Experimental investigation and Mechanical behaviour of SiC and Gr Reinforcement in Aluminium Matrix Composite

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Abstract

Composites possess excellent wear resistance in addition to other superior mechanical properties such as strength, modulus and hardness in comparison with conventional alloys. Metal matrix composites are being used widely to replace conventional materials in many applications, especially in the automobile and aircraft industries where the performance requirements are getting more and more demanding. Aluminium based composites have been considered as substitute materials for use in the fabrication of brake rotors, pistons, cylinder liners and cylinder heads. Of all the commercial aluminium alloys, 6061 is a popular choice a matrix material to prepare metal matrix composites. Tribological characteristics of several metal matrix composites involving glass, fly ash, SiC, Al 2O3 as discontinuous dispersoids have been reported by many researchers. Hybrid composites are better substitutes for single reinforced composites. Few investigations have been reported on the wear behavior of hybrid composites containing SiC and graphite particles as the reinforcements. In the light of the above, the present work deals with the investigation of wear resistance measured in terms of —weight loss of the aluminium matrix composites reinforced with SiC and graphite particles based on the design of experiments (DOE) techniques. The metal matrix composites were fabricated by stir casting process. Rockwell hardness measurements were made using the 'B' scale. Wear studies have been conducted using a pin-on-disc type wear test rig. A five-level central composite rotatable design was chosen for experimentation and a mathematical model was developed. The results reveal that an increase in graphite content for the same amount of SiC reduces hardness of the composite. In addition, the composite also exhibits a lower weight loss. The predicted values of the weight loss are in close agreement with the experimental ones .

Keywords: Stir Casting, Metal Matrix Composite Aluminium 7 series Alloy, Impact, Hardness, Mechanical Properties, and Microstructure.

1. INTRODUCTION:

Most common methods for the production of composites are based on casting techniques such as squeeze casting and powder metallurgy methods. On account of the excellent physical and mechanical properties of composite materials, they are applied widely in automobile technology and electronic engineering, and recently in passenger cars also The matrix material selected for the present investigation was Al 6061 silicon carbide and graphite. This alloy was chosen as the matrix, owing to its high strength and the option of modifying the strength of the composites by adopting optimal heat treatment. This alloy is mostly used for making automobile components.

2. LITERATURE REVIEW:

1. Investigation on mechanical properties of Aluminum Hybrid Composite

- Base metal : Aluminum alloy (A356.2)
- Reinforcement : Sic and RHA
- Manufacturing method : Stir casting

- The Sic amount strongly influences the mechanical properties of the composite, where the optimal amount of Sic stands at 8 wt %

2. Wear characteristics of Hybrid Aluminum Matrix composites reinforced with Graphite and Silicon Carbide particles.

- Base metal : Aluminum alloy (Al6061)
- Reinforcement : Sic and Gr (3,7.5,10 wt %)
- Manufacturing method : Stir casting
- Hybrid composite with 7.5 wt % exhibits better wear characteristics.

3. Fabrication characteristics and tribological behavior of Al/Sic/Gr Hybrid Aluminum Matrix Composite : A Review

- Base Metal : Aluminum Alloy (Al6061 and Al2024).
- Reinforcement : Sic And Gr.
- Manufacturing Method : Powder Metallurgy And Liquid Metallurgy.
- In The Variation Of 0,5 And 10 Wt.%, 5% Of Gr And 10% Of Sic Stands Optimal For Positive Mechanical Behavior And Powder Metallurgy Or Casting Method Is Preferred.

4. Effect of Sic content on the Processing, Compaction behavior, and Properties Of Al6061/Sic/Gr Hybrid Composites

- Base Metal : Aluminum Alloy (Aa6061).
- Reinforcement : Sic (0,10,20,30,40wt.%) And Gr (9wt.%).
- Manufacturing Method : Cold Pressing.
- The Wear Resistance Of The Hybrid Composite Containing 20 Vol.% Sic And 9 Vol.% Gr Is Superior.

5. Mechanical and Wear Properties of SiC/Graphite Reinforced Al359 Alloy-based Metal Matrix Composite.

- Base metal : Aluminum Alloy AL359
- Reinforcement: Si and Cp
- Manufacturing method : stir casting
- The wear test was conducted at the loading of 1 N, 3 N, and 5 N; with the velocity of 1 m/s, 1.5 m/s, 2 m/s, and 2.5 m/s and with the sliding distance of 2000 m and 2500 m.

6. Influence of silicon carbide on tribological behavior of AA2024/Al2O3/SiC/Gr hybrid metal matrix squeeze cast composite using Taguchi technique

- Base metal : Aluminum alloy AL203
- Reinforcement: Sic and Gr
- Manufacturing method : Taguchi technique
- Overall, the study indicated that the reinforcement percentage is the most influencing factor in dry sliding wear and COF. 3 wt % of SiC particulates exposed better tribological properties.
- AA2024/Al2O3/SiC/Gr reinforced composite was improved by 78% compared with AA2024/Al2O3/Gr.

7. Characterization of Aluminium – Silicon carbide metal matrix composites.

- Base Metal : Aluminum Alloy (AA 7075).
- Reinforcement : Silicon carbide.
- Manufacturing method : Stir casting (200 – 500rpm).

- As the percentage of filler material (SiC) increases, the hardness and compressive strength increases.

- Filler material added in higher percentage showing lower density.

8. Fabrications methods of particulate reinforced Aluminium metal matrix composite – A review.

- Fabrication methods used for AMMCs are of two types, solid state processing and liquid state processing.

- Stir casting is most common liquid state process. It is simple & cost effective.

- Powder metallurgy is mostly used solid state process.

It provides uniform distribution but costlier than stir casting.

9. A review on fabrication methods, reinforcements and mechanical properties of aluminum matrix composites

- Methods employed in the production of aluminum casting were Stir Casting, Squeeze Casting, Centrifugal Casting, Equal channel angular pressing, Powder metallurgy, and Gas pressure infiltration.

- Out of these methods stir casting process is economical and can be used to cast complex shapes, while another method has complications such as high set up, die manufacturing, equipment cost

3. MATERIALS AND EXPERIMENTAL WORK:

Base material Aluminium 6061, reinforcement Silicon carbide and Chromium are the materials selected for this experiment. The mechanical behaviour of the composite is observed and suitable application will be selected according to the results. Stir Casting was used to prepare the hybrid composite specimens. Aluminium 6061 was cut into small pieces, correct weight ratio is weighed and placed in the preheater. Aluminium 6061 was cut into small pieces and placed inside the crucible. The AI 6061 pieces are melted at 800°C. At this stage, the preheated silicon carbide and graphite reinforcement particles of various proportion are added to molten alloy with proper stirring process.

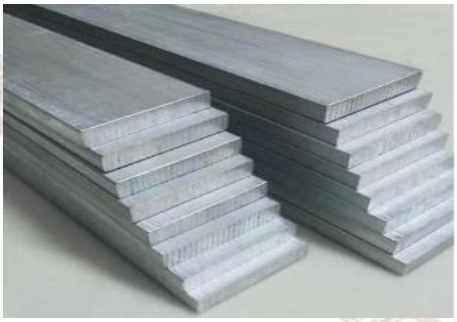


Fig 3.1 Aluminium alloy 6061

Fig 3.2 Silicon carbide powder

Fig 3.3 Graphite Powder

Fig 3.4 Stir Casting Setup

Fig 3.5 Hardness Testing Machine

COMPOSITIONS:

- **Sample 1 - Al 6061**
- **Sample 2 - Al6061 + 8% SiC + 3% Graphite**
- **Sample 3 - Al6061 + 12% SiC + 3%Graphite**
- **Sample 4 - Al6061 + 6% SiC + 4% Graphite**
- **Sample 5 - Al6061 + 10% SiC + 4%Graphite**
- **Sample 6 - Al6061 + 12% SiC + 4%Graphite**
- **Sample 7 - Al6061 + 8% SiC + 5% Graphite**
- **Sample 8 - Al6061 + 12% SiC + 5%Graphite**

Fig 3.6 Hardness Test Specimen

HARDNESS TEST:

Rockwell Hardness Test is used to find out the hardness value of the sample. The most widely used technique for determining indentation hardness is the Rockwell hardness test. Prior to applying the testing load in the Rockwell hardness test, a little minor force is applied to seat the indenter into the test piece and remove the impact of any surface defects. This results in more accuracy. A 1 kN standard load is utilized with a 1/16inch ball indenter. Wait for 30 seconds after applying the load to get the close value.

WEAR TEST:

Wear testing is a method of assessing erosion or sideway displacement of the materials. To obtain fundamental information on the mechanisms that occur in the wear of materials. In this test, the test piece is fixed to the testing machine while applying the load, RPM, and timing. The timing is constantly fixed at 6 minutes, and the wear is tear as 0 indicates. when the machine starts. The disc is rotated, and the test piece is wear during the given process. And the testing analysis and comparison of the wear is shown in the graph.

Fig 3.7 Wear Testing Machine

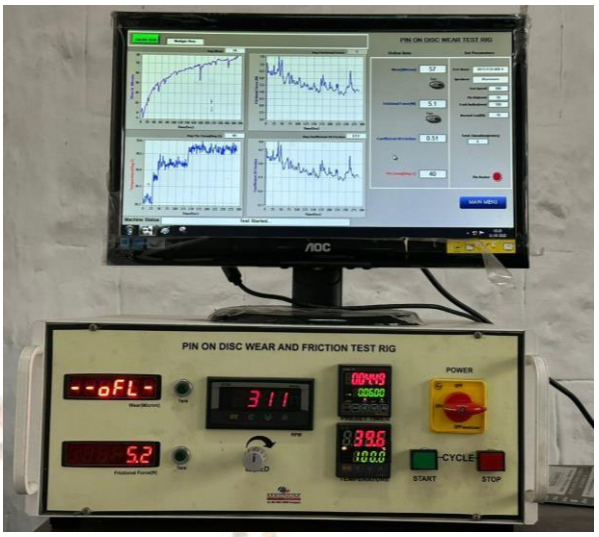


Fig 3.8 Wear graph

4. RESULTS AND DICUSSIONS:

HARDNESS: Hardness value is increased in large amount with the addition of Silicon carbide and it increases slightly according to the addition of weight percentage of Graphite. The hardness value of the composites is shown in Table 4.1.

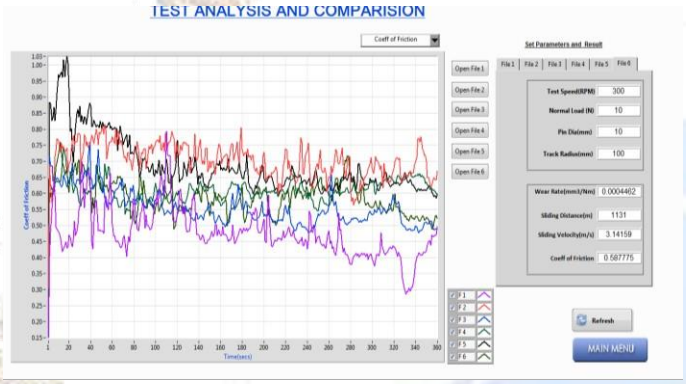
Table 4.1 Hardness value

S.No	Specimen Composition	Rockwell Hardness (HRB)
1	AL 6061	47
2	Al 6061+ 8% SiC+ 3% Graphite	67
3	Al 6061+ 12% SiC+ 3% Graphite	69
4	Al 6061+ 6% SiC+ 4% Graphite	64
5	Al 6061+ 10% SiC+ 4% Graphite	66
6	Al 6061+ 12% SiC+ 4% Graphite	65
7	Al 6061+ 8% SiC+ 5% Graphite	64
8	Al 6061+ 12% SiC+ 5% Graphite	63

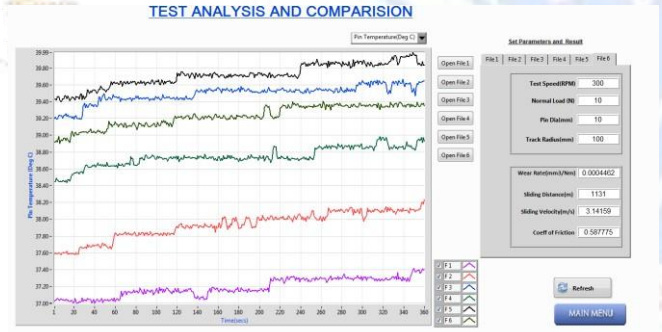
Wear:

- In this method, there will be a die of diameter 15 mm. Which will be fixed with the rotating disc.
- Then the loading capacity will be connected with the die. Which will be connected to the monitoring unit.
- The disc will be rotated according to the given RPM and time will be noted.
- By this the initial weight and final weight of the work piece will be tabulated.
- We can conclude weight loss for each component by using this wear testing machine

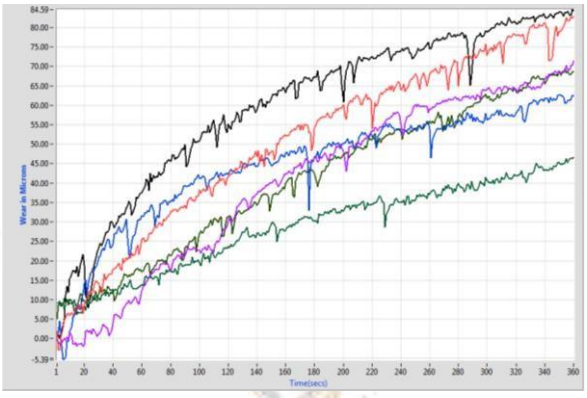
4.1 WEAR TEST COMPARISON



4.2 COF COMPARISON



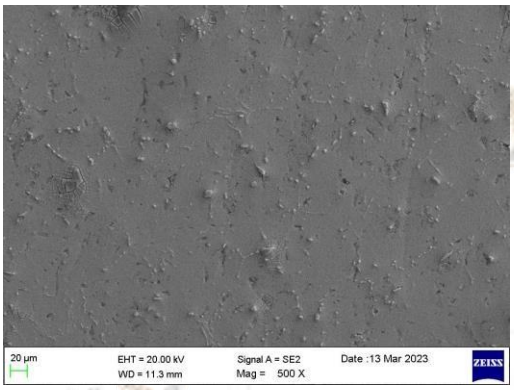
4.4 PIN TEMPERATURE COMPARISON

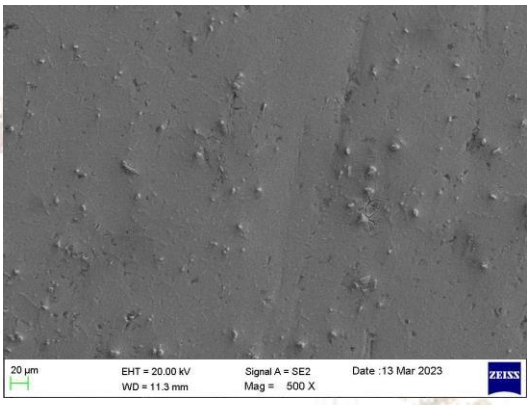


4.5 SCANNING ELECTRON MICROSCOPE (SEM ANALYSIS)

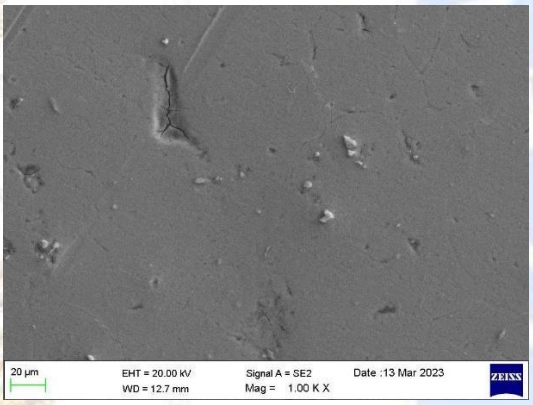
➢ SAMPLES

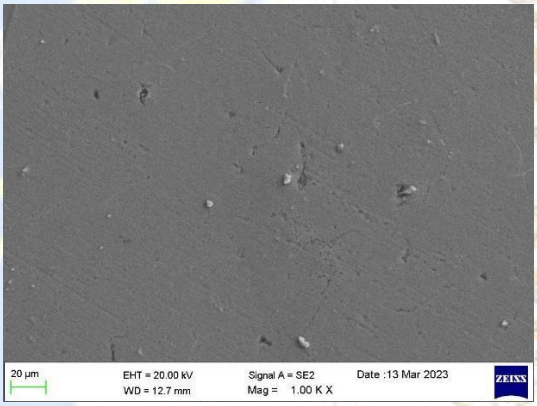
1. Al 6061+ 12% SiC+ 5% Gr





2. Al 6061+ 6% SiC+ 4% Gr





5. CONCLUSION:

SEM analysis is done for the two different samples and found that 6% of reinforcement is completely mixed with aluminium. By hardness test we can conclude that percentage of Sic is resulted in increase of hardness in the composition. By wear test results, wear resistance is improved with the addition of graphite. Therefore specimen 8 with composition (AL6061+12%Sic+5%gr) results in better wear resistance and average hardness, so specimen 8 is suitable for wear resisting parts in automobile component.

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