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DEVELOPMENT OF ALUMINIUM HYBRID METAL MATRIX COMPOSITE

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ABSTRACT

Aluminium MMCs plays vital role in the modern industrial sectors due to their excellent tribological properties. The present study involves the development of Aluminium metal matrix composite reinforced with particulate Sic and Al_2O_3 by stir casting method. Weight fraction of 7.5% of Sic, 7.5% of Al_2O_3 is reinforced with base Aluminium Alloy matrix. The fabricated aluminium alloy was solution treated and then precipitation treated for T-6 condition. Casted composite and heat treated composite machined carefully to prepare specimens for micro hardness, tensile strength and micro structure as per the ASTM standards. Mechanical properties include micro hardness; microstructure and tensile properties were evaluated for the composite before and after heat treatment. Micro hardness and tensile strength was improved by 34% and 7% by heat treatment. The micro graphs of hybrid composite studied and revealed the uniform distribution of reinforcements in the matrix. Further significant improvement in micro structure observed in heat treated hybrid composite.

Keywords: hybrid MMC's, silicon carbide sic, aluminum oxide Al_2O_3.

INTRODUCTION

In composites, Aluminium alloy based composites reinforced with particulate ceramics have great attention in automobile, transport industries, aircraft industries and variety of other applications because of their excellent corrosive resistance; wear resistance, light weight and strength. These metal alloys have good strength and ductility whereas the ceramics are stiff and brittle. The combination of properties high strength , temperature résistance, specific stiffness, specific ductility and good formability can be achieved by reinforcing ceramics Sic, Al2O3, B4C or combination of ceramics with base alloys. Proper controlling of proportion, distribution of ingredients of composite and process conditions the combined properties can be enriched. Llyod, D.J.et.al. [1] described the microstructure of Sic reinforced aluminum alloys produced by molten metal method. It was shown that stability of Sic in the variety of manufacturing processes available for melt was found to be dependent on the matrix alloy involved. K. Komaiet.al. [2] reported the superior mechanical properties Al7075-SiCw composites. T.J.A. Doel et.al. [3] reported the improved tensile strength and lower ductility of the Al7075 reinforced with 5μm and 13 μm Sic particles than that of unreinforced material. S.W. Kim et al. [4] concluded that the hardness of aged Al7075 alloy increases. R. Clark et al. [5], in their studies on Al7075 reported that, pre-aging at various retrogression temperatures improves the hardness, tensile properties and electrical resistivity.

The Stir casting is the liquid state method of casting composites, in which preheated ceramic particulates are mixed with molten metal by a mechanical stirrer. It follows the conventional method of casting and minimizes total cost of product. Hence this technique is the most economical and applicable for large quantity production of metal matrix composites. The cost of preparing composites material using a casting method is about one-third to half that of competitive methods, and for high volume production, it is projected that the cost will fall to one-tenth [6]. In general, the solidification synthesis of metal matrix composites involves producing a melt of the selected matrix material followed by the introduction of a reinforcement material into the melt, obtaining a suitable dispersion. The next step is the solidification of the melt containing suspended dispersions under selected conditions to obtain the desired distribution of the dispersed phase in the cast matrix. In preparing metal matrix composites by the stir casting method, there are several factors that need considerable attention, including the difficulty of achieving a uniform distribution of the reinforcement material, wettability between the two main substances, porosity in the cast metal matrix composites, and chemical reactions between the reinforcement material and the matrix alloy [7] The hardness and the Impact strength increases with increasing in composition percentage of Sic Also homogeneous dispersion of Sic particulates in the Aluminum matrix results an improved distribution without applying stirring process, with manual stirring process and with 2-step method of stir casting technique respectively [8]. The density, tensile strength and wear resistance improved with increase in composite percentage of Al2O3 reinforced with Al7075 [9].The hybrid Al7075 metal matrix developed by stir casting method by varying weight fraction of Al2O3 and fixed weight percentage of Sic The micro hardness and wear resistance improved by increasing weight fraction of reinforcement [10].

EXPERIMENTAL PROCEDURE

Al7075 hybrid metal matrix is fabricated by stir casting method. It is an attractive and economical casting technique which allows conventional metal processing route.

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Al 7075 melted above 850 ºC in a graphite crucible and the reinforcements were preheated up to same temperature for proper mixing. Preheated Sic and Al_2O_3 were mixed in the metal slurry mechanically and then mixed by using motorised stirrer with 600rpm at 850 ºC. The molten metal poured in preheated moulds and allowed to cool. Casted metal matrix was machined to remove cluster formation on the surface and then cut into required dimension by using fan-saw cutting machine.

The non-metallic reinforcements may not be distributed uniformly with base metal to form matrix because of their mechanical properties and results to poor strength. Stir casted Hybrid MMC further heat treated as per T-6 condition. Aluminium MMC was solution treated by heating up to 470 ºC and soaked at that temperature for two hours, further followed by rapid quenching. The quenched sample was artificially aged or precipitation hardened by soaking at 170 ºC by 24 hours. The solution treatment dissolves all the eutectic grains like Cu-Al2, Mg-Al2, Zn-Al2 and Mg2Si and on quenching it becomes super saturated solid solution with all the eutectic components. Subsequent precipitation hardening accelerates the eutectic components to precipitates all over the matrix of solid solution of base aluminium. The soaking for 24 hours saturates the precipitation of the components and strengthens the alloy both by hardness and other mechanical properties.

The chemical composition of the aluminium alloy (AL7075) includes 90.01% Aluminium, 8% silicon carbide, 8% aluminium oxide, 0.21%Chromium, 1.42% of Copper, 0.42% iron, 2.42% magnesium, 0.12% manganese, 5.4% zinc and some materials like silicon and titanium as shown in the Figure-1.

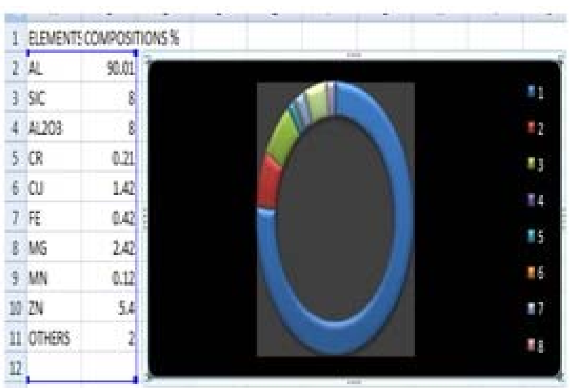

Figure-1. Composition of Al7075.

The dove tail shaped specimen was machined as per the ASTM standards for tensile testing before and after heat treatment. Figure-.2 shows the dimensions of the specimen and specimen preparation by drilling machine as shown in the Figure-3. The specimen was tested using universal testing machine of 5Ton capacity. The specimens are shown in the Figure-s after applying tensile load.

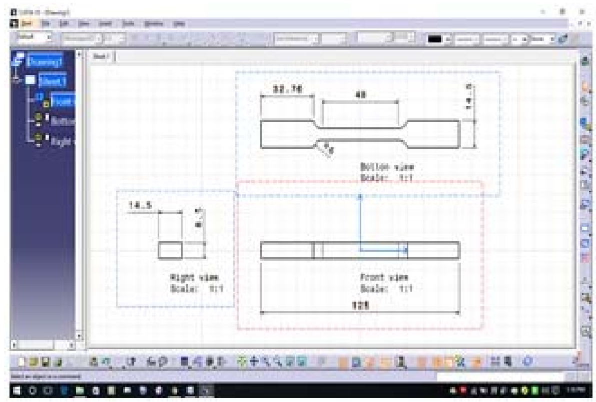

Figure-2. Dimensions for specimen.

Figure-3. Specimen preparation.

RESULTS AND DISCUSSION

Micro hardness:

Micro hardness of a substance (as an alloy) is measured by an indenter that penetrates microscopic areas and measures the hardness of the composite material aluminium alloy. The composite material was machined according to the required dimension for the micro hardness and micro structure testing. For testing of the micro hardness the dressing can be done as per the required dimension as shown in the Figure-4.

Figure-4. Specimen for tensile testing.

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The dressing can be done by means of “Backlight” which is in the form of powder by means of casting method. Micro hardness was tested for the hybrid MMC before and after heat treatment using Vickers hardness tester by applying 500g load as shown in the Figure-5. The specimen for micro hardness and the Vickers hardness tester are shown in Figure-6 and 7.

Figure-5. Specimen after testing.

Figure-6. Specimen for micro hardness.

Figure-7. Vickers hardness tester.

Homogeneous distribution of reinforcement particles resulted by heat treatment enhances the hardness of MMC. The results of micro hardness of specimens before and after heat treatment are compared in the graph as shown in the Figure-8.

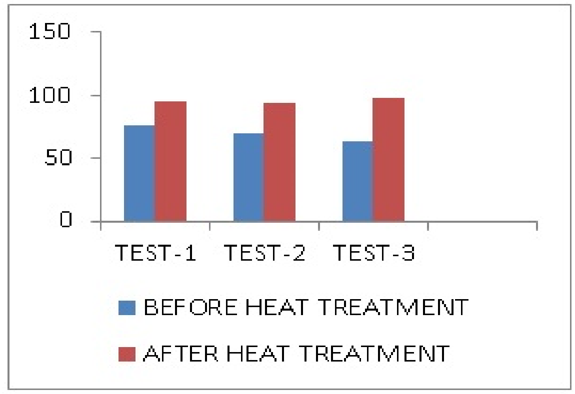

Figure-8. Hardness before and after heat treatment.

Tensile testing

Tensile test was performed to determine tensile properties of MMC including yield strength and ultimate tensile strength of the specimens at room temperature.

The graphs between load verses displacement of one specimen before and after heat treatment as shown in the Figure-9 and 10. Improved yield strength, ultimate tensile strength and elongation percentage were observed in the graph, after heat treatment.

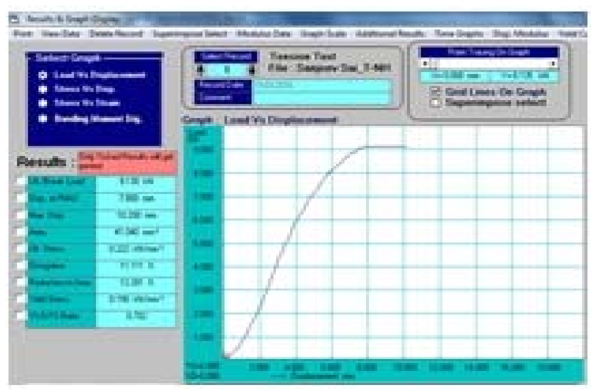

Figure-9. Load vs. Displacement before heat treatment.

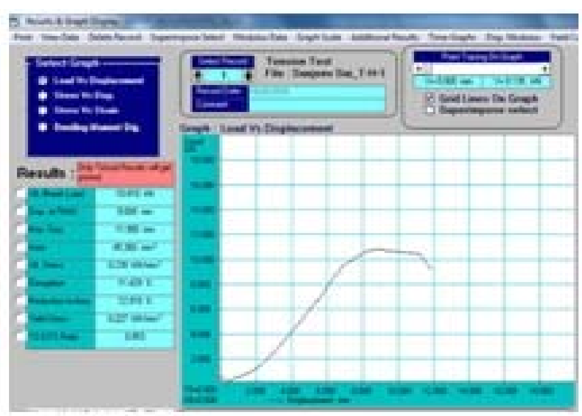

Figure-10. After heat treatment.

The microstructure of the material can strongly influence physical properties like strength, ductility, hardness, toughness, corrosion resistance and wear resistance. The specimen was polished and then followed etching of surface. Etching can be done by means of Keller reagent and H.F solution. Micro structure of a prepared surface specimens tested by inverted metallurgical microscope range of 25X -500X magnification. Micro structure of polished surface resulted cluster formation of reinforcement particles as shown in the Figure-11. Clear identification of non-metallic particles distribution in between metallic particles resulted by etching process as shown in the Figure-12. The formation of dendritic structure resulted by solidification process observed before heat treatment of composite. Sic and Al_2O_3 particles melted and mixed homogeneously by heat treatment and uniform distribution of reinforcements resulted as shown in the Figure-13 & 14.

Figure-11. Polished surface.

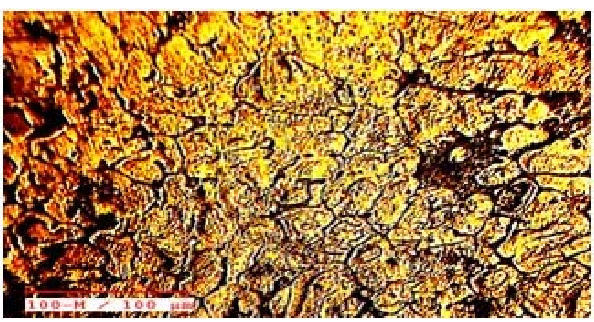

Figure-12. Etched surface.

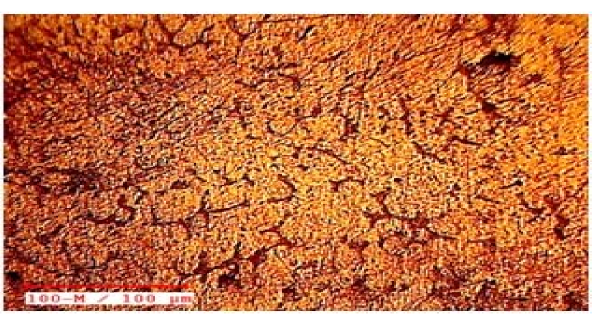

Figure-13. After heat treatment with 200X.

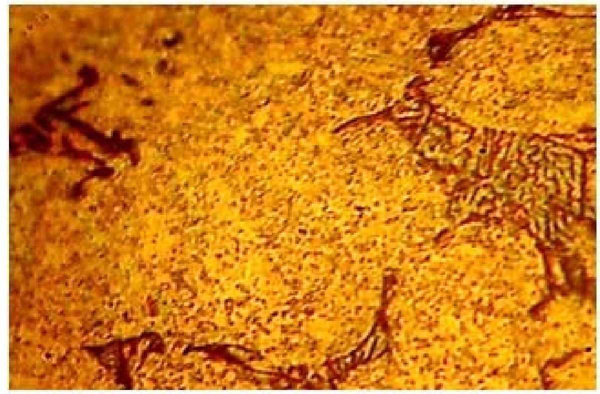

Figure-14. After heat treatment with 500X.

CONCLUSIONS

Hybrid Al7075 MMC fabricated by stir casting method effectively. The experimental study reveals the enhanced mechanical properties micro hardness, tensile strength and microstructure by heat treatment process. The micro hardness improved by adding reinforcements to the base alloy. The addition of Sic particles improved the hardness and the improved wear properties results by the addition of Al_2O_3. Further the mechanical properties enriched by heat treatment. Micro hardness and tensile strength improved by 34% and & & 7% by heat treatment process. Homogeneous mixture of the reinforcement particles with molten metal was observed in the microstructure.

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