# Experimental Investigation of Wear Characteristics on AL/SIC/GR Composite Material

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**Abstract— A composite material is a 'material system' composed of a combination of two or more micro or macro constituents that differ in form, chemical composition and which are essentially insoluble in each other. The study of wear characteristics and mechanical properties on Aluminium Matrix Composites (AMCs) reinforced with silicon carbide (SiC) and graphite (Gr) particles are carried out. In this composite Al6063 is used as matrix material with fixed quantity of SiC of 10 Wt% and varying graphite quantity from 2 to 6 Wt%. The composite were fabricated by using Friction stir casting (FSC) method. The friction and wear characteristics of the composite is investigated under dry sliding condition and compared with original aluminium alloy. The wear test is carried out by using pin on disk method at normal loads and at constant velocity. The wear mechanism of composites and original alloy is compared by using scanning electron microscope (SEM) image of the worn surfaces.**

**Index Terms— AMC, FSC, SEM**

## I. INTRODUCTION

A composite material is a 'material system' composed of a combination of two or more micro or macro constituents that differ in form, chemical composition and which are essentially insoluble in each other. The strenuous efforts to develop metal matrix composites with light metal matrices in the eighties have paid off with successful applications in automobile and transport systems.

Recently new materials have taken the important position in engineering field. Those materials fulfil the demand of almost all engineering applications maintaining tremendous mechanical and physical properties. In present situation, various scientists and researchers have developed the unavoidable compatible new engineering materials. Various materials have been combined with each other and give intended properties in each and every part of the world i.e. the development of new materials give another unique property and are different from their base materials. From the ancient age, this idea has been effective for mankind.

As advanced engineering materials, composites are used in many applications where high wear resistance is required; these include electrical contact brushes, cylinder liners, artificial joints, and helicopter blades. Aluminium castings have played an integral role in the growth of the aluminium industry since its inception in the late 19th century. The first commercial aluminium products were castings, such as cooking utensils and decorative parts, which exploited the novelty and utility of the new metal. Those early applications rapidly expanded to address the requirements of a wide range of engineering specifications. Casting processes were developed to extend the capabilities of foundries in new commercial and technical applications. The technology of molten metal processing, solidification, and property development has been advanced to assist the foundry man with the means of economical and reliable production of parts that consistently meet specified requirements. Today, aluminium alloy castings are produced in hundreds of compositions by all commercial casting processes, including green sand, dry sand; composite mould, plaster mould, investment casting, permanent mould, counter-gravity tow-pressure casting, and pressure die casting.

## II. WEAR TEST

For the pin-on-disk wear test, two specimens are required. One, a pin with a radiused tip, is positioned perpendicular to the other, usually a flat circular disk. A ball, rigidly held, is often used as the pin specimen. The test machine causes either the disk specimen or the pin specimen to revolve about the disk centre. In either case, the sliding path is a circle on the disk surface. The plane of the disk may be oriented either horizontally or vertically. The pin specimen is pressed against the disk at a specified load usually by means of an arm or lever and attached weights. Other loading methods have been used, such as, hydraulic or pneumatic. Wear results are reported as volume loss in cubic millimetres for the pin and the disk separately. When two different materials are tested, it is recommended that each material be tested in both the pin and disk positions.

The amount of wear is determined by measuring appropriate linear dimensions of both specimens before and after the test, or by weighing both specimens before and after the test. If linear measures of wear are used, the length change or shape change of the pin, and the depth or shape change of the disk wear track (in millimetres) are determined by any suitable metrological technique, such as electronic distance gauging or stylus profiling. Linear measures of wear are converted to wear volume (in cubic millimetres) by using appropriate geometric relations. Linear measures of wear are used frequently in practice since mass loss is often too small to measure precisely. If loss of mass is measured, the mass loss value is converted to volume loss (in cubic millimetres) using an appropriate value for the specimen density. Wear results are usually obtained by conducting a test for a selected sliding distance and for selected values of load and speed. One set of test conditions that were used in an inter laboratory measurement series. Other test conditions may be selected depending on the purpose of the test.

Wear results may in some cases be reported as plots of wear volume versus sliding distance using different specimens for different distances. Such plots may display non-linear relationships between wear volume and distance over certain portions of the total sliding distance, and linear relationships over other portions. Causes for such differing relationships include initial “break-in” processes, transitions between regions of different dominant wear mechanisms, etc. The extent of such non-linear periods depends on the details of the test system, materials, and test conditions.

Fig.1. Pin On Disk Apparatus

## III. TEST SPECIMENS

The typical pin specimen is cylindrical or spherical in shape. Typical cylindrical or cube shaped pin specimen diameter ranges from 2 to 10 mm. The typical disk specimen diameters range from 30 to 100 mm and have a thickness in the range of 2 to 10 mm. The specimen is prepared using advanced lathe machine. And the surface used for testing the wear is polished in order to remove unwanted roughness. The surface is polished using different grades of emery paper. In this test the specimen dimension is 10×10×25mm. it is a square shaped specimen. The dimension of the specimen should be in accurate otherwise it will not fit in the apparatus.

Fig.2. Specimen for Wear Test

## IV. OPERATING PARAMETRS

Sliding velocity= 1.57m/s

Distance= 4000m

Loads= 10N, 20N, 30N

Temperature= Room temperature

Dry sliding condition

## V. PROCEDURE

Immediately prior to testing, and prior to measuring or weighing, clean and dry the specimens. Take care to remove all dirt and foreign matter from the specimens. Use non chlorinated, non-film-forming cleaning agents and solvents. Steel (ferromagnetic) specimens having residual magnetism should be demagnetized. Report the methods used for cleaning.

Measure appropriate specimen dimensions to the nearest 2.5 μm or weigh the specimens to the nearest 0.0001 g.

Insert the disk securely in the holding device so that the disk is fixed perpendicular (61°) to the axis of the resolution. Insert the pin specimen securely in its holder and, if necessary, adjust so that the specimen is perpendicular (61°) to the disk surface when in contact, in order to maintain the necessary contact conditions.

Add the proper mass to the system lever or bale to develop the selected force pressing the pin against the disk.

Start the motor and adjust the speed to the desired value while holding the pin specimen out of contact with the disk. Stop the motor.

Set the revolution counter (or equivalent) to the desired number of revolutions. Begin the test with the specimens in contact under load. The test is stopped when the desired number of revolutions is achieved. Tests should not be interrupted or restarted.

Remove the specimens and clean off any loose wear debris. Note the existence of features on or near the wear scar such as: protrusions, displaced metal, discoloration, micro cracking, or spotting.

Re measure the specimen dimensions to the nearest 2.5 µm or reweigh the specimens to the nearest 0.0001 g, as appropriate. Repeat the test with additional specimens to obtain sufficient data for statistically significant results.

## VI. RESULTS AND DISCUSSION

The wear test is done by using ASTM standard G99. In pin on disc apparatus the specimen is the pin which attached to a holder and is slides on the disc. It is a computerized apparatus so the result is generated by the computer. The wear is calculated by using the following equations:

Volume loss = Height loss (microns) × Area ($mm^2$)
Wear rate = volume loss/ sliding distance (m)
Specific wear rate = wear rate/ load (N)
Wear resistance = sliding distance/ volume loss ($mm^3$)

Table I. Results of Wear Test

| Load | Specific wear rate | Wear rate | Wear resistance |
|---|---|---|---|
| N | mm3/Nm | mm3/m | m/mm3 |
| 10 | 0.001060425 | 0.01060425 | 94.30181295 |
| 20 | 0.00084155 | 0.016831 | 59.41417622 |
| 30 | 0.000711675 | 0.02135025 | 46.83785904 |
| 10 | 0.00033115 | 0.0033115 | 301.9779556 |
| 20 | 0.000281788 | 0.00563575 | 177.4386728 |
| 30 | 0.000329483 | 0.0098845 | 101.1684961 |
| 10 | 0.00025885 | 0.0025885 | 386.3241259 |
| 20 | 0.000240675 | 0.0048135 | 207.7490392 |
| 30 | 0.000278158 | 0.00834475 | 119.8358249 |
| 10 | 0.0004452 | 0.004452 | 224.6181491 |
| 20 | 0.000361975 | 0.0072395 | 138.1310864 |
| 30 | 0.000399117 | 0.0119735 | 83.51776841 |

The table shows the results of the three different composite having different graphite content. From the results the composite having 4% graphite content shows greater wear resistance comparing with the other. This is because when we are adding graphite particles, it will increases the van der wall forces between the particles. This will reduce the dislocations and thus the wear resistance increases. By using this data following graphs are plotted.

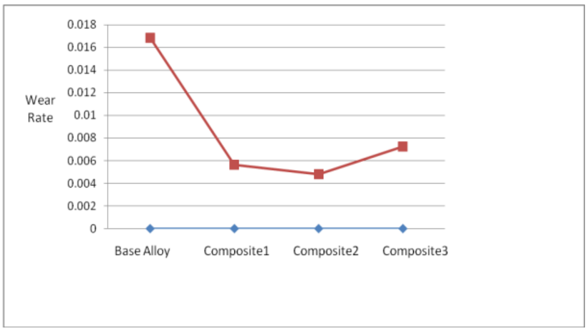


Fig. 3. Wear Rate Behaviour

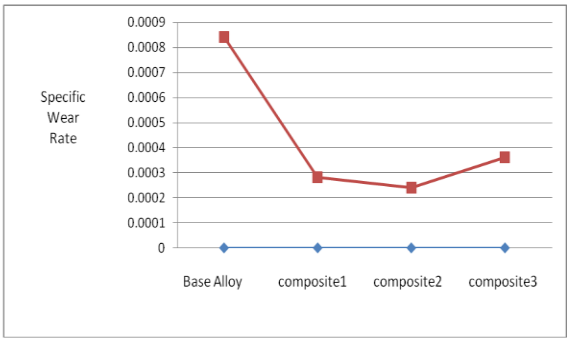


Fig.4. Specific wear Rate Behaviour

From the graph we can understand that the composite2 having graphite content 4% shows lesser wear rate compared with other. When we add 6% graphite content the wear rate increases. This is because the addition of graphite beyond a limit will reduce the bond strength between the particles. This will reduce the wear resistance. The load applied is varied that is 10N, 20N and 30N and when load increases the wear rate also increases.

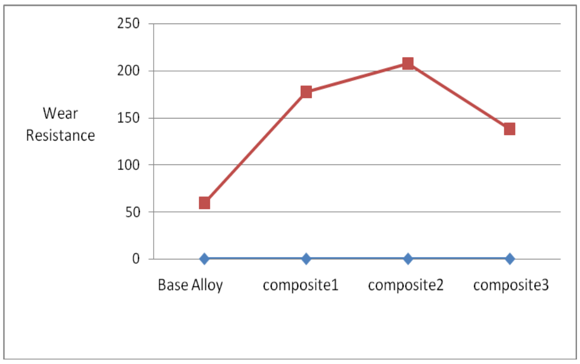


Fig.5. Wear Resistance Behaviour

## VII. SEM ANALYSIS

The SEM of the worn surface of the composite material is taken. The wear is carried out at different load and at constant velocity. The SEM will give the microscopic view of the worn surface.

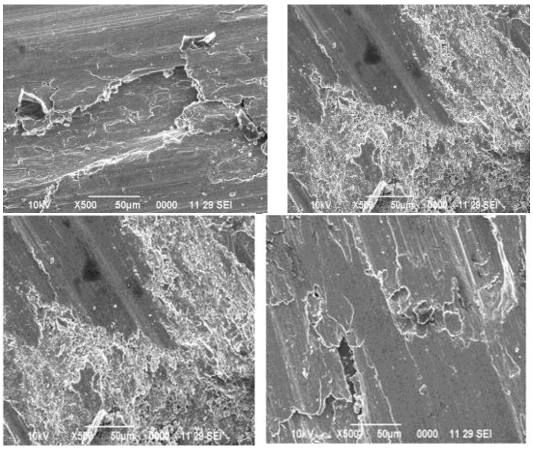

Fig.6. SEM of Worn Surfaces of Base alloy and Different Composite Material

From the SEM image we can understand that the composite3 have less wear compared to others. So the composite3 shows greater wear resistance compared to other composites. After testing the Al6063 base alloy and composites, the surface was characterised by long and continuing grooves as seen in Fig. Base alloy shows a heavily deformed surface which may be associated with Sic pick up, while the 4% Gr, MMC surface contains less scars and cracking of crater-shaped areas. The hybrid surface shows signs of discontinued grooving and possible pick up of debris. But the surface of the 6%Gr composite showed a high tendency to grooving owing to the less resistance offered by the high volume fraction of hard particulate.

From the results the composite having 4% graphite content shows greater wear resistance compared with other composite material and base alloy. This is because the graphite content in the composite will increase the van der wall force between the reinforcement materials. Due to this there will a great bond between the alloy and reinforcement. This will reduce the dislocation between the molecules. Thus the wear resistance of the material increases.

## VIII. CONCLUSION

The study of wear characteristics and mechanical properties on Al6063/SiC/Gr composite material is completed successfully. From the results it is found that the composite material having graphite content 4% shows greater wear resistance compared with other composite materials.

The main application of Al6063 is in the field where there is a greater chance of wear can takes place. So by replacing Al6063 alloy by this composite material we can reduce the wear to some extent and also we can increase life of the material.

From the experimental investigation following conclusions were drawn:

- The Al6063/SiC/Gr composite material has been successfully casted by using friction stir casting method.
- The wear resistance of the composite material increases with the addition of graphite content till 4% and then decreases.
- The increase in the wear resistance is due to the strong bond between the particles which is due to van der wall force.

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