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Fabrication and Testing of Metal Matrix Composites by Stir Casting Method

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Abstract*: Metal matrix composites (MMCs) possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. In our project we have prepared the material for automobile purpose. We have reduce the weight and corrosion of the material by using fly ash, copper and magnesium and also increase the specific strength, hardness of the material. In automobile industry they need light weight and high strength material for making the automobile parts like engine blocks, piston, cylinder liner etc., for this purpose we are using al 7075 alloy, fly ash, copper, magnesium. The basic reason of reinforce metal matrix is used to increase the strength and hardness of the composite material preparation. In this paper presentation is prepare for proportion of metal matrix composites for automobile industry.*

Index terms*- Aluminum metal matrix, Stir casting process, Reinforcement.*

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I. INTRODUCTION

Now days with the modern development need of developments of advanced engineering materials for various engineering applications goes on increasing. To meet such demands metal matrix composite is one of reliable source. Composite material is one of the reliable solutions for such requirement. In composites, materials are combined in such a way as to enable us to make better use of their parent material while minimizing to some extent the effects of their deficiencies. The simple term 'composites' gives indication of the combinations of two or more material in order to improve the properties. In the past few years, materials development has shifted from monolithic to composite materials for adjusting to the global need for reduced weight, low cost, quality, and high performance in structural materials. Driving force for the utilization of MMCs in areas of aerospace and automotive industries include performance, economic and environmental benefits. [4]

In MMC one of the constituent is aluminum, which forms percolating network and is termed as matrix phase. The other constituent is embedded in this aluminum and serves as reinforcement. These advantages can be used to achieve better properties. Mechanical properties of composites are affected by the size, shape and volume fraction of the reinforcement, matrix material and reaction at the interface. Many reports that with the increase in volume percentages of fly ash, hardness value increases in Al–fly ash (precipitator type) composites and also reports that the tensile elastic modulus of the ash alloy increases with increase in volume percent (3–10) of fly ash

We have prepared the Al7075 (copper, magnesium) particle reinforced Al MMCs, report improvement in elastic modulus, tensile strength, compressive strength and fracture properties with an increase in the reinforcement content. The interface between the matrix and reinforcement plays a critical role in determining the properties of MMCs. Stiffening and strengthening rely on load transfer across the interface.

Toughness is influenced by the crack deflection at the interface and ductility is affected by the relaxation of peak stress near the interface. Then the aluminum-fly ash, with copper and magnesium (87.6%, 5.6%, 3.4%, and 3.4%) composites were prepared by stir casting route.

II. PROCESSING OF MMC

Metal Matrix Composites are composed of a metallic matrix (aluminum, magnesium, iron, cobalt, copper) and a dispersed ceramic (oxides, carbides) or metallic (lead, tungsten, molybdenum) phase.

Metal Matrix Composites are composed of a metallic matrix (Al, Mg, Fe, Cu etc) and a dispersed ceramic (oxide, carbides) or metallic phase (Pb, Mo, W etc). Ceramic reinforcement may be silicon carbide, boron, alumina, silicon nitride, boron carbide, boron nitride etc. whereas Metallic Reinforcement may be tungsten, beryllium etc. MMCs are used for Space Shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs and a variety of other applications.

From a material point of view, when compared to polymer matrix composites, the advantages of MMCs lie in their retention of strength and stiffness at elevated temperature, good abrasion and creep resistance properties.
Most MMCs are still in the development stage or the early stages of production and are not so widely established as polymer matrix composites. The biggest disadvantages of MMCs are their high costs of fabrication, which has placed limitations on their actual applications. There are also advantages in some of the physical attributes of MMCs such as no significant moisture absorption properties, non-inflammability, low electrical and thermal conductivities and resistance to most radiations. [4]

Table 2.1 a comparative analysis of different technique used for fabrication

Method	Range of shape and size	Range of volume fraction	Damage to reinforcement	Cost
Stir casting	wide range of shapes; Larger size; up to 500 kg	Up to 0.3	No Damage	Least expansive
Squeeze casting	limited by pre form shape Up to 2cm height	Up to 0.5	severe damage	Moderate expansive
Powder metallurgy	wide range; restricted size		Reinforcement fracture	Expansive
Spray casting	Limited shape, large shape	0.3-0.7		Expansive

III. STIR CASTING

In a stir casting process, the reinforcing phases are distributed into molten matrix by mechanical stirring. Stir casting of metal matrix composites was initiated in 1968, when S. Ray introduced this system. The cast composites are sometimes further extruded to reduce porosity, refine the microstructure, and homogenize the distribution of the reinforcement.

A major concern associated with the stir casting process is the segregation of reinforcing particles which is caused by the surfacing or settling of the reinforcement particles during the melting and casting processes. The final distribution of the particles in the solid depends on material properties and process parameters such as the wetting condition of the particles with the melt, strength of mixing, relative density, and rate of solidification .The distribution of the particles in the molten matrix depends on the geometry of the mechanical stirrer, stirring parameters, placement of the mechanical stirrer in the melt, melting temperature, and the characteristics of the particles added.

An interesting recent development in stir casting is a two-step mixing process. In this process, the matrix material is heated to above its liquids temperature so that the metal is totally melted. The melt is then cooled down to a temperature between the liquids and solidus points and kept in a semi-solid state. At this stage, the preheated particles are added and mixed. The slurry is again heated to a fully liquid state and mixed thoroughly. This two-step mixing process has been used in the fabrication of aluminum. Among all the well-established metal matrix composite fabrication methods, stir casting is the most economical. For that reason, stir casting is currently the most popular commercial method of producing aluminum based composites. [3]

IV. OBJECTIVE OF THE PAPER

The main objective of the paper is to study and prepare the metal matrix composites by using fly ash, copper, magnesium (mixing ratio is 87.6%, 5.6%, 3.4%, 3.4%) which is used to reduce the weight and corrosion and also increase the strength of the material. It is very useful for make the automobile parts like engine blocks, cylinder liner, piston etc.

A. **Composite Material**

For composite material selection of Matrix and reinforcement are of prime importance. For this research work we had selected material as follows.

B. **Matrix**

Aluminium alloy 2000, 6000 and 7000 series are used for fabrication of the automotive parts.MMC under study consist of matrix material of aluminium alloy Al7075. An advantage of using aluminium as matrix material is casting technology is well established, and most important it is light weight material. Aluminium alloy is associated with some disadvantages such as bonding is more challenging than steel, low strength than steel and price is 200% of that of steel. But with proper reinforcement and treatment the strength can be increased to required level.
In our project Al7075 alloy plays major role for making composite material. The chemical composition is shown in the table

Table 3.1 Al7075 chemical composition

Al	Cr	Cu	Fe	Mg	Si	Ti	Zn
87.1-91.4	0.18-0.28	1.2-2	0.5 max	2.1-2.9	0.4max	0.2 max	5.1-6.1

Table 3.2 chemical composition of this project

Al 7075	Fly ash	Cu	Mg
87.6%	5.6%	3.4%	3.4%

C**. Reinforcement**

Particles of Al7075 alloy, fly ash, copper, magnesium are meshing used as reinforcement.

Fly ash:-Fly ash is one of the residues generated in the combustion of coal. It is an industrial byproduct recovered from the flue gas of coal burning electric power plants. Depending upon the source and makeup of the coal being burned, the components of the fly ash produced vary considerably, but all fly ash includes substantial amounts of silica (silicon dioxide, SiO2) (both amorphous and crystalline) and lime (calcium oxide, CaO). In general, fly ash consists of SiO2, Al2O3, Fe2O3 as major constituents and oxides of Mg, Ca, Na, K etc. as minor constituent. Fly ash particles are mostly spherical in shape and range from less than 1 µm to 100 µm with a specific surface area, typically between 250 and 600 m^2/kg. The specific gravity of fly ash vary in the range of 0.6-2.8 gm/cc. Coal fly ash has many uses including as a cement additive, in masonry blocks, as a concrete admixture, as a material in lightweight alloys, as a concrete aggregate, in flow able fill materials, in roadway/runway construction, in structural fill materials, as roofing granules, and in grouting. The largest application of fly ash is in the cement and concrete industry, though, creative new uses for fly ash are being actively sought like use of fly ash for the fabrication of MMCs. [2]

Cu:-It is used to reduce the corrosion of the material and Addition of copper particle has shown increase in tensile strength and it has good compatibility with aluminium alloy.

Mg:-In addition of magnesium particles which is used to reduce the corrosion and increase the reinforcement of the material.

V. PROCEDURE

First of all, 6kg of aluminium alloy was melted in a resistance heated muffle furnace and casted in a clay graphite crucible. For this the melt temperature was raised to 993K. Then the aluminium-fly ash, with copper and magnesium (87.6%, 5.6%, 3.4%, and 3.4%) composites were prepared by stir casting route. For this we took 6kg of aluminum alloy and then fly ashes were added to the Al melt for production of four different composites. The fly ash particles were preheated to 373K for two hours to remove the moisture. Commercially aluminium alloy was melted by raising its temperature to 993K. Then the melt was stirred using a mild steel stirrer. Fly-ash particles were added to the melt at the time of formation of vortex in the melt due to stirring. The melt temperature was maintained at 953K-993K during the addition of the particles. Then the melt was casted in a clay graphite crucible. The hardness testing measurement was carried out. The hardness of the samples was determined by Brinell hardness testing machine with 1500kg load and 5 mm diameter steel ball indenter.

A. **CASTING**

Casting is a manufacturing process by which a liquid material is usually poured into a mould, which contains a hollow cavity of the desired shape and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Stir casting method is also implied in the casting of the aluminum composite material in which Al7075 mixed with the other material such as Fly ash, copper and magnesium by the stirring process and the process done during the molten state of the aluminum material. Fly ash is preheated before adding with the aluminum material. When the material is heated to a certain temperature in the crucible furnace and it attains the liquid state. Then the liquid form of the material is poured into the mould cavity and the material is allowed to for solidifying inside the mould. After few minutes the material to be removed from the mould.

B. **CASTING PROCESS**

The mould cavity of the desired shape with proper allowance for shrinkage is prepared and the mould cavity is made in the circular form. After preparing the mould, the metal is melted with the acceptable quality and temperature. At the initial step, the fly ash is pre heated from 150°C to 400°C. Mainly fly ash is preheated to remove the moisture content in it. The crucible furnace is used for the heating process and the furnace is made up of graphite.

Fly ash of 5.6%, copper and magnesium of 3.4% are to be added with the Aluminum 7075 material. Initially some amount of preheated fly ash is added along with the aluminum during the start of the heating process. Then the aluminum material is heated up to 800°C in the crucible furnace. When the aluminum 7075 material reaches the molten state, the remaining amount of preheated fly ash, copper and magnesium is added to the molten state of the material inside the crucible furnace.

The experimental setup of Stir casting consists of a long stainless steel rod with the small blades at the one end and the other end of the rod is attached with the small size A.C motor. Stir casting is carried out inside the crucible furnace. After adding the preheated fly ash, copper and magnesium with the molten material of aluminum 7075 the Stir casting process is to be carried out. When the supply is given to the motor it makes the steel rod to rotate with the small blades at the end of the rod also rotates and the molten material along with the other material gets stirred and the material gets mixed well.

When the Stir casting process is done the material is mixed with each other and after that the material is heated for liquid state temperature. When the heating process is finished, then the heated composite material which is in the liquid form is poured into the mould cavity. Then the composite material is poured into all other cavities in the mould.

The heated composite material poured into the mould cavity is allowed to solidify for few minutes inside the cavity. After the few minutes of solidification the composite material gets removed from the mould. The mould which is made of sand is broken to remove the solidified composite material from the mould. Then the casted aluminum composite material to be machined for the testing

MACHINING PROCESS

When the casting process is finished then the material is to be machined for the tests such as tensile test, impact test and hardness test. The material is machined according to the requirement for the tensile test and the machined material for tensile test.

Fig 5.1 Pouring process

Fig 5.2 composite material

VI. COMPARISON REPORT FOR COMPOSITE AND LM16

A. BRINELL HARDNESS TEST

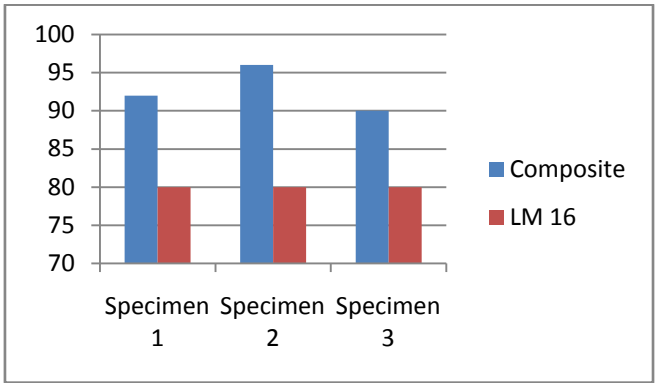

Fig 6.1 variation between composite and LM16

B. IMPACT TEST

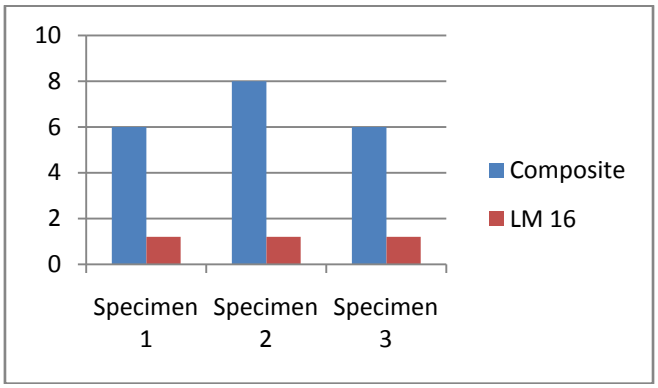

Fig 6.2 variation between composite and LM16

C. TENSILE TEST

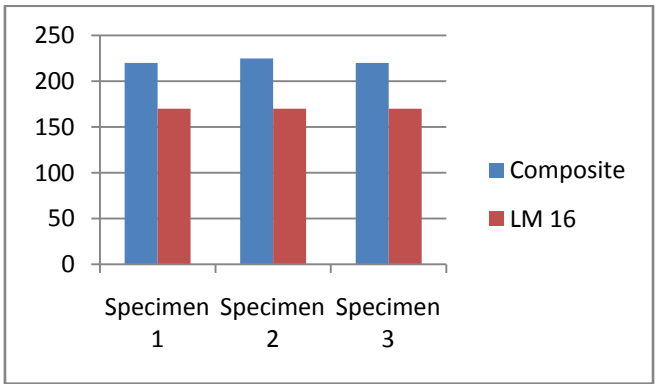

Fig 6.3 variation between composite and LM16

VII. CONCLUSION

In present study the aim is study the various operating parameter of stir casting process. And to prepare MMC with help of stir casting process. For this Aluminium (7075) is selected as matrix phase while fly ash, Cu and magnesium act as reinforcement. With the help of stir casting process we had successfully manufactured MMC at less cost. While manufacturing MMC we come to know that process parameter are platy a major role for uniform distribution of reinforcement. We had some following conclusion.

The Stir casting process is done for the material aluminum lm-6 along with fly ash, zinc then the composite material of aluminum is formed and after the casting process the material is machined. The tests such as tensile test, impact test and hardness test has been done on the material aluminum material. The result shows that there is increase in tensile strength and hardness.

Reference

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