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A review on change in mechanical properties of aluminum metal matrix composite by different reinforced particles

[1] Mandeep Singh, [2] Arvinder Singh Channi

[1] M.Tech Scholar, Department of Mechanical Engineering, Yamuna Institute of Engineering & Technology, Gadholi, Yamuna Nagar, Haryana, India

[2] Associate Prof, Department of Mechanical Engineering, Yamuna Institute of Engineering & Technology, Gadholi, Yamuna Nagar, Haryana, India

Abstract
Aluminum and its alloys are broadly used in automobile and aerospace industries due to their excellent mechanical properties, low density, high corrosion resistance and wear and low thermal coefficient of expansion. With these excellent properties and relatively low production cost Aluminum and its alloys have variety of applications in scientific and technological viewpoints.
The aim involved in present paper is to the study of behavior of Aluminum with different reinforced particles like Graphite, Alumina (Al_2O_3), SiC, fly ash, etc composites made by stir casting technique. In order to perform these tests reinforcement of different percentage is used and tests like Hardness, toughness, impact, Density and Tensile test are performed on the samples prepared by using stircasting technique
Tensile test is performed to measure the maximum elongation and reduction in area of metal matrix composites where as hardness tester is employed to evaluate the bonding between the matrix and reinforced particles with constant load and constant time. SEM XRD and EDS is performed to know the presence of reinforced Alumina particles in the metal matrix composite and elemental composition of samples respectively. The outline of the fabrication indicates that the method is relatively successful as the results clearly shows that on increasing the weight percentage of reinforcement there is an increase in hardness and tensile strength.

Keywords: aluminum alloys, reinforcement, mechanical properties, stir casting, SEM, MMC

Introduction
Composite materials are made by blending two or more materials – often ones that have very different properties. The two materials work together to give the composite unique properties. Therefore the new material formed may be preferred for many reasons such as they are light in weight, stronger, less expensive as compared to traditional materials.
Metal matrix composites (MMC) are prepared by diffusing a reinforced material into a metal matrix. Like other composites, aluminum matrix composite are not considered as a single material but a family of material whose density thermal, electrical properties and stiffness can be altered. Therefore composite materials have adjustable coefficient of thermal expansion, improved wear resistance and proper corrosion resistance. These materials are also possessed with high thermal and electrical conductivity, high temperature stability, low density, high stiffness and high strength. These properties can be attained with the proper choice of matrix and reinforcement.
Composite materials comprises of a matrix that is in solid form and reinforcement which is in powdered form. Its main purpose is to distribute and transfer load to the reinforcement and the transfer of load depends upon bonding which depends on type of matrix, type of reinforcement and fabrication technique. The matrix can be selected on the basis of oxidation and corrosion resistance or other properties. Generally Al, Ti, Ni, Cu, Mg, Pb, Fe, Ag, Zn, and Si are used as matrix material. In a composite material two materials work together to gve the composite unique properties. Therefore the new material may be preferred for many reasons such as they are light in weight, stronger, less expensive as compared to traditional materials. This is the main reason that composite materials are acquiring wide spread acceptance due to their characteristics of behavior with their high strength to weight ratio.
MMCs made components have been successfully employed in automotive, aerospace, thermal management and opto-mechanical assemblies. Presently companies like Toyota, Honda and Ford are using metal matrix composites in manufacturing driving shafts, disc brakes, engines, cylinder liners etc.

Stir casting method of fabrication
The preparation of Metal Matrix Composites involves blending of dispersed phase into a matrix metal in molten state, followed by its Solidification. In order to obtain high grade of mechanical properties of the composite, a good interfacial bonding (wetting) between the dispersed phase and the liquid matrix should be acquired. Therefore the most widely used, simplest and cost effective approach of liquid state fabrication is Stir Casting. Stir Casting is a method of composite materials fabrication, in which a dispersed phase is blend with a molten matrix metal by means of mechanical stirring. The composite material in molten state is then cast by conventional casting methods and sometimes is may also be fabricated by conventional Metal forming technology.
In stir casting the aluminium is placed in a graphite crucible and melted in a resistance furnace. When the melt is in liquid

state, the impeller is introduced in to the melt. The impeller is rotated at specified rotation to create a vortex in the melt. The reinforcement particles are introduced in to the melt through the side of the vortex formed. The vortex sucks the particle and distributes it in to the melt. The vortex method is considered to be a better known technique used to create and maintain a proper distribution of the reinforcement particles in the matrix alloy. Stirring for sometime followed by mixing is done to obtain homogeneous distribution of particles. The next step involves the solidification of the melt which contains suspended particles under desired conditions to obtain the required distribution of the dispersed phase in the cast matrix. In order to prepare metal matrix composites by the stir casting technique, there are various factors that need to be considered in attention, including

1. Porosity
2. The difficulty in achieving a uniform distribution of the reinforced material
3. Wettability between the two main materials.

Therefore present paper focuses on the review of Aluminum alloy matrix composites reinforced can be successfully fabricated by the stir casting method. The important process parameters for synthesizing of composite by stir casting process involves stirring speed and time, melting and pouring temperature, stirrer design and position, particle-preheating temperature, mould type and size, particle incorporation rate, reinforcement particle size and amount. A typical stir casting setup is shown in fig below:

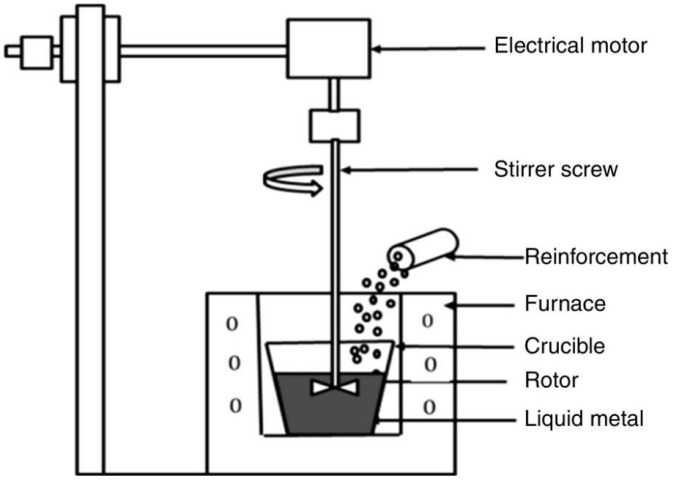

Fig 1: Stir casting setup

Amol Mali *et al*., [1] have studied the results of Al365 with alumina and fly ash as reinforcement. The varing weight %age of fly ash as well as alumina were taken as 2%, 4%, 6%, 8% and 10% by weight. After manufacturing the specimen mechanical behavior of these specimens were studied by carrying out tensile test, compression test, impact test, hardness and wear test. Aluminum matrix composites have been successfully prepared by stir casting technique with proper and fairly uniform distribution of Fly ash & Al_2O_3 particles. It is found from the mechanical testing that the hardness, tensile strength and compression strength increases with increase in weight percentage of reinforced particles but at the same time elongation of sample decreases. Therefore, from tensile test it is found UTS increases from 151.27 Mpa to 192.74 Mpa and elongation decreases from 2.2% to 0.03%. It is also observed that there is increase in compression strength from 679.91 Mpa to 796.21 Mpa and increase in hardness from 90 BHN to 94 BHN

Sharanabasappa R Patil *et al*., [2] have examined the results of an experimental study of the mechanical properties of fly ash and Alumina reinforced in aluminum alloy (LM25) composites samples, carryout by stir casting technique. The essential mechanical properties were examined the hardness test, tensile strength and ductility impact strength. It was found that the hardness & tensile strength of the aluminum alloy (LM25) composites increases with the increase in weight percentage of Al_2O_3 upto a certain limit. In addition to this if more amount of reinforcement is added then the charpy test shows decrease in impact load absorption. Therefore the prime objective of study is to fabricate the hybrid metal matrix composite successfully by using Alumina and Fly ash as particulate. The obtained results of hybrid composite are also compared with simple composite & with parent metal so that it shows significant properties. The properties like tensile strength and hardness increases from 140 Mpa to 190 Mpa and 57 BHN to 62 BHN respectively and decrease in elongation and impact strength from 7% to 2% and 5.5 kg-m to 4 kg-m respectively.

Prashant Kumar Suragimath *et al*., [3] have developed aluminum metal matrix composite and then identify its mechanical properties by using silicon carbide particulate MMCs with an aim to generate a conventional low cost method of producing MMCs. It is also utilized to obtain homogeneous dispersion of ceramic material. Aluminum alloy (LM6) and SiC, Fly Ash has been selected as matrix and reinforcement material respectively. Experiment has been conducted by varying weight percentage of Fly Ash (5% and 15%) while keeping SiC as constant(5%). The output of experiment shows that on increasing quantity of Fly Ash there is increases in Impact Strength, Tensile Strength, Wear Resistance of the specimen and decrease in the percentage of Elongation of specimen. This experimentation gives better properties of these materials such as high tensile strength, refractoriness, high hardness, wear resistance etc. which make them suitable to be used as reinforcement in MMCs.

Prasanna *et al*., [4] have done an experimental investigation of the mechanical properties of SiC, E-Glass and Red mud reinforced aluminium alloy (LM25) composites samples, processed by stir casting route are reported and analyzed. The main mechanical properties examined were the hardness, tensile strength and ductility impact strength. The key factors of MMC's are stiffness and specific strength, high electrical and thermal conductivity, excellent wear resistance. The present study aims at the development of Aluminum based Sic, E-Glass and Red mud particulate reinforced hybrid metal matrix composites. The results they obtained shows that on addition of reinforcing materials like Red mud, E-Glass and SiC the properties like tensile strength, Impact strength and reduces % Elongation were improved. But addition of E-Glass minimizes the hardness. Therefore, the new value of tensile strength is 30% more than original vale that is from 182.64 to 238.26 N/mm^2 and elongation goes on decreasing form 7% to 4%. The impact strength also shows an increase from 6.8 kg-m to 8.5 kg-m.

K.K.Alaneme *et al*., [5] has studied low cost – high performance Aluminum matrix hybrid composites along with the use of bamboo leaf ash that is agro waste ash and silicon

carbide as complementing reinforcements were investigated. The outcome of process shows that the ultimate tensile strength, hardness and percent elongation of the hybrid composites goes on decreasing with increase in bamboo leaf ash content. The fracture toughness of the hybrid composites were however is better than that of the single reinforced Al 10% by wt SiC composite. Only the 2% wt bamboo leaf ash containing hybrid composite had precise strength value as compared to that of the single reinforced composite. Also in 5% wt of NaCl solution, it was noticed that the 2% and 3% by wt of bamboo leaf ash containing hybrid composites had higher corrosion resistance in comparison to that of single reinforced Al - 10% by wt SiC composite but in case of 0.3 M H_2SO_4 solution the reverse trend was observed, where the single reinforced had improved corrosion resistance. The hardness, ultimate tensile strength and percent elongation of the hybrid composites decreased with increase in BLA content. The fracture toughness of the hybrid composites was observed to be superior to that of the single reinforced Al - 10% wt SiC composite. Therefore it is concluded that hardness and tensile strength tend to decrease by 10.94% and 23.29% respectively also specific strength decreases by 2% and elongation decreases to small extent with increase in BLA content

Prabhakar Kammer *et al*. [6] studied that the conventional monolithic materials have restrictions in achieving a good combination of toughness, high strength, high stiffness and density. In comparison to unreinforced alloys metal matrix composites (MMCs) possess significantly superior properties including good wear resistance, high specific strength, damping capacity and specific modulus. Due to the high strength and low weight th metal matrix composites of aluminum are predominant in use among all other MMC's. The key features of MMC's are specific strength and stiffness, excellent wear resistance, high electrical and thermal conductivity. The present investigation aims at the development of Aluminum based Fly ash and E-Glass particulate reinforced hybrid metal matrix composites. To conduct tensile and compression test the test specimens are prepared as per ASTM standard size by facing and turning operations. The final result shows the max increase in tensile strength from 121.98 N/mm^2 to 198.98 N/mm^2 and max increase in compressive strength from 763.61 N/mm^2 to 954.65 N/mm^2.

A.P.S.V.R. Subrahmanyam *et al*. [7] fabricated a hybrid composite with base metal aluminum alloy (AlSi10Mg) and rice husk ash and fly ash are used as reinforced particles. A rice husk ash and fly ash particles of 5, 10 and 15% each by weight are added to develop metal matrix composites using liquid metal processing route. SEM study is used to study surface morphology. On testing, it is concluded that on increase in quantity of rice husk the tensile strength of the composite is found to be decreased and is observed maximum when fly ash and rice husk ash are taken each of 10% weight. On the other hand hardness of MMC increased with increased % of RHA and decreased with increased % of Fly ash. The microstructure study shows that reinforcements in 10% each by wt. are distributed uniformly and tightly packed when compared to other combinations of reinforcements probably due to the surface formed by reinforcement combination with the matrix alloy. Therefore, more elongation is found with decrease in rice husk ash and increase in fly ash. The final results shows increase in hardness from 63 BHN to 69 BHN and ultimate tensile strength increases from 350 Mpa to 410 Mpa

Conclusion

Based on the results from the researches it is found that the mechanical properties like tensile strength, yield strength, Hardness are increasing as compare to simple composite while the percentage of reinforcement increasing. While the other end elongation gets reduced in composite as percentage reinforcement gets increased. With the help of stir casting process metal matrix composites were successfully manufactured at less cost. While manufacturing MMC's we come to know that operating parameter are partly major roles for uniform distribution of reinforcement.

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