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Aluminium Metal Matrix Composite Reinforced With Glass Particulates

Madhu Kumar Y. C.[1]*, Umashankar[2]

[1]Research Scholar, Mechanical Dept., Siddaganga institute of Technology, Tumkur, India

[2]Mechanical Dept. Siddaganga Institute of Technology, Tumkur, India

Abstract – In the present work an effort has been made to prepare Al6061-Glass particulate metal matrix composite with different weight percent of reinforcements (3%, 6%, 9%, and 12%) through stir casting technique. The homogeneous dispersion of the composite and reinforced particles distribution were study by optical microscopy and XRD. The fabricated composite specimens were subjected to mechanical testing to evaluate the mechanical properties such as hardness and tensile strength using Vickers hardness and universal tensile testing instrument. It was observed from the results that the hardness increase with increase in wt% of reinforcement up to 9wt% and decreased for 12wt%. Tensile strength increased with increase in wt% of reinforcement particle up to 9wt% and decreased for 12wt%.

Keywords—Al 6061; Glass Particulate; Stir Casting; XRD; Tensile Strength; Hardness.

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1. INTRODUCTION

Metal matrix composites (MMCs) possess significantly improved mechanical properties such as hardness, young's modulus, yield strength and ultimate tensile strength. Aluminum alloys are used in many engineering applications like cylinder liners, connecting rods, due to their light weight and high strength characteristics. The aluminum matrix can be strengthened by reinforcing hard ceramic particles like Sic, Al_2O_3 and B_4C etc. several fabrication techniques have been employed for production of composites like solid state method, liquid state method and insitu process. However stir casting is most widely used preferred process to give more uniform dispersion. It is the most economical method in production of metal matrix composites. Stir casting process enhances better bonding between matrix and reinforcement. Many research work as been carried out on studies of tensile strength and hardness in MMCs containing Sic, Al_2O_3, and TiB2 as reinforcement material but use of glass particulate is very limited with the Al matrix. Glass particulate is having good hardness, wear resistance and less dense (2.53g/cc) [1, 3].

In the present work glass particulate having an average particle size of 105µ with 3% to 12wt% weight percentage added in to the molten Al6061 matrix at a temperature of 750ºc by stir casting. Further the composites prepared were subjected to evaluation of mechanical properties.

2. EXPERIMENTAL DETAILS

In the present study aluminum alloy Al6061 has been used as matrix material. The chemical composition of matrix material is as shown in table1. The glass particulate with size of 105µm and with varying weight percentage of 3, 6, 9 and 12 wt% are being used as reinforcing material for the fabrication of composites. The composites were prepared by using stir casting route. Initially Al6061 alloy ingots were charged in to graphite crucible and heated to a temperature of 750ºc. A glass particle was preheated to a temperature of 200ºc in an oven to remove the absorbed gases from the particulate. After degassing and slag removal the melt was stirred continuously with the help of stirrer to get a fine vortex. The preheated glass particulates were added in to the vortex of the molten alloy and stirring of the slurry was performed for 5-10 minutes at 250rpm to improve the distribution of the particulates in the molten Al6061 alloy. Composite mixture was poured in to preheated permanent mould at a temperature of 775ºc [4].

TABLE 1: Shows the Chemical Composition of the Al6061 Alloy

Elements	Cu	Mg	Si	Fe	Mn	Cr	Zn	Al
Wt%	0.4	1.2	0.8	0.7	0.15	0.45	0.25	Bal

From castings the samples were cut and polished as per metallographic procedure for micro structural analysis. XRD analysis was conducted to identify the presence of glass particulate in Al6061 matrix. Micro hardness test was performed on prepared composite and the alloy was measured on polished test samples using Zwick micro-Vickers hardness tester as shown in fig 1 under a load of 50 grams for 10 seconds. The tensile specimens from the fabricated composites were prepared as per ASTM E08M standard. The dimensions of the tensile specimen as shown in figure. The tensile tests were carried out using computerized universal testing machine [5].

Fig. 1. Zwick Micro Vicker's hardness testing machine

3. RESULTS AND DISCUSSION

Microstructure analysis

The optical micrographs of Al-glass particles of different weight percentage are prepared using optical microscopy. Fig 2a-d reveals the optical micrographs of the fabricated Al 6061- glass particulate. Bonding is perfect between matrix and reinforcement due to preheating of the reinforcement that the distribution of glass particles in the aluminum matrix is fairly homogeneous.

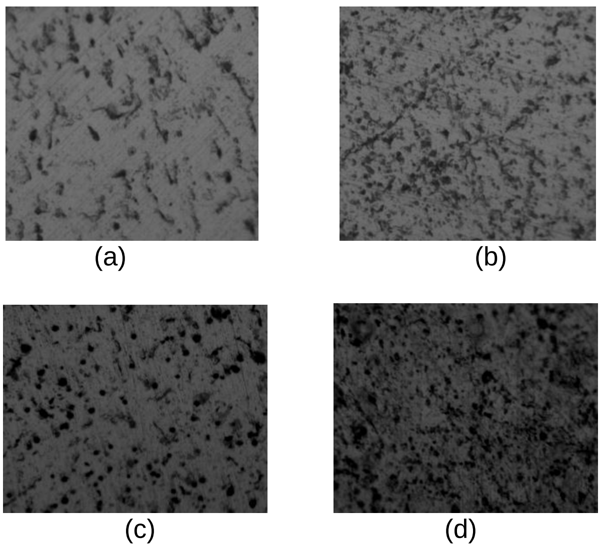

Fig. 2. Photomicrographs of the Al6061-Glass particulate MMCs (a) 3%, (b) 6%, (c) 9%, and (d) 12%.

Hardness

The average values are plotted in graph hardness versus wt% of reinforcements as shown in figure3. An average of three readings was taken for each hardness value. By increasing the amount of glass particulates by wt% the hardness of the composites increases. The hardness is increased by adding the glass particulates, as these particles are harder than Al 6061 alloy. Which render their inherent property of hardness to soft matrix. It has been observed that when percentage of glass particulates increases and increases the hardness value up to 9wt% there is a sudden decrease in hardness value. The decrease in hardness value is due to cluster formation which leads to porosity.

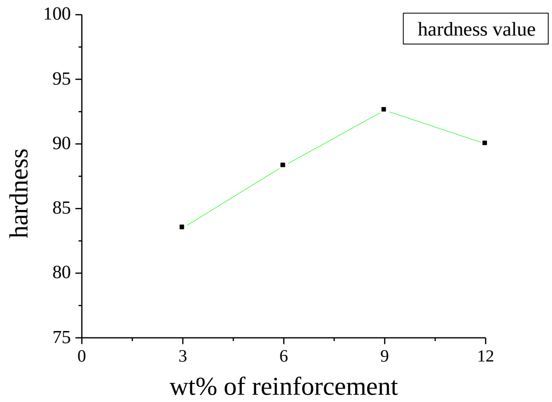

Fig. 3. Hardness versus wt% of reinforcement

Tensile strength

Figure 4 shows the value of tensile strength of the fabricated composites the tensile strength of composites is increased from 119Mpa to 158Mpa by the influence of glass particulates. The addition of glass particulate in the matrix prevents the dislocation movements. The maximum load bearing effort in the MMCs is the strengthening due to high dislocation density caused as a result of coefficient of thermal expansion difference between the matrix and reinforcement. The large difference in coefficient of thermal expansion between matrix and reinforcement gives rise to more number of dislocations in the composites. These more number of dislocations prevents the dislocation movement. Hence the tensile strength of the composites is increased. The applied stress increasing the amount of grain boundaries acts as obstacle to the dislocation movement and end up with dislocation pile up at the grain boundary region. The effect of these two obstacles leads to increase in the strength of the composite [5, 7].

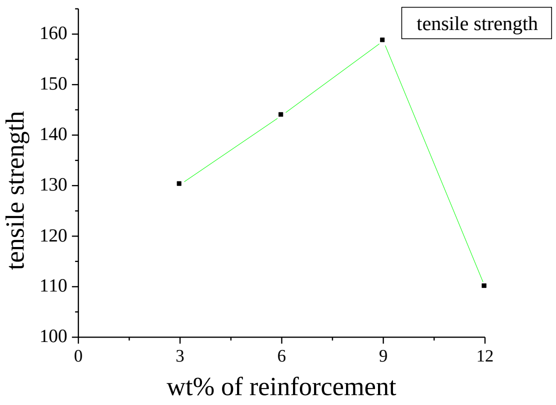

Fig. 4. variation of tensile strength of the composites with the different wt% of glass particulate

4. CONCLUSIONS

In the present investigation the Al-glass particulates composites were prepared by stir casting method with different weight percentage (3%, 6%, 9% and12%) of reinforcement and the microstructure, mechanical properties, wear properties were evaluated. Al-glass particulates composites were successfully fabricated. The microstructures studies revealed the uniform distribution of the particulates in the matrix alloy. Microhardness of the composites was increased with respect to addition of weight percentage of glass particulates up to 9wt% of glass particulates. The tensile strength of the composites has enhanced up to 9wt% of glass particulates.

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Corresponding Author

Madhu Kumar Y.C.*

Research Scholar, Mechanical Dept., Siddaganga institute of Technology, Tumkur, India

E-Mail – madhuyc3@gmail.com