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Effect of volume fraction (Al_2O_3) on tensile strength of Aluminium 6061 by varying stir casting furnace parameters: A Review

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Abstract - *Aluminium metal matrix composites (AMMCs) are potential materials for various applications due to their good physical and mechanical properties. The addition of reinforcements into it improves the stiffness, specific strength, wear, creep and fatigue properties compared to the conventional engineering materials and It was revealed that aluminium with reinforcement of Al_2O_3 composites have a higher tensile strength than 6061 aluminium alloy with reduced ductility. Fabrication of this metal matrix is done by stir casting technique which is one of the prominent and economical techniques for development and processing of the same. It has been found that with the increase in weight percentage of reinforcement particles in the aluminium metal matrix, the new material exhibits lower wear rate against abrasive wearing. This article is just an assessment of effect of reinforcement (Al_2O_3)on AMC's mechanical properties with various process parameters of stir casting process, such as stirrer design and it's speed, stirring temperature, stirring time (holding time) and concentration of Al_2O_3 .*

Keywords - Aluminum metal matrix composites, Stir casting process, 6061 Aluminium alloy; Al_2O_3 composites; Tensile strength.

1. INTRODUCTION:

Metal matrix composites are metals reinforced with other metal, ceramic or organic compounds. They are made by dispersing the reinforcements in the base metal matrix. Reinforcements are usually used to improve the properties of the base metal like strength, stiffness, conductivity, etc. Aluminium MMCs are broadly used in aircraft, aerospace, automobiles and various other fields. The most commonly applied reinforcements are Silicon Carbide (SiC) and Aluminium Oxide (Al_2O_3). SiC reinforcement increases the tensile strength, hardness, density and wear resistance of Aluminium and its alloys. The particle distribution plays an important role in the properties of the Al MMC and is improved by intensive shearing. Al_2O_3 reinforcement has good compressive strength and wear resistance ability.

Why Alluminium based MMC?

MMCs have certain important mechanical properties, namely higher transverse strength and stiffness, higher shear and compressive strengths and good high temperature capabilities. MMC reinforcements can be mainly divided into five major categories: continuous fibres, discontinuous fibres, whiskers, wires and particulate (including platelets). With exception of wires, same are metals, reinforcements are generally ceramics. These ceramics are oxides, carbides and nitrides which are used because of their excellent combinations of specific strength and stiffness at both ambient temperature and increased temperature.

Stir Casting:

Stir casting is a liquid state method of composite materials fabrication, in which scattered phase (ceramic particles, short fibers) is mixed with a molten metal by means of mechanical stirring. The liquid composite material is then cast by usual casting methods and may also be processed by conventional Metal forming technologies. In preparation of metal matrix composites by stir casting technique, some of determinants that needs considerable attention are as follows,

- To obtain uniform dispersion of the reinforcement material,
- To achieve binding between the two main substances,
- To minimize porosity in the cast metal matrix composite.

Process Parameters:

A) Stirrer Speed:

Stirring speed is an important parameter which promotes binding between matrix and reinforcement i.e. wettability. Stirring speed decides formation of vortex which is responsible for dispersion of particulates in liquid metal.

B) Stirring Time:

As stirring promote uniform distribution of reinforcement partials and interface bond between matrix and reinforcement, stirring time plays an essential role in stir casting method. Stirring should be optimum because less stirring leads to non-uniform distribution of particles and excess stirring forms clustering of particles at some places.

C) Concentration of Al_2O_3 :

The properties like hardness and impact strength increases with Al_2O_3 and SiC. The change in these properties is moderate for 10 percent addition of alumina and silicon-carbide and marginal changes with 15 and 20 percent. Addition of alumina and silicon-carbide improves the tensile strength of composites.

D) Reinforced Feed Rate:

Non-uniform feed rate promotes clustering of particles at some places which causes the porosity and inclusion defect, so to obtain a good quality of casting the feed rate of powder particles of reinforcement material should be steady.

E) Stirrer Design:

It is very important parameter in stir casting process which is required for vortex formation. The blade angle and quantity of blades decides the pattern of flow the liquid metal. The stirrer is immersed till two third depth of molten metal. All these are required for uniform distribution of reinforcement in liquid metal, proper interface bonding and to prevent clustering. As there are many parameters such as preheat temperature of mould and reinforcement, pouring of melt which are needed to be concentrate.

EXPERIMENTAL SETUP:

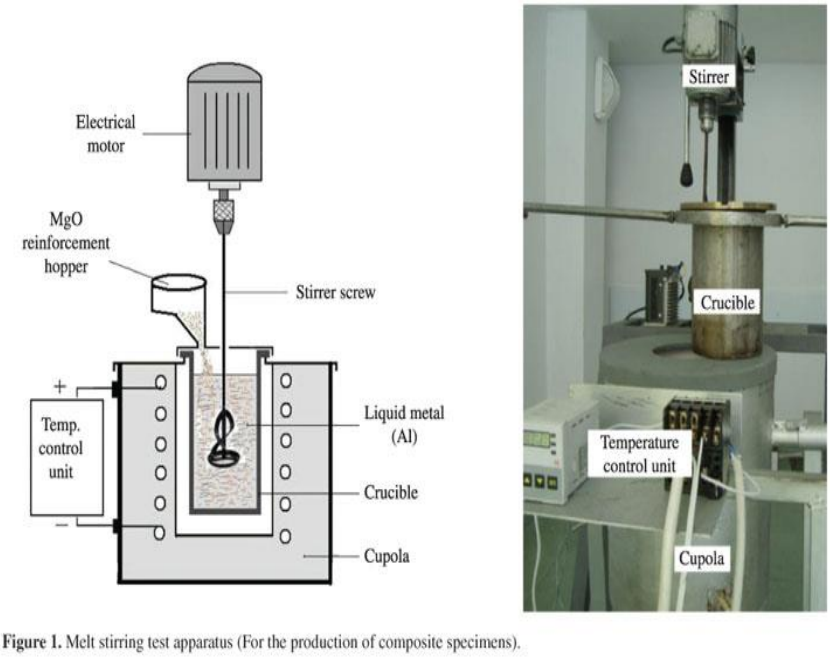

Figure 1. Melt stirring test apparatus (For the production of composite specimens).

Fig-1 Stir casting apparatus

2. LITERATURE REVIEWS:

B.Vijaya Ramnath,C. Elanchezhian, RM. Annamalai, S. Arvind, [1]"Aluminium Metal Matrix Composites – A Review"

Due to their good physical and mechanical properties, Aluminium matrix composites (AMCs) are potential materials for various applications. The addition of reinforcements into them improves the stiffness, specific strength, wear, creep and fatigue properties compared to the conventional engineering materials. This paper presents the overview of the effect of addition of different reinforcements in aluminium alloy highlighting their advantages and disadvantages. Major issues like agglomerating phenomenon, bonding of fiber-matrix and the problems related to dispersion of particles are discussed in this paper. Effect of various reinforcements on AMCs on the mechanical properties like tensile strength, strain, hardness, wear and fatigue is also discussed. Some of the important applications of various AMCs are also given in this work.

Madeva Nagaral.et al. [2] "Effect of Al_2O_3 particles on Mechanical and wear properties of" Al alloy metal matrix composites"

Researcher's attempts were carried out at Particulate reinforced aluminium matrix composites are being considered for their surpassing mechanical and tribological properties over the conventional aluminium alloys, and therefore, these composites have gained extensive applications in automotive and aerospace industries. In this investigation, the fabrication of 6061Al composites with different weight percentage of Al2O3 particles up to 0-9% was processed by liquid metallurgy route. For each composite, reinforcement particles were preheated to a temperature of 200°C and then dispersed in steps of three into the vortex of molten 6061Al alloy rather than introducing all at once, there by trying to improve wettability and distribution. Microstructural characterization was carried out for the above prepared composites by taking specimens from central portion of the casting. Microstructural characterization of the composites has exhibited fairly uniform distribution of Al_2O_3 particulates. XRD analysis revealed the presence of Al_2O_3 and other phases. The tensile strength and hardness of the resultant composites were examined. It was revealed that the 6061Al- Al_2O_3 composites have a higher tensile strength than 6061 aluminium alloy with reduced ductility. It was found that an increase in the Al_2O_3 content in 6061Al alloy contributed in enhancing the hardness of the composites. The wear test was conducted using computerized pin on disc wear tester with counter surface as EN31 steel disc (HRC60).

Khalid Almadhoni, et al. [3] "Review of Effective Parameters of Stir Casting Process on Metallurgical Properties of Ceramics Particulate Al Composites"

The low density, environment resistance and adequate mechanical and physical properties of aluminium metal matrix composites (AMMC's) make them one of the most interesting material alternatives for the manufacture of lightweight parts for many types of modern engineering equipments. Fabrication of aluminum and it's alloys based casting composite materials by stir casting is one of the prominent and economical technique for development and processing of metal matrix composites materials. The major challenges of this technique are to achieve sufficient wetting of particles by liquid metal, to get a homogeneous mixture of ceramic particles and to reduce porosity in the cast metal matrix composite. This article is just a review of stir casting for production of aluminum metal matrix composites, different process parameters of stir casting process, such as design of stirrer, stirrer speed, stirring temperature, stirring time, preheat temperature of reinforcement and mould, reinforcement feed rate, wettability-promoting agent and pouring of melt, and difficulties encountered in successful fabrication of AMMC's by stir casting technique.

T. Mohan. et al. [4] "Experimental Investigation Of Tensile and Impact Behavior Of Aluminium Metal Matrix Composite For Turbocharger"

In this study, recent developments in material technology help to find and fabricate new materials which may take the place of existing materials for various applications. Among those, composite materials play an important role which is combination of two or more materials with distinct physical and chemical properties. This work focuses on developing an Aluminium metal matrix composite (AMMC) material for turbocharger components made by wrought aluminium alloy with different weight fractions of aluminium oxide which makes five different forms of composites. This work uses stir casting process. The fabricated composites are tested for their tensile and impact properties. The result shows that composite with higher percentage of aluminium oxide has high tensile strength than other composites.

D. Sujan, Et . al [5] "Physio-mechanical Properties of Aluminium MetalMatrix Composites Reinforced with Al2O3 and SiC"

Particulate reinforced metal matrix composites (MMCs) are potential materials for various applications due to their beneficial physical and mechanical properties. This paper presents a study on the performance of stir cast Al_2O_3 and SiC reinforced metal matrix composite materials. The results shows that the composite materials exhibit improved physical as well as mechanical properties, such as, low coefficient of thermal expansion, high ultimate tensile strength, high impact strength, and hardness. It has been found that with the increase in weight percentage of reinforcement particles in the aluminium metal matrix, the new material exhibits lower wear rate against abrasive wearing. Being extremely lighter than the conventional gray cast iron material, theAl-Al_2O_3 and Al-SiC composites could be potential green materials for various applications in the automobile industry, for instance, in making car disc brake rotors.

Ajit Kumar Senapati. Et al. [6] "Experimental Study on Mechanical Properties of Aluminium Alloy Reinforced With Silicon Carbide and Fly Ash, Hybrid Metal Matrix Composites"

Aluminium based metal matrix composites (MMCS) are advanced materials, which are having the properties of high specific strength and modulus, greater resistance, high elevated temperature and low thermal expansion coefficient. These composites are widely used in industries like aerospace, defense, automobile. The composites are fabricated using stir casting process and mechanical and metallurgical properties of aluminum alloy LM6 metal matrix composite are investigated. The composite exist of aluminum alloy LM6 reinforced with silicon carbide and fly ash accordingly. Mechanical properties such as tensile, hardness, and compression test of the sample are measured. The results of the research work reveals that the proposed hybrid composites are compared with Al-Si Alloy based metal matrix composites at corresponding values of test parameters.

Mr. Ravindra Mamgain. Et. al [7] "Effect of Volume fraction (Al_2O_3+SiC)p on the Mechanical properties of Al (6061) Hybrid Metal Matrix Composite"

The present work deals with the Effect of Volume fraction (Al2O3+SiC) on the mechanical properties of Al (6061). Hybrid metal matrix composite using aluminum alloy Al 6061 as matrix and alumina, silicon-carbide as a reinforcing material prepared by using stir casting process. The alumina and silicon-carbide amounts varied as 10, 15, and 20 percent by volume. The mechanical properties like hardness, tensile strength, and impact strength have been investigated. On addition by volume percent of alumina and silicon-carbide, the effect on mechanical properties has been examined. The properties like hardness and impact strength increases with Al2O3 and SiC. The change in these properties is moderate for 10 percent addition of alumina and silicon-carbide and marginal changes with 15 and 20 percent. Addition of alumina and silicon carbide increases tensile strength of composite.

Chennakesava Reddy.et al. [8] "Tensile Behaviour Of 6063/ Al_2O_3 particulate metal matrix composites fabricated by investment casting process"

The use of investment casting process has been studied to prepare Al6063/ Al_2O_3 metal matrix composites. The tensile properties have been investigated. The EDS report confirms the presence of Al5Cu2Mg8Si6, Al4CuMg5Si4 and Mg2Si compounds in the 6063/ Al_2O_3composites. The yield strength and fracture strength increases with increase in volume fraction of Al_2O_3, whereas ductility decreases. The ductile fracture is observed in 10% volume fraction composite and the brittle fracture is observed in 20% and 30% volume fraction composites.

3. CONCLUSION:

It has been found from literature reviews, that aluminium based metal matrix composites have been successfully fabricated using stir casting method by three step addition of reinforcement combined with preheating of particulates and the increase in volume fraction of Al_2O_3 which decreases the fracture toughness of the aluminium metal matrix composites(AMMC). Al_2O_3 SiC reinforced aluminium metal matrix composites by using stir casting technique exhibits improved physical and mechanical properties, such as, low coefficient of thermal expansion, high ultimate tensile strength, high impact strength, and hardness. Strength of prepared composites both tensile and yield was higher, in case of composites, while ductility of composites was less when compared to as cast 6061Al. Further, with increasing wt% of Al_2O_3 shows improvements in tensile strength. Stir casting process is cost effective and conventional route for manufacturing of composite material. Processing temperature, holding time influences on the viscosity of liquid metal and particles distribution, also induces some chemical reaction between matrix and reinforcements. Speed as well as design of the stirrer blade and preheating processes are also the important factors to be considered in the production of cast aluminium metal matrix composites's,as these have an impact on quality and properties of casting.

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