A Study of Tribological properties and Corrosion Behavior of Short E Glass Fiber and Fly Ash Reinforced with Aluminum 7075 Composite

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Abstract:-Composite materials have been increasingly used in aerospace and automotive applications over the last two decades and have seen a dramatic increase in usage in non-aerospace products in the few years. The use of hybrid composites materials is over attractive because of their outstanding strength, stiffness and light-weight properties. An additional advantage of using hybrid composite is the ability to tailor the stiffness and strength to specific design loads. Metal Matrix Composites (MMC’s) consist of either pure metal or alloy as the matrix material, while the reinforcement generally a ceramic material. Among the MMC’s aluminum composites are predominant in use due to their low weight and high strength. Hence, it is proposed to form a new of composite. Al 7075 alloy reinforced with E-glass fiber and Fly ash particulates to form MMC’s using the graphite die for casting. The MMC is obtained from different composition of E-glass and Fly ash particulates (varying the E glass with constant Fly ash and varying fly ash with constant E-glass percentage). The test specimens are prepared as per ASTM standard size by turning and facing operations to conduct hardness, wear and corrosion tests. The test specimens are tested for hardness as per ASTM standard. Wear as per ASTM standards G99 by using dry sliding pin on disc machine. It is observed that the MMC obtained has got better hardness, wear and corrosion behavior when compared to Al 7075 alone.

Keywords: Al 7075, Fly Ash, E-Glass, Wear and Corrosion behavior and SEM

I. INTRODUCTION

Traditional materials do not always provide the necessary properties under all service conditions. Metal matrix composites (MMC’s) are advanced materials resulting from a combination of two or more materials (one of which is metal and the other a non-metal) in which tailored properties are realized. In recent years there has been a considerable interest in the use of metal matrix composites (MMC’s) due to their superior properties. Though many desirable mechanical properties are generally obtained with the fiber reinforcement, these composites exhibit an isotropic behavior and are not easily producible by conventional techniques. MMCs reinforced with E Glass and fly ash particulates tend to offer modest enhancement of properties. Among the MMCs the most metal used is aluminum reinforced with E Glass and fly ash. Generally aluminum is light weight, which is foremost requirement application and is less expensive than other light metals such as titanium and magnesium. Moreover, when a reinforcement material is added to Aluminum matrix, the properties will further enhance, thereby making it a prospective material for many light weight applications. Metal-matrix composites are either in use or prototyping for the space shuttle, commercial airliners, electronic substrates, bicycles, automobiles and a variety of other applications.

In this paper the different combination of fly ash and E glass fiber as reinforcement and matrix in Al 7075 was used with the help of simple casting technique called stir casting. Other reinforcement are also used in place of fly ash (2%,4%) and glass fiber(1%,3%,5%) in Al alloy 7075 and studied the effect of all these combination on microscopic and microscopic behavior such as wear rate, wear loss, hardness, corrosion microstructure and SEM etc.
II. EXPERIMENTAL DETAILS

A brief description of the matrix material as well as reinforcement material used in synthesis of composites as follows:

Matrix Alloy: Aluminum alloy 7075 was used as matrix synthesis of composites. The composition of the matrix alloy was analyzed and the chemical composition of the matrix alloy as given below:

<table>
<thead>
<tr>
<th>Component</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Cr</th>
<th>Zn</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>0.4</td>
<td>0.5</td>
<td>1.2-2</td>
<td>0.3</td>
<td>0.18-0.28</td>
<td>5.1-6.1</td>
<td>87.2-91.5</td>
</tr>
</tbody>
</table>

Table 1.1 Chemical Composition of Al-7075.

Reinforcements: The composition of the reinforcements analyzed and the chemical composition of the reinforcements as given below:

<table>
<thead>
<tr>
<th>Component</th>
<th>SiO₂ (%)</th>
<th>Al₂O₃ (%)</th>
<th>Fe₂O₃ (%)</th>
<th>CaO (%)</th>
<th>LOI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bituminous</td>
<td>20-60</td>
<td>5-35</td>
<td>10-40</td>
<td>1-12</td>
<td>0-15</td>
</tr>
<tr>
<td>Sub bituminous</td>
<td>40-60</td>
<td>20-30</td>
<td>4-10</td>
<td>5-30</td>
<td>0-3</td>
</tr>
</tbody>
</table>

Table 1.2 Chemical Composition of fly ash

<table>
<thead>
<tr>
<th>Component</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>CaO</th>
<th>MgO</th>
<th>B₂O₃</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>Fe₂O₃</th>
<th>F₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity in %</td>
<td>55.2</td>
<td>14.8</td>
<td>18.7</td>
<td>3.3</td>
<td>7.3</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Table 1.3 Chemical Composition of E glass fibers

A) AL Based MMC Preparation by stir casting method

A stir casting setup as shown in Figures Consisted of a resistance Muffle Furnace and a stirrer assembly was used to synthesize the composite.
An electric resistance furnace was used for melting the alloy for casting purpose. 7075 aluminum was cut into small pieces and were put into the crucible which is preheated and then it was kept for melting in the furnace. Molten metal was super-heated to 1000°C. Flux was sprinkled on the surface of the liquid metal; to prevent oxidation degassing was carried out by adding chloro ethane to remove hydrogen from the molten metal. In order to avoid void formation during solidification. The pre heated E-Glass and fly ashes were then added into the crucible and by using a mechanical stirrer it was thoroughly mixed. The temperature of the molten metal was measured (above 700°C) and then poured into the die preheated to 250°C.

B ) Wear Testing Measurements
Wear is a process of removal of material from one or both of two solid surfaces in solid contact. Dry sliding wear tests number of specimen was conducted by using a pin on disc machine supplied by DUCOM was shown in figure.

In this experiment test was conducted the following parameters
- Load
- Speed
- Time

In the present experimental, the parameters such as speed, time and Track Diameters kept constant throughout for all the experiments. These Parameters are given in Table:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>15 min</td>
</tr>
<tr>
<td>Speed</td>
<td>600rpm</td>
</tr>
<tr>
<td>Track diameter</td>
<td>80mm</td>
</tr>
</tbody>
</table>

Table 2.1 Parameters

C ) Corrosion Test:
The Corrosion test carried out using static immersion weight loss method as per standards;
D) Corrosion Models

![Corrosion Models](image)

**Figure 3: Corrosion model**

### III. RESULTS AND DISCUSSIONS

A) Effect of different reinforcements on weight loss of MMCs under dry sliding condition.

**Effect of Load on Wear Rate:**

Wear rate and wear resistance for the MMCs were obtained by:

Wear Rate: - It is defined as wear volume per unit distance travelled

\[ \text{Wear Rate} = \frac{\text{Wear Volume (mm}^3\text{) / Sliding distance (m)}}{\text{}} \]

Or

\[ \text{Wear rate} (10^{-3} \text{ mm}^3/N-m) = \text{wt. loss} \times 10^{-3} \times \pi \times \frac{d^2}{4} \times \text{load} \times S.D \times \text{time} \]

Sliding distance can be calculated as:

\[ \text{Sliding distance} = \text{Sliding Speed} \times \text{Time} \]

\[ = \left( \pi \times \frac{D \times N}{60} \right) \times t \]

Wear Volume = \( \pi \times r^2 \times h \)

Where,   
- \( D \) = Diameter of wheel track (80mm),
- \( r \) = radius of pin (6 mm),
- \( N \) = R.P.M (600),
- \( \pi \) = 3.14 (constant),
- \( V \) = Sliding Speed (2.513 m/s).
- \( t \) = time in second

Wear Resistance: - wear resistance is a reciprocal of wear rate.

\[ \text{Wear resistance} = \frac{1}{\text{wear rate}} \]

\[ (a) \]

![Wear rate vs time](image)

![Wear rate vs load](image)

**Figure 4: Wear rate vs. load and time for constant fly ash 2 % and 4%**

From the above figure 4(a) it was concluded that, as the load increases the wear rate decreases with increasing the percentage of E glass fiber.
B) Scanning Electron Microscopy (SEM) Analysis for Worn Samples at 4kg Load
The cleaned, dried and etched specimens is prepared and subsequently mounted on specially designed aluminum stubs using (holder).

![SEM micrographs](image)

(a) Figure 5: SEM of MMC with 2 wt. % Fly ash and 1 wt. % E–glass fiber at (a) 100X, (b) 500X, (c) 1000X

(b) Figure 6: SEM of MMC with 4 wt. % Fly ash and 1 wt. % E–glass fiber at (a) 100X (b) 500X, (c) 1000X

Scanning electron micrographs at lower magnification shows that the distribution of fly ash and Glass fiber throughout the MMCs. Scanning electron micrographs at higher magnification shows the particle-matrix interfaces.

The above figures show that Figure 5 and 6 shows the surface morphology of aluminum alloy 7075 with fly ash (2%, 4%) and E glass fiber (1%) composite, tested under ambient temperature with load and speed. The structures of the worn surfaces are greatly dependent on sliding speed, load and hardness of particles (reinforcement). Comparing these figures it can be visualized that one of the common features observed in all three MMCs, i.e. the formation of grooves and ridges running parallel to the sliding direction. These wear scars are the primarily characteristic of abrasive wear. On further analyzing, it has been found that grooves are fine on the worn pin surface of Al alloy 7075 with fly ash (2%, 4%) wt. as compared to others from the micrographs some cracks have appeared and these cracks are propagated in different directions. This might be due to strain hardening of aluminum based metal matrix composites with applied load and due to pulling up of hard phase particle.
From the figure 4(b) clearly indicated wear vs. time, here we concluded the as the fly ash increases the wear also increases.

C) Effect of Different Reinforcements MMC’s On Corrosion Test

![Graph](image)

**Figure 7: Corrosion rate vs. Samples number for 0.5N and 1N**

From the above graph we can conclude that as the time for corrosion increases corrosion rate decreases and as also increase in normality, corrosion rate also increases.

C) Scanning Electron Microscopy (SEM) Analysis on Corroded Specimen

![Images](image)

**Figure 8: SEM of MMC with 2 wt. % Fly ash and 1wt % E – glass fiber at (a) 100X, (b) 500X, (c) 1000X, (d) 2000X for 1Normality**

**Figure 9: SEM of MMC with 4 wt. % Fly ash and 1wt % E – glass fiber on corrosion specimen at (a) 100X, (b) 500X, (c) 1000X, (d) 2000X for 1Normality**

Scanning electron micrographs at lower magnification shows that the distribution of fly ash and Glass fiber throughout the MMCs. Scanning electron micrographs at higher magnification shows the particle-matrix interfaces for the corrosion specimen as shown in the above figure. The fly
ash content increases the corrosion increases and the corrosion rate decreases with the time as shown in the figure 7 and it clearly indicated by the SEM picture of different magnification as shown in the figures 8 and 9.

**IV CONCLUSION**

The conclusions drawn from the present investigation are as follows:

- Aluminum based metal matrix composites have been successfully fabricated by stir casting technique with fairly uniform distribution of fly ash and E-glass fiber.
- The wear rate showed the two stages of wear for all the applied loads. At the initial stage run-in wear occurred up to 1 km sliding distance and in later stage wear approaches to steady state.
- The effect of wear rate vs. load, as the fly ash composition increases the wear rate also increases and decreases with the load.
- SEM images revealed that fly ash (2%, 4%) and glass fiber (1%) particulates are fairly distributed in Aluminum alloy Matrix of worn specimen at 4kg load of different magnification.
- Test conducted to determine the corrosion rate revealed that as the time for corrosion increases corrosion rate decreases and also there is increase in normality and corrosion rate and also SEM images are revealed.

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VIII. G .Straffelini,M.Pellizzare,wear vol.256,2004 pp 754-763

IX. V.C.UVARAJA a*, N. Natarajan** Comparision on Al6061 and Al7075 Alloy With Sic And B4c Reinforcement Hybrid Metal Matrix Composites.