Abstract—Aluminum metal matrix composites are finding increased applications in many areas. Adding of the third element to the metal matrix make the composite hybrid. In this work Aluminum 7068 as matrix and Silicon Carbide and Alumina as reinforcement has been used. The %wt of reinforcement are varied to study the difference in aluminum property. Following are the samples are first sample is Al7068 with 2% SiC and 8% Al2O3, second sample consist of Al7068 with 4% SiC and 6% Al2O3, third sample consist of Al7068 with 6% SiC and 4% Al2O3 and the fourth sample is of Al7068 with 8% SiC and 2% Al2O3. The materials are obtained by stir casting technique. The casted composite specimens were machined as per ASTM standards. The aim is to study the mechanical and tribological properties of Al-7068 alloy reinforced with SiC and Al2O3 composite with various weight fractions were prepared by stir casting method.

Keywords: Al-7068 alloy, SiC, Al2O3, Stir Casting, Mechanical and Tribological properties.

I. INTRODUCTION

Composites are materials in which two phases are combined, usually with strong interfaces between them. They usually consist of a continuous phase called the matrix and discontinuous phase in the form of fibres, whiskers or particles called the reinforcement. Composite materials have been most promising material compared to conventional materials in almost all field of engineering applications. Aluminium metal matrix composites have been the subject of interest for many researchers as, the aluminium alloy overcomes the drawbacks of ferrous materials and the composite provides the desired characteristic of specific performance. MMC’s combine the metallic properties of matrix alloys (ductility and toughness) with ceramic properties of reinforcements (high strength and high modulus) and lead to higher strength in tension and compression and higher service temperature capabilities. Aluminum alloy possesses good strength to weight ratio, excellent corrosion resistance and good ductility.

Aluminium 7068 alloy is a heat treatable wrought alloy with good fatigue strength, good anodizing response, and high thermal conductivity. It was designed as a higher strength alternative to aluminium7075 for ordnance applications. It also provides the highest mechanical strength of all aluminium alloys. Alumel 7068 alloy is the strongest aluminum alloy, and comparable to that of some steels. Aluminium alloys possess many outstanding attributes that lead to a wide range of aeronautical field applications which require high strength, light mass and energy savings characteristics. At 7068 alloy is one of the most famous 7xxx series aluminum alloys which can provide high mechanical strength with alloying elements. An aluminium 7068 alloy can use in Connecting rods, Auto sport gearbox actuators, Automobile shock absorbers, Fuel pumps for racing engines, Rocker arms for racing engines, Motorcycle gears.

Silicon Carbide material is chosen as reinforcement material because it is widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plates in bulletproof vests. SiC particle-reinforced aluminium alloy composites are particularly sought after owing to their superior stiffness, strength and wear resistance. Silicon carbide has the density close to aluminium and is best for making composite having good strength and good heat conductivity. Silicon carbide (SiC), also known as carborundum, is a compound of silicon and carbon with chemical formula SiC.

Alumina material is chosen as reinforcement material because it is highly wear resistant and also has good properties such as good thermal conductivity, high strength and stiffness, excellent size and shape capability, resistance against strong acid and alkali attack at elevated temperatures and better thermal shock resistance. Aluminum oxide, commonly referred to as alumina, possesses strong ionic interatomic bonding giving rise to its desirable material characteristics. It can exist in several crystalline phases which all revert to the most stable hexagonal alpha phase at elevated temperatures.
A. Literature Survey

[1] S. Dhanasekaran et al. 2015 studied the SiC and Al₂O₃ Reinforced Aluminum Metal Matrix Composites for Heavy Vehicle Clutch Applications in which the effect of reinforcement volume fraction on microstructure and mechanical properties of the composites have been investigated. The 20% SiC and 10% Al₂O₃ reinforced composites have been identified as optimized composites for clutch pressure and face plate application.

[2] S. Senthil Murugan et al. 2017 investigated the Mechanical Properties of SiC, Al₂O₃ Reinforced Aluminum 6061-T6 Hybrid Matrix Composite were Al₂O₃ percentage (7%) constant and increasing SiC percentage (10, 15, and 20%). The main objective of the study is to compare the values obtained and choose the best composition of the hybrid matrix composite from the mechanical properties point of view and it was found that on increasing the amount of SiC into the matrix, the ceramic will develop a strong interface bond with the matrix and this bond, in turn, improves the properties of composites.

[3] S. Nallusamy et al. 2016 analysed the of Wear Resistance, Cracks and Hardness of Metal Matrix Composites with SiC Additives and Al₂O₃ as Reinforcement was made by keeping 7% of Al₂O₃ constant along with increase in 10, 15 and 20% of SiC. It was observed that, the strengthened Aluminum metal matrix in addition of SiC and Al₂O₃ decreases the range of wear rate. Also found that the coefficient of friction increased by means of raising the load and quantum of reinforcement.

[4] Sartaj et al. 2016 studied the mechanical, tribological property and wear behaviour of Al7068 alloy/alumina composite with various weight fractions (3%, 5%, 7%) were prepared by stir casting method and result of tribological properties showed that the load increases the wear rate increases. Maximum wear rate can be observed in Al7068 alloy and least wear rate is observed in As-cast alloy with 7% alumina. The decrease in wear rate may be attributed to the alumina particles which act as load bearing in the Al7068 matrix and resist wear. Due to the absence of ceramic particle as reinforcement in as-cast alloy it has a maximum wear rate.

[5] Madhusudhan et al. 2016 studied the mechanical characterization of Al7068-ZrO₂ reinforced Metal Matrix Composites were significant improvement in Hardness and Tensile strength was found with increase in Zirconium dioxide particles in weight percentage of composites. As expected, the percentage elongation diminished with increased weight percentage of reinforcement in the Aluminum matrix.

[6] Balaji et al. 2015 conducted various tests on Al7075 reinforced with SiC to know the various properties such as tensile strength, hardness and wear. From Micro structure analysis conducted on the material revealed that uniform distribution of SiC particles in the metal matrix system.

B. Problem statement and objective

With an extensive literature survey a comparatively aluminum alloy 7068 is used for the development and characterization of composites in the present work. In the present investigation Al 7068 alloy was chosen as Metal matrix material because of its wider applications for aerospace and automotive industries. It is observed that the reinforced particle can increase hardness and strength of composite. Among the manufacturing processes, the conventional stir casting is an attractive processing method for producing AMCs as it is relatively inexpensive and offers a wide selection of materials and processing conditions. At present very limited information is available on the Silicon Carbide and Alumina reinforced with Al 7068 alloy composites. Therefore the present investigation makes an attempt to synthesize the Silicon Carbide and the Alumina reinforced Al 7068 alloy composites by stir casting method. Later these composites will characterize in terms of their Mechanical and Tribological properties.

II. METHODOLOGY

A. Preparation Of Samples By Stir Casting

The matrix material used in the present experimental investigation is Al 7068 whose chemical composition (in weight %) is listed below in Table 1. For stir casting induction furnace is used. Approximately 2 Kg of Aluminum 7075 in solid was melted at 800°C in the induction furnace, and then preparing the alloy Aluminum 7068 by adding zinc metals in weight percentage. Preheating of reinforcement Silicon Carbide and Alumina was done for one hour to remove moisture and gases from the surface of the particulates. The stirrer was then lowered vertically up to 3 cm from the bottom of the crucible (total height of the melt was 9 cm). The speed of the stirrer was gradually raised to 800 rpm and the preheated reinforced particles were added with a spoon at the rate of 10-20g/min into the melt.
The speed controller maintained a constant speed of the stirrer, as the stirrer speed got reduced by 50-60 rpm due to the increase in viscosity of the melt when particulates were added into the melt. After the addition of reinforcement, stirring was continued for 5-8 minutes for proper mixing of prepared particles in the matrix. The melt was kept in the crucible for approximate half minute in static condition and then it was poured in the mould. The casted rods were rapidly cooled to room temperature.

### TABLE I
CHEMICAL COMPOSITION OF AL-7068 ALLOY (WEIGHT PERCENTAGE)

<table>
<thead>
<tr>
<th>Weight (%)</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Zr</th>
<th>others</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN</td>
<td>-</td>
<td>-</td>
<td>1.6</td>
<td>-</td>
<td>2.2</td>
<td>-</td>
<td>7.3</td>
<td>-</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>MAX</td>
<td>0.12</td>
<td>0.15</td>
<td>2.4</td>
<td>0.10</td>
<td>3.0</td>
<td>0.05</td>
<td>8.3</td>
<td>0.10</td>
<td>0.15</td>
<td>0.05</td>
</tr>
</tbody>
</table>

![Fig 2.1 Specimen](image)

### TABLE II
SAMPLE SPECIFICATION

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>AL7068 Pure</td>
</tr>
<tr>
<td>S1</td>
<td>2%SiC+8% Al₂O₃</td>
</tr>
<tr>
<td>S2</td>
<td>4%SiC+6% Al₂O₃</td>
</tr>
<tr>
<td>S3</td>
<td>6%SiC+4% Al₂O₃</td>
</tr>
<tr>
<td>S4</td>
<td>8%SiC+2% Al₂O₃</td>
</tr>
</tbody>
</table>

B. **Tensile Testing Machine**

The Tensile strength of the composite is obtained using the Universal Testing Machine. Specimen produced under the standard of ASTM E8 standards. The specimen dimensions are overall length 160mm, gauge length 50mm, grip section length 50mm, grip dia 20mm. Tensile test is used to measure the applied load and the elongation of the specimen over some distance. Tensile test are used to determine the modulus of elasticity, elastic limit, elongation, proportional limit, and reduction in area, yield strength, and yield point. Tensile properties dictate how the material will react to forces being applied in tension. A tensile test is a fundamental mechanical test where a carefully prepared specimen is loaded in a very controlled manner while measuring the applied load and the elongation of the specimen over some distance. The ultimate tensile strength (UTS) or more simply, the tensile strength is the maximum engineering stress level reached in a tension test. The strength of a material is its ability to withstand external forces without breaking. The following figure 2.2 and 2.3 shows the tensile test specimen and universal testing machine.
Fig. 2.2 Tensile test specimen

Dimensions of tensile specimen

Here the Overall length = 160mm
Gauge length = 50mm
Grip section length = 50mm
Dia = 12.5mm
Grip dia = 20mm

Fig. 2.3 Tensile Testing Machine

Fig 2.4 Tensile test specimens
C. **Brinell hardness testing machine**

Hardness is the resistance of a material to localized deformation. A hard material surface resists indentation or scratching and has the ability to indent or cut other materials. Hardness of the four stir casted samples was tested on Brinell Hardness Tester. In the Brinell hardness test, a hardened steel ball is pressed into the flat surface of a test piece using a specified force. The ball is then removed and the diameter of the resulting indentation is measured using a microscope. The Specimen used is of ASTM E10 standards. Readings on 2 locations were taken and average reading of each sample was considered.

Brinell hardness number is given by

$$BHN = \frac{2P}{\pi D (D - \sqrt{D^2 - d^2})}$$

Where,

- $P$—load in Kg
- $D$—diameter of indenter in mm
- $d$—diameter of indentation in mm

Indenter diameter: 5mm
Load applied: 250 Kgs

![Fig 2.5 Brinell hardness Tester](image)

D. **Wear Testing Machine**

Dry sliding wear tests for different number of specimens was conducted by using a pin-on-disc machine (Model: Wear & Friction Monitor TR-201 CL DST- FIRST)

![Fig 2.6 (a) Pin on disc wear testing machine](image)  ![Fig 2.6 (b) Display unit](image)
The pin was held against the counterforce of a rotating disc with wear track diameter 60 mm. The pin was loaded against the disc through a dead weight loading system. For each type of material, test were conducted at 60mm track diameter and load of (2kg) and the sliding speed of (600) rpm. The surfaces of the pin samples was slides using emery paper (80 grit size) prior to each test in ordered to ensure effective contact of fresh and flat surface with the steel disc.

**Basic specification**

Specimen standard dimension is

Length =32mm  
Diameter =10mm

**In this test**

Track dia =60mm  
Time =300sec  
Speed =600rpm  
Load =2kg

![Fig 2.7 Wear test specimens](image)

### III. RESULT AND DISCUSSION

#### A. Tensile Test

The tensile tests were conducted on these samples at room temperature using a Universal Testing Machine. The tensile testing specimen was machined according to ASTM E8 standard. The specimen dimensions are overall length 160mm, gauge length 50mm, dia 12.5mm, grip section length 50mm,grip dia 20mm. Ultimate tensile strength (UTS) or ultimate strength, is the maximum stress that a material can withstand while being pulled before necking, which is when the specimens cross-section starts to significantly contract. The repeat tests were performed for composites with different percentage of reinforcement in specimens. Table 3 shows the result of tensile tests. The graph for tensile test is shown below. Among all tested samples the specimen-S3 with composition AL7068 + 6% SiC + 4% Al₂O₃ gives better ultimate tensile i.e., 111.8 N/mm².
### TABLE III

RESULTS OF TENSILE TEST

<table>
<thead>
<tr>
<th>SL.NO</th>
<th>Sample Name</th>
<th>Composition</th>
<th>Tensile strength (Trial1)</th>
<th>Tensile strength (Trial2)</th>
<th>Tensile strength (AVERAGE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S AL7068Pure</td>
<td></td>
<td>77.052</td>
<td>80.520</td>
<td>78.786</td>
</tr>
<tr>
<td>2</td>
<td>S1 AL7068+2%SiC+8% Al2O3</td>
<td>113.421</td>
<td>100.410</td>
<td>106.915</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>S2 AL7068+4%SiC+6% Al2O3</td>
<td>86.932</td>
<td>119.220</td>
<td>103.076</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>S3 AL7068+6%SiC+4% Al2O3</td>
<td>111.941</td>
<td>111.659</td>
<td>111.8</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>S4 AL7068+8%SiC+2% Al2O3</td>
<td>93.911</td>
<td>111.906</td>
<td>102.508</td>
<td></td>
</tr>
</tbody>
</table>

**B. Hardness test**

Brinell hardness tester machine is used for the hardness measurement. Hardness test was performed on alloy composites to know the effect of silicon carbide and alumina particles in matrix material. The specimen as per ASTM E10 for brinell hardness test. The polished specimens were tested using brinell hardness tester. A load of 250Kg and indenter diameter 5mm was applied on specimens. The hardness was determined by recording the lengths of indentations produced. Table 4 shows the result of average hardness number. Among all tested samples the specimen S3 with composition AL7068 + 6% SiC + 4% Al2O3 gives brinell hardness number i.e., 107.
TABLE IV
RESULT OF HARDNESS TEST

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Composition</th>
<th>Hardness BHN (Trial1)</th>
<th>Hardness BHN (Trial2)</th>
<th>Hardness BHN (AVERAGE)</th>
<th>% Increase In Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>AL7068Pure</td>
<td>76</td>
<td>72</td>
<td>74.0</td>
<td>---</td>
</tr>
<tr>
<td>S1</td>
<td>AL7068+2%SiC+8% Al₂O₃</td>
<td>85</td>
<td>95</td>
<td>90.0</td>
<td>21.62</td>
</tr>
<tr>
<td>S2</td>
<td>AL7068+4%SiC+6% Al₂O₃</td>
<td>95</td>
<td>107</td>
<td>101.0</td>
<td>36.45</td>
</tr>
<tr>
<td>S3</td>
<td>AL7068+6%SiC+4% Al₂O₃</td>
<td>107</td>
<td>107</td>
<td>107.0</td>
<td>44.59</td>
</tr>
<tr>
<td>S4</td>
<td>AL7068+8%SiC+2% Al₂O₃</td>
<td>107</td>
<td>95</td>
<td>101.0</td>
<td>36.48</td>
</tr>
</tbody>
</table>

Fig 3.3 Average Hardness Number

Fig 3.4 Specimen after Hardness Test

C. Wear Testing

Wear is a process of material removal phenomena. When two surfaces with a relative motion interact with each other, due to friction it results in the progressive loss of material from contacting surfaces in relative motion. The prepared specimens were subjected to wear against a rotating EN-32 pin on disc under dry sliding wear testing machine. The tests were carried out at room temperature without lubrication for 300sec. In this test, track Dia = 60mm and time = 300sec are kept constant while load and speed are varied. The characteristics are determined by the comparison of the alloys for varying percentages of SiC and Al₂O₃ along with Aluminum. The results shows at 600rpm at 2kg weight, specimen S1 (AL7068+2%SiC+8% Al₂O₃) shows less wear 530μm and specimen S3 (AL7068+6%SiC+4% Al₂O₃) shows highest wear 1250μm. The table and graphs are as follows
TABLE V
RESULTS WEAR TEST

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Composition</th>
<th>Load (Kg)</th>
<th>Speed (rpm)</th>
<th>Time (sec)</th>
<th>Wear (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>AL7068Pure</td>
<td>2</td>
<td>600</td>
<td>300</td>
<td>780</td>
</tr>
<tr>
<td>S1</td>
<td>AL7068+2%SiC+8% Al₂O₃</td>
<td>2</td>
<td>600</td>
<td>300</td>
<td>530</td>
</tr>
<tr>
<td>S2</td>
<td>AL7068+4%SiC+6% Al₂O₃</td>
<td>2</td>
<td>600</td>
<td>300</td>
<td>1100</td>
</tr>
<tr>
<td>S3</td>
<td>AL7068+6%SiC+4% Al₂O₃</td>
<td>2</td>
<td>600</td>
<td>300</td>
<td>1250</td>
</tr>
<tr>
<td>S4</td>
<td>AL7068+8%SiC+2% Al₂O₃</td>
<td>2</td>
<td>600</td>
<td>300</td>
<td>830</td>
</tr>
</tbody>
</table>

Fig 3.5 Comparison of Specimen S1, S2, S3, S4

Fig 3.6 Comparison of Specimen S1, S, S3, S4
IV. CONCLUSION

From the experiments conducted to study the effects of adding various volumes fractions of SiC and Al₂O₃ to Al-7068 alloy. Following conclusions can be drawn.

1. Synthesis of Composite material AL7068 alloy reinforced with SiC and Al₂O₃ have been successfully fabricated by stir casting technique.
2. The results confirmed that stir formed Al 7068 alloy with SiC and Al₂O₃ reinforced composites is clearly superior to base Al 7068 alloy in the comparison of tensile strength and hardness.
3. The tensile strength of aluminum composite was studied and the maximum tensile strength observed was 111.8 N/mm² at 6% SiC + 4% Al₂O₃.
4. The 107 brinell hardness number which is higher for 6% SiC + 4% Al₂O₃.
5. For wear test, the testing was conducted at a speed of 600rpm and 2kg weight, specimen S1 (AL7068+2%SiC+8% Al₂O₃) shows less wear 530μm and specimen S3 (AL7068+6%SiC+4% Al₂O₃) shows highest wear 1250μm.

REFERENCES