Mechanical Characterization of Al 7005/S Glass/Fly Ash Hybrid Metal Matrix Composites

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Abstract- **The current work is aimed at fabricating hybrid metal matrix composites involving a unique system of matrix and reinforcement phases. The matrix phase selected for our work is Al 7005 while the reinforcement phase selected is S Glass and Fly ash. This unique combination has resulted in better properties. The compositions of reinforcements are fixed at 1% and 3% of S Glass fiber with 2% and 6% of fly ash. The results of tests carried out on Al 7005/S glass and fly ash composites for varying composition are reported in this work. The tensile strength has increased with the addition of S Glass majorly attributed to the phenomena of micro-coring and subsurface interracial bonding. While the Compression strength has also increased due the phenomena of micro-coring and agglomeration. The hardness of the specimens has increased as compared to base metal. Microstructural evaluation of the composite subsystem was done to identify the dispersion of reinforcements in the material.**

Keywords: Aluminum alloy (Al 7005), Fly ash, Hybrid Metal Matrix Composites, Mechanical properties. S Glass Fibers

1. INTRODUCTION

Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density. To overcome these shortcomings and to meet the ever increasing demand of modern day technology, composites are most promising materials of recent interest. Metal matrix composites (MMCs) possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys.

Processing of composite materials is a major drawback, however latest research has made it simple by making use of unique process methodology, Each variety of composite materials ranging from polymer matrix composites to metal matrix composites require changes in the way , the material processing takes place.

Metal matrix composites are new generation hybrid materials that are trending in the society currently, metal matrix composites are unique combinations of a metal phase namely aluminium, copper etc with reinforcements such as silicon carbide, boron carbide, alumina, S Glass fibres, E Glass fibres, Fly ash, Rice husk ash and graphite.

Metal matrix composites can be fabricated via stir casting, compo casting, and powder metallurgy route; however each process has its own advantages and disadvantages.

Hybrid composites are unique class of materials with more than one reinforcements generally used for high performance. Fly ash is used in hybrid composites for improving ductility while S Glass is used to improve tensile strength. This unique combination can enhance the properties of composites as a whole.

2. MATERIAL AND METHODS

2.1 Procurement of Material

Al 7005 alloy was procured from Fenfee metallurgical with spectroscopy and chemical analysis conducted on it to check its elemental composition and was cut into small pieces for melting it in Stir casting furnace. S Glass fibers in the form of chopped roving’s of 11 to 14 microns size were procured from Marktech composites.

C-type fly ash with fine grain structure was procured from KPCL Thermal power plant at, Shakthi nagar, Raichur District.

2.2 Identifying the Proportions of Constituent Elements

From exhaustive literature survey and discussions with experts and drawing their expertise, the composition was established and benchmarked; the composition is as shown in table – 1

Table 1: Gives the different proportions of Composites

Base Metal	S Glass %	fly ash %
Al 7005	0	0
Al7005	1	2
Al 7005	1	6
Al7005	3	2
Al7005	3	6

2.3 Fabrication of composites

The hybrid composite specimens in current research were fabricated en route stir casting process. In order to stir cast the specimens, aluminium 7005 alloy, Fly ash and S glass fibres were weighed in accordance with the weight percentage established. Aluminium 7005 alloy was initially melted in a graphite crucible in an electric resistance furnace fitter with a thermally insulated stirrer. The temperature of the system was set at 750ºC. Degassing tablets having a chemical composition of hexachloroethane (C_2Cl_6) was used to remove entrapped gases inside the molten metal.

Reinforcements were initially preheated and then added to the molten metal with constant stirring by the stirrer. The stirring is carried out for 10 minutes at constant speed in order to ensure uniform dispersion and proper mixing of the reinforcements.

The mixture of molten metal and reinforcements were then poured into the preheated mould and allowed to solidify.

After solidification, the cast metal was removed from the mould and machining was done in accordance with the required size as per ASTM standards.

2.4 Specimen preparation

The specimens were machined in accordance with the ASTM standards. The tensile test specimens were fabricated as per ASTM E8-95 standards with diameter of 12.5 mm and gauge length of 62.5 mm. The compression test specimens were fabricated as per ASTM E9 standards with diameter of 15 mm and length 20 mm. The Brinell hardness test specimens were fabricated as per ASTM E10 standards. The hardness test specimens were of diameter 15 mm and length 20 mm.

3. EXPERIMENTAL TESTS

3.1 Microstructure

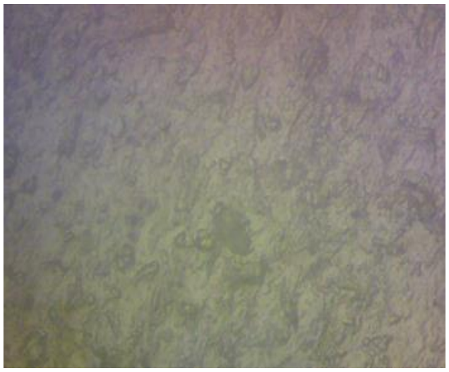

Fig 1.Microstructure of al7005 with 1% s glass and 2% flyash

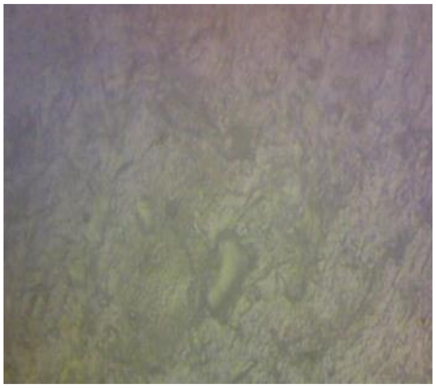

Fig 2. Microstructure of Al7005 with 1% s glass and 6% flyash

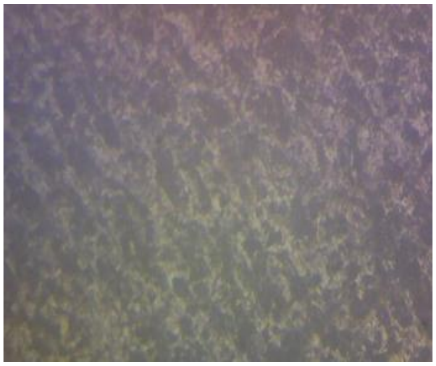

Fig 3. Microstructure of Al7005 with 3% S glass and 2% fly ash

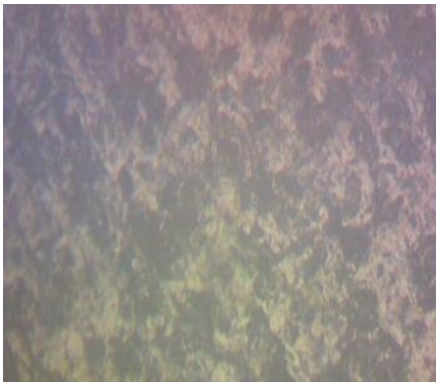

Figure 4. Microstructure of Al7005 with 3% S glass and 6% fly ash

The micro structural evaluation of the composite specimens is essential to obtain a clear understanding of the physical properties. A thorough knowledge of the microstructure will give the required information about particle dispersion, grain size, and distribution of the reinforcement in the alloy. The performance of the composite is highly influenced by its microstructure. The physical properties depend on the microstructure, reinforcement particle size, shape and distribution in the alloy. The microstructure shown gives a detailed descriptive report of dispersion of reinforcements in the matrix phase. In the micrographs uniform distribution of reinforcements in matrix was obtained by proper stirring action.

3.2 Hardness

Brinell hardness tests were carried out in accordance with ASTM E10 standards. Three readings were taken on each specimen and average of these three readings was done to obtain the final hardness value in BHN.

Fig shows the variation of Brinell hardness number for different specimens. From the figure, it is clear that the specimen with 1% S-glass and 2% Fly ash shows greater Brinell hardness number compared to other composite specimens but is lesser than as cast specimen.

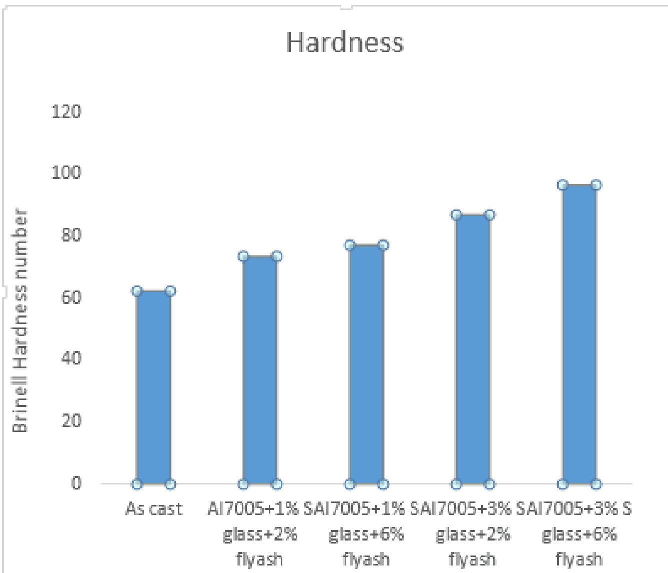

Fig 5. Variation of Brinell hardness number with varying composition of S-glass and Fly ash.

3.3 Tensile test

Tensile test was carried out as per ASTM E8-95 standards on an Instron tensile testing machine. Three specimens were fabricated for each composition and tested, the average of tensile strength values for all the three specimens were taken to authenticate the result for the specimen.

The tensile properties, such as, tensile strength and yield strength were extracted from the stress-strain curves. It is clear that ultimate tensile strength of composite having Al 7005 with 3% S-glass and 6% Fly ash is greater compared to others but it is lesser than the parental material.

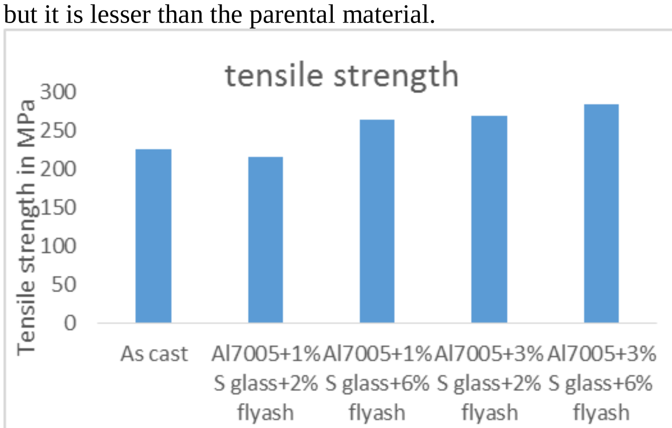

Fig 6. Variation of ultimate tensile strength with varying composition of S-Glass and Fly ash

3.4 Compression test

Compression test was carried out as per ASTM E9 standards on an Instron make Universal testing machine. Three specimens were fabricated for each composition and tested, the average of compression strength values for all the three specimens were taken to authenticate the result for the specimen.

As seen from the figure the compressive is observed to be maximum with 3% S-glass and 6% fly ash which are greater than the parental element. But by increasing the fly ash content the strength decreases. Increasing S glass composition tend to increase its compressive strength.

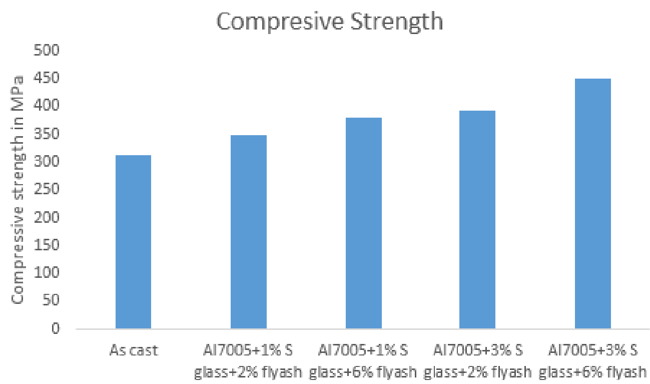

Fig 7. Variation of compressive strength with the weight fraction of S-Glass and fly ash.

CONCLUSION

Effective observation of the results obtained clearly provides an insight for drawing the following conclusions after suitable inference is drawn.

- The hardness of the specimens increased from 62.2 to 96.6 by varying the composition of S Glass and fly ash, it was found to be maximum for 3% S Glass and 6% Fly ash.
- The addition of S glass and fly ash tailored tensile strength of the hybrid composites.
- The compression strength was also enhanced due to addition of reinforcements.
- The microstructure of the specimens gave a thorough overview of uniform dispersion of S glass fibres and Fly ash particles in the Aluminium 7005 alloy.

The results are thus indicative of the fact that there is enormous improvement in the properties of the composite as compared to base metal. Henceforth it can be concluded that the hybrid composite developed yields a high performance material for its use in advanced engineering applications.

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