Evaluation of mechanical properties of Al-2618, Frit and Graphite based AMMC

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Abstract:
Composites from last few decades, shows excellent properties compared to other alloys and materials. Due to the demand and need in the fields of aerospace, automobiles, for weight, cost, quality, including the performance –hence play vital role in application fields. Several processing techniques available for fabrication of ‘Al’ – MMCs out of which stir casting method was employed by using reinforcements ,Frit and Graphite.Al-2618 with frit and graphite based composite with varying graphite by Weight in 0%, 2%, 4%, 6% and 8% and keeping constant 6% Frit experimental study was carried. The result shows excellent values for2% graphite based for tensile strength, compression strength and hardness values. The microstructures of the composites were also studied.

Keywords — MMC, Al

I. INTRODUCTION

Recent days researches mainly focuses on the development of hybrid metal matrix composites for structural applications because of their desirable combinations of mechanical characteristics. Combination of more than one reinforcement materials to a single matrix material enhances the mechanical strength, hardness and tensile properties. The present study was aimed at evaluating the physical properties of Aluminium-2618 combined with Frit and Graphite reinforcement materials. Different weight percentages of Frit and Graphite materials are fabricated using stir casting method. The fabricated materials are tested for Tensile, Hardness and Compression tests. The specimens are also tested for microstructure.

A. STIR-CASTING

It is the simplest fabrication method by casting technique – commercial, comes under liquid phase fabrication method, which also consumes lesser time compared to the solid phase and it also called as vortex or stir casting.
A. TENSION TEST

The tension test set up is shown in Fig.2. For each composition, five identical specimens were tested as per ASTM standard and average results were reported. The samples were loaded along the longitudinal direction. Load v/s elongation diagrams of the all tested specimens were recorded.

Tensile test was carried out at ambient room temperature (27°C). Tensile tests were carried out using computerized UTM with serial data transfer connection made to RS – 232 and with the data acquisition set up connected to the UTM. Tests were repeated for five times and an average values were considered and final average results were tabulated. The tensile specimens were machined as per the ASTM standard E8 as shown in Fig.3 and Fig.4 shows the prepared tensile test specimen.

B. COMPRESSION TEST:

Similar to the tensile test, compression test was carried out on the compression test prepared as per the ASTM standard E9. As per ATM E9 standard specimen diameter maintained was 20 ± 0.2mm and specimen height was 60 ± 3 mm. Fig.6 shows the geometry of compression test specimen.

C. HARDNESS TEST

The hardness tests were conducted using Vickers cum Brinell hardness testing system as per ASTM E10 -15 standards. The tests (indentations) were repeated for six Brinell indents for each specimen and average values were tabulated and plots have been drawn for all the considered categories. A test sample was ground with arrangement of emery papers down to coarse size of 600 estimated and cleaned with diamond paste of 1-2 micron size. Further the test sample was cleaned through electrolytically and etching was also done.

III. RESULTS AND DISCUSSIONS

In this section experimental results obtained for the tensile, compression and hardness tests for aluminium combined with (0-8%) graphite, and 6% frit composites. Different combinations are
described in Table 1. Additionally microstructure information was also discussed.

The weight percentage of Frit is kept constant as 6% and reinforcement Graphite is added in varying weight percentages of 2%, 4%, 6% and 8%. The specimens are prepared as per ASTM standards and tested for Tensile strength, hardness and compression strength to obtain optimum composition.

**TABLE 1: DIFFERENT COMPOSITIONS OF COMPOSITE MATERIALS**

<table>
<thead>
<tr>
<th>Type of the Specimen (Wt.%)</th>
<th>Tensile Strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-2618 + 0% Gr + 6% Frit</td>
<td>145</td>
</tr>
<tr>
<td>Al-2618 + 2% Gr + 6% Frit</td>
<td>150</td>
</tr>
<tr>
<td>Al-2618 + 4% Gr + 6% Frit</td>
<td>155</td>
</tr>
<tr>
<td>Al-2618 + 6% Gr + 6% Frit</td>
<td>160</td>
</tr>
<tr>
<td>Al-2618 + 8% Gr + 6% Frit</td>
<td>165</td>
</tr>
</tbody>
</table>

A. **Tensile Strength:**

Since all the composites exhibit brittle nature, they are evident for only a macroscopic deformation (elastic region) up to the maximum load which could be sustained by the composites and till it fails. These composites may follow linear relationship till the fracture of the composites.

From the Fig.8, it was observed that, an initial decrement was observed for plain Aluminum-2618 sample and maximum value of the tensile strength was achieved for the Aluminium with 2% Graphite, and 6% frit combination and further addition of graphite, there is a sudden fall was observed. This is because of improper/localized distribution of graphite particles in the Aluminium-2618.

Fig.5 shows the final failed / experimented tensile strength component. It is showing the brittle kind of failure of the component, addition of the graphite leading to the change in the macro and micro structural variations which leads to the change in the overall behaviour of the composites tested/prepared.

**Fig.9: Comparison of percentage of elongation values for different compositions**

Fig.9 shows the slight variation in the percentage elongation for all the materials as listed in table 1. Maximum value of elongation was recorded for Al-2618 with 6% Gr and 6% Frit – based composites and least value was seen for Al + 2% Gr + 6% Frit.

Similarly, yield stress was recorded for the same components. Maximum yield stress was recorded for Al + 2% Gr + 6% frit - composites, least value
was observed for Al + 0% Gr + 6% Frit – based composite as shown in fig.10.

![Fig.10: Comparison of yield stress values for different compositions](image)

**B. Compressive Strength**

Results of compression test are shown in, Fig 11, it was observed that compressive strength varies as graphite percentage was increased. Maximum value of compressive strength was observed for Al + 2% Gr + 6% Frit composites, least value was recorded for Al + 0% Gr + 6% Frit composites.

![Fig.11: Comparison of compressive strength values for different compositions](image)

C. **Hardness Test**

The hardness test was carried out for the hybrid composite made of aluminum, with graphite and frit with varying propositions by using 10mm ball indenter by applying 500kg of load for 30 seconds in a Brinell’s hardness tester.

![Fig.13: Comparison of hardness values for different compositions](image)

D. **Microstructure Analysis**

Especially for the Microstructure analysis, specimens were prepared by following some standard procedures and with lot of care. All the specimens to be tested were mounted in a special observed plate and then through this plate etching or surface preparation of the specimens to be tested were done. Then this plate is mounted in an analyzer to capture the Microstructure images of different magnifications.
For the Microstructure analysis, images were captured in the microscope with the maximum capacity of 500X magnification. In this study four images have been presented for all the categories discussed in the Table 1. Among four images first one is of 100X magnification for unetched specimen, second one for 100X magnification for kellers etched third and fourth one are for etched specimens with 200X and 500X magnifications respectively.

Fig.14: Microstructure Images for Al + 0% Graphite + 6% Frit composites

From Fig.14, shows the microstructure consists of eutectic silicon (flake type) dispersed in the interdendritic region and fine precipitates of impurities in the matrix of aluminum solid solution were also found along with some unwanted cavities.

Fig.15: Microstructure Images for Al + 2% Graphite + 6% Frit composites

Fig.15 shows the microstructure consists of partially modified eutectic silicon dispersed in the inter dendritic region and fine precipitates of alloying elements in the matrix of aluminum solid solution. Some cavities are also observed.

Fig.16: Microstructure Images for Al + 6% Graphite + 6% Frit composites

Fig.16 shows the microstructure consists of completely modified eutectic silicon dispersed in the inter dendritic region and fine precipitates of alloying elements in the matrix of aluminum solid solution. Some cavities are also observed.

Fig.17: Microstructure Images for Al + 4% Graphite+ 6% Frit composites

Fig.17 shows the microstructure consists of fully modified eutectic silicon dispersed in the inter dendrites region and fine precipitates of alloying elements in the matrix of aluminum solid solution.
IV. CONCLUSIONS

The conclusions drawn from the present investigation are as follows:

It is observed that Aluminium-2618 with 2% graphite particles with 6% Frit have shown tensile strength increases by 6.78% and compression increases by 9.78% poor values were recorded for the increment beyond 2% of graphite particles with 6% frit. This is because of increment in the brittleness of the specimens prepared.

It is also observed that Aluminium-2618 with 2% graphite particles with 6% Frit have shown hardness increases by 4.69% and poor values were recorded for the increment beyond 2% of graphite particles with 6% frit. This is because hardness starts decreasing due to uneven localized distribution of Frit particles in aluminum.

Increase in the graphite percentage beyond 2% to the Aluminium-2618 and 6% Frit, resulting in the decrease in the tensile strength, yield stress and percentage elongation due to the reduction in the elasticity of the Aluminum.

Microstructure results showed the presence of Graphite and Frit particles in AMMCs. This clearly shows that the reinforced Graphite and Frit particles have been distributed constantly throughout in the AMMCs, thus strengthening and resulting in good quality composite.

REFERENCES


