Synthesis and Mechanical Characterization of duel particle reinforced hybrid composites

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Abstract—

In the present work deals with the synthesis of novel. AA6351 alloy based aluminium matrix composites which have been prepared through liquid metallurgy route using alumina and graphite as reinforced materials. The developed composites and base alloy were characterized by scanning eloron microscope (SEM). The effect of dual reinforcement content on the compression strength, yield strength, tensile and hardness of the hybrid composites were examined. Scanning Electron Microscope images reveal the nearly uniform distribution of dual particles throughout the matrix. The developed composites and base alloy were characterized by scanning. The tensile tests showed that tensile load of the composites increased with increase in weight percentage of dual particles. The test results showed that the composites reinforced with 20wt% Al$_2$O$_3$/3wt% Gr reveal higher compression strength, yield strength, tensile strength and hardness compared to the pure Al matrix.

Keywords— Stirring, Compression strength, SEM, Dual particles, Aluminum matrix composites(AMCs)

INTRODUCTION

In the recent scenario increase demand for less weight and highly performing materials are exist. Such materials find their applications in structural, non-structural, marine, automobile and aerospace industries. Particulate reinforced aluminum matrix composite possesses a bunch of remarkable improved properties including high specific strength, light weight, excellent corrosion resistance and good wear resistance compared to non-reinforced matrix alloy [1-3]. Recently, various kinds of ceramic particles used as the reinforcement in aluminum matrix composites like Si$_3$N$_4$, BN, TiC, B$_4$C, Mica, TiO$_2$, SiO$_2$, ZrO$_2$, TiB$_2$, ZrB$_2$ and WC [4-6]. In the last two decades, most of the investigators have focused essentially on the study of mechanical behavior of dual particles reinforced hybrid composites. These reinforcements have high elastic modulus, superior hardness, high melting points and outstanding mechanical, physical and casting, slurry casting, squeeze casting, stir casting and in situ tribological properties [7].

Currently, a huge number of investigators employed combined hybrid dual particle reinforced aluminum matrix composites which were stated eventually in the literatures [12-15]. Gurpreet Singh [12] synthesized AA6082/SiC/B$_4$C AMCs by stir casting method and they stated an notable enhancement in the tribological and mechanical properties of the obtained composite. S. Venkat Prasat et al. [13] examined the tribological properties of AlSi10Mg/fly ash/graphite AMC synthesized by liquid metallurgy method and stated that dual particles significantly enhanced the tribological behavior of aluminum alloy. K.R. Ramkumar et al., [14] investigated the AA7075 aluminum alloy reinforced with TiB$_2$/Gr particles by in situ method and they reported that the machining and mechanical properties of the composites increase when compared to the base alloy. B. Rajeswari et al., [15] studied the influence of Al$_2$O$_3$ /SiC particles, stirring speed and processing temperature on the mechanical properties of AA7075/Al$_2$O$_3$/SiC composites. They stated that the presence of 6%Al$_2$O$_3$/6%SiC dual particles with optimum stirring speed (550 rpm) and processing temperature (750°C) provides improved mechanical properties to the composite. A very few number of work is available on the development of AA6351 aluminum alloy based MMCs by a combination of stir casting method. In the present research work, involves the different weight percentage of alumina particles and the constant weight percentage of graphite particles reinforced 6351 aluminum alloy based matrix composites were produced by a stir casting method. The mechanical and microstructural observations between the aluminum alloy and dual particles were described.
EXPERIMENTAL PROCEDURE

The Al6351 aluminum alloy was used as matrix material. The 1000 gram of AA6351 aluminium alloy was initially melted in a graphite crucible using an electrical resistance furnace. Alumina and graphite particles were preheated to 400°C and 300°C respectively. The gauged quantity of hybrid particles (4 wt.% Al₂O₃/3 wt.% Gr) was included to molten aluminum. The composite mixture was stirred frequently for five minutes at every interval of thirty minutes. Finally the molten composite was poured into a preheated die. The similar procedure was followed to get the composites to various wt % - 8, 12, 16, 20% Al₂O₃ with 3% Gr. Both the developed Composites and the base matrix alloy were subjected to compression test, hardness test, tensile test and microstructure characterization. Fig. 1 shows the photograph of stir casting setup. The samples are polished using a normal metallographic procedure. Keller’s reagent is used as an etchant and the microstructure of the specimens were observed consequently by scanning electron microscope. The macro-hardness was measured using Brinell hardness tester at a load of 500g applied for duration of ten seconds at five different locations on all samples. The compression specimens were prepared as per ASTM E9 standard. Characterization of tensile strength has been carried out using a sub-size geometry corresponding to the testing standard ASTM E8. Compression and tensile testing was carried out on the samples using the computerized universal testing machine.

III. RESULTS AND DISCUSSION

A. Microstructure of AA6351/Al₂O₃/Gr AMCs.
Microstructural examinations show the nearly uniform distribution of dual particles and also exhibit the clean, stable and clear interface between the matrix and the reinforcement. It should improve the load bearing capacity of the composites. The occurrence of dual particle content in the Al matrix alloy can quite notably modify the microstructure and the mechanical properties of the AMCs [5, 14].

**B. Hardness of AA6351/Al₂O₃/Gr AMCs**

Figure 3 illustrates the Brinell macro-hardness of AA6351/Al₂O₃/Gr composites. The hardness of AA6351/20 wt% Al₂O₃ /3 wt% Gr composite is 64BHN which is 56.09% higher than AA6351 soft matrix material. The improvement in hardness can be attributed to the nearly uniform distribution of dual hybrid particles in the matrix [17]. Moreover, the foremost reason for the escalation in hardness of the composites containing reinforcement particles is more enriched resistance against plastic deformation [5, 13, 20]. AA6351 alloy with 20 wt% of Al₂O₃/3 wt% of Gr AMCs exhibit the peak hardness.

**C. Tensile and Yield strength of AA6351/Al₂O₃/Gr AMCs**

Figure 4 illustrates the tensile and yield strength of AA6351/Al₂O₃/Gr composites. The strength of the composites increases linearly with the increase in dual particle content. The occurrence of aluminium oxide particles in these composites enriches the tensile strength and also it compensates enough against the weakening effects of graphite. The occurrence of reinforcement particles in the composite which act as an hindrance to the motion of dislocation lead to additional increment in tensile strength [16, 18]. Furthermore, the clear interface between the base matrix and the reinforcement remarkably conveys the load from the matrix alloy to the reinforcement content. Therefore the tensile strength and yield strength of the composite is enhanced.
D. Compression strength of AA6351/Al\textsubscript{2}O\textsubscript{3}/Gr AMCs

Figure 5 illustrates the effect of dual particle content on the compression strength of the composites. The compression strength has been noticed to increase with the increase in dual particles and they are significantly higher than the strength of the base matrix alloy. It could be attributed to the enhanced dislocation density caused by thermal coefficient expansion (CTE) misuit between matrix and reinforcement, which leads to improved the compression strength of the composites [16, 19].

Fig. 5. Variation of compression strength with varying content of Al\textsubscript{2}O\textsubscript{3} and 3 wt.% graphite hybrid composites.

IV. CONCLUSIONS

The mechanical behaviors of AA6351/Al\textsubscript{2}O\textsubscript{3}/Gr composites were examined and the following conclusions were obtained.

- SEM micrographs display the nearly uniform distribution of (Al\textsubscript{2}O\textsubscript{3}/Gr) dual particles in the composites.

- The compression strength, tensile strength, yield strength and the hardness are improved drastically with the increase in weight percentage of dual particles.

- AA6351 alloy with 20 wt.% Al\textsubscript{2}O\textsubscript{3}/3 wt.% Gr particle reinforced AMCs reveal the improved mechanical properties when compared to the base matrix alloy.

- The compression strength of the AMCs has been increased from 179 MPa to 258 MPa because of the increasing wt.% of reinforcing particles.

REFERENCES


