition of the composite among the different specimen. The first sample show chemical composition of Al6082.The percentage of Si particles increase in the all sample of composition due to adding of Al_2O_3. For increase tensile strength of material because adding Al_2O_3. By addition of silicon to Al reduce the melting temperature fluidity and addition of zinc permit the precipitation hardening

Table No 7-Chemical Composition of Composite

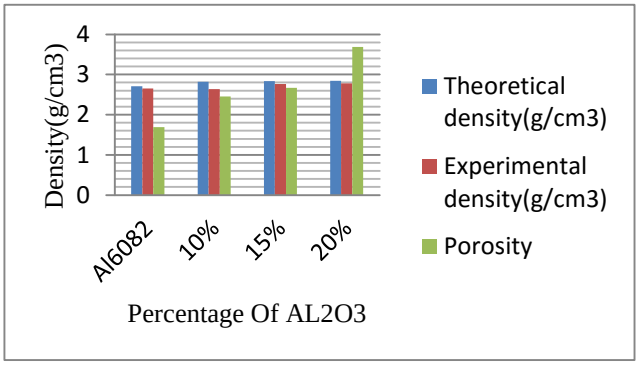
Element	Al6082	10%	15%	20%
Si	1.2700	1.3600	1.4200	1.5500
Fe	0.3300	0.2500	0.3060	0.2630
Cu	0.0236	0.0123	0.0265	0.0285
Mn	0.5853	0.6120	0.7130	0.5850
Mg	0.7583	0.7060	0.6130	0.7580
Zn	0.2060	0.1630	0.1410	0.2060
Ti	0.0285	0.0250	0.0330	0.0285
Cr	0.0298	0.0368	0.0226	0.0298
Al	Rem	Rem	Rem	Rem

6.4 Density test

Table 8 indicates thickness and porosity of composite. The expansion in thickness of the composites is because of the higher thickness of the fortification. The expansion in porosity with the increment in level of molecule division is be because of the increment in microspores and interspaces between the framework and the support. The lessening in porosity is because of the quickened response, decrease in microspores and interspaces between the network and the fortification.

Table No 8- Show Density of Composition

Properties	Al6082	10%	15%	20%
Theoretical density(g/cm3)	2.711	2.719	2.833	2.844
Experimental density(g/cm3)	2.655	2.634	2.766	2.777
Porosity	1.69	2.45	2.67	3.09



Graph 4 Shows Variation of Density and Composite

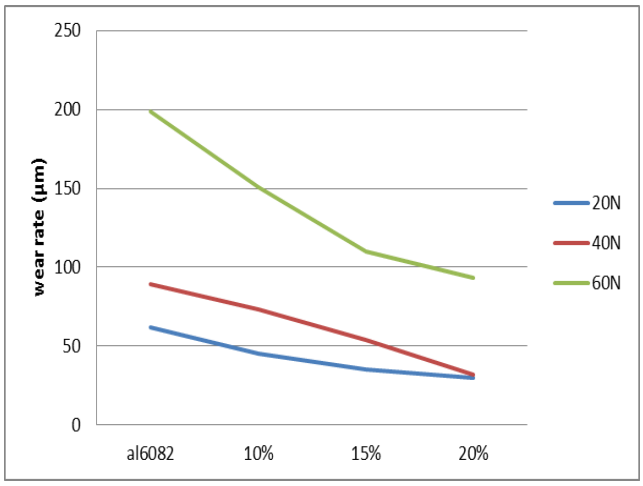
6.5 Wear Test

Sliding wear examination demonstrates the variety of wear rate with synthesis of alumina particles. its demonstrate the impact of alumina on wear rate for various load condition with rpm.the diagram demonstrates wear rate of composite for various load and track breadth. Al-based composite demonstrates a diminishing in wear rate with expanding substance of Al_2O_3 support which goes about as hindrance to shear disfiguremen

Table No 9- Show Wear Rate of Composite

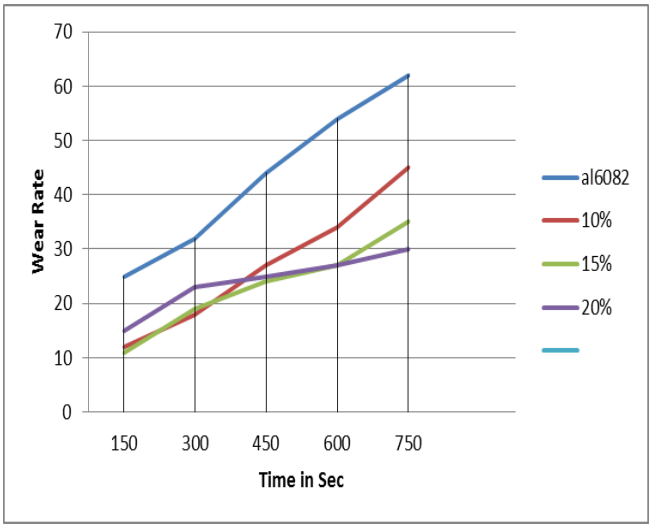
Sr.no	Material	Load N	Wear rate(μm)
1	Aluminium 6082	20	62
2		40	89
3		60	199
4	Al6082 with10% Al_2O_3	20	45
5		40	73
6		60	151

7	Al6082with15% Al_2O_3	20	35
8		40	54
9		60	110
10	Al6082with20% Al_2O_3	20	30
11		40	32
12		60	93

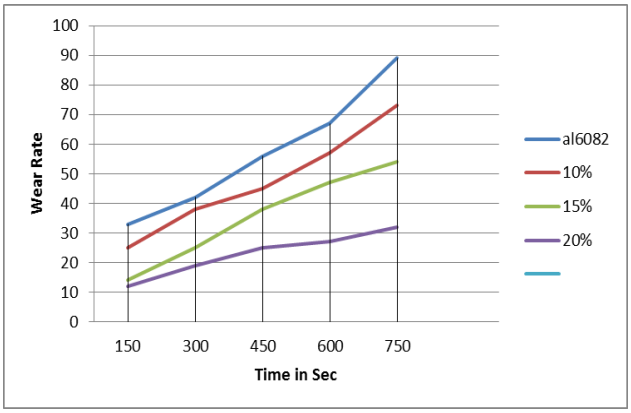


Graph 5. Show Wear Rate Of Composites

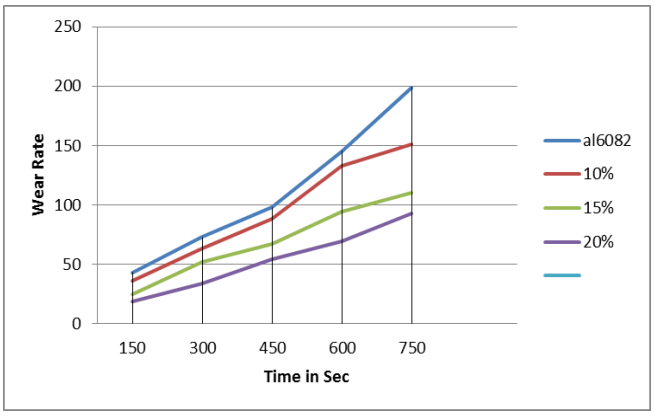
The graph show wear rate of Al-based composite with addition of Al_2O_3.The wear rate of pure aluminum is greater than other composite.the reniforcement particals is increased so wear rate is decreased. The load is increased that wear rate is increased.but rpm is increased so wear rate is decreasd.the adding Al_2O_3 then reduced wear rate.The graph a,b,c shows wear rate vs time of composite.



Graph 6. 20 N



Graph 7. 40 N



Graph 8. 60 N

7 CONCLUSIONS

Tensile strength of the composite materials increases with increase in Al_2O_3 reinforcement. tensile strength of base metal tensile strength 220.94 [N/mm^2] , yield strength 131.26 [N/mm^2] and elongation12.20 % and maximum strength was found 265.41 [N/mm^2], yield strength 157.04 [N/mm^2] and elongation 6.82%. Hardness of composite is increased when addition of reinforcement material. Density of metal matrix composite cast is almost relevant to the theoretical densities. Changes chemical composition of composite for all sample is increased Si particles so effect on strength of materials the sample 15 % is best chemical composition as compare to other sample. After conduct wear test so find out wear properties of materials. When load is increased that wear rate is increased but adding reinforcement so decreased wear rate of composite. The rpm is increased so wear rate of material is reduced.

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