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# An Overview on Effect of Reinforcement and Process Parameters on Properties of Aluminium Based Metal Matrix Composite.

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**Abstract -** *Aluminum alloys are widely used in aerospace and automobile industries due to their low density and good mechanical properties, better corrosion resistance and wear resistance, low thermal coefficient of expansion as compared to conventional metals and alloys. The excellent mechanical properties of these materials and relatively low production cost males them a very attractive candidate for a variety of applications both from scientific and technological viewpoints. In this paper an attempt has been made to provide a literature review on the overall performance of reinforced composites fabricated by stir casting method and effect of process parameters on properties of Aluminium based MMC. The literature review framework in this paper provides a clear overview that the process parameters play important role for optimum properties of Aluminium based Metal Matrix Composites.*

**Keywords -***Al based Metal Matrix Composites, Process Parameter, Reinforcement, Aluminium alloy.*

## I. Introduction.

Aluminum alloys are preferred engineering material for automobile, aerospace and mineral processing industries for various high performing components that are being used for varieties of applications owing to their lower weight and excellent thermal conductivity properties. Among several series of aluminium alloys, heat treatable Al6061 and Al7075 are much explored, among them Al6061alloy are highly corrosion resistant and are of excellent extricable in nature and exhibits moderate strength and finds much applications in the fields of construction, automotive and marine applications. Aluminum alloy 7075 possesses very high strength, higher toughness and are preferred in aerospace and automobile sector. The composites formed out of aluminium alloys are of wide interest owing to their high strength, fracture toughness, wear resistance and stiffness. Further these composites are of superior in nature for elevated temperature application when reinforced with ceramic particle.

In recent years, Automotive, medical and sport equipment industries pushed advances in materials further to introduce new generation materials particularly having low density and very light weight with high strength, hardness and stiffness. One of the important of these advanced materials is composites, research in aluminium metal matrix composites has been receiving growing attention from investigators because of their increasing applications in various industries. This is because of their superior mechanical properties such as high(strength/weight)ratio and high thermal conductivity. These composites are manufactured by introducing hard ceramic reinforcements such as zirconia, alumina and silicon carbide(SiC) into the aluminium base matrix in the form of particulates, fibres or whiskers. These particles when uniformly distributed in the matrix increases its strength, stiffness, resistance to wear, corrosion and fatigue and elevated temperature characteristics of the matrix. Among these reinforcements SiC is found to be chemically compatible with aluminium forming a sufficiently strong bond with the matrix without developing a inter-metallic phase. Further, addition of SiC improves the thermal conductivity of the base metal and its workability.

There are several methods employed in manufacturing of MMCs. Of these, the Stir casting method is very popular due to its unique advantages. In this method the reinforcing particles are introduced into the melt and are stirred thoroughly to ensure their homogeneous mixing with the matrix alloy. The properties of the particle reinforced metal matrix composites produced this way are influenced to a large extent by the type, size and weight fraction of the reinforcing particles and their distribution in the cast matrix.

An enduring problem with MMC is that they are difficult to machine. This is due to the high hardness of the reinforcement materials which in many cases are significantly harder than the commonly used high speed steel tools and carbide tools.

**Advantages of Aluminium:**

- Aluminium is very light metal with specific weight of 2.7 gm/cm$^3$, about a third that of steel. For example the use of aluminium in vehicles reduces the weight and results in decrease energy consumption. Its strength can be adapted to the application required by modifying the composition of its alloys

- Aluminium is an excellent heat and electricity conductor and in relation to its weight is almost twice as good conductor as copper. This has made aluminium the most commonly used material in major power transmission lines.

- Aluminium is a good reflector of visible light as well as heat and that together with its low weight makes it an ideal material for reflectors, for example, light fittings or rescue blankets.

- Aluminium is ductile and has a low melting point and density. In a molten condition it can be in a number of ways. Its ductility allows products of aluminium to be basically formed lose to the end of the product.

- Aluminium is 100 percent recycle able with no down grading of its qualities. The re-melting of aluminium requires little energy, only about 5 percent of the energy required to produce the primary metal initially is needed in the recycling process. Pure Aluminium has also some limits according to properties, so to enhance properties aluminium alloys are used.

## II. Stir Casting Method of Fabrication of MMC.

Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers)is mixed with a molten matrix metal by means of mechanical stirring as shown in figure. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies.

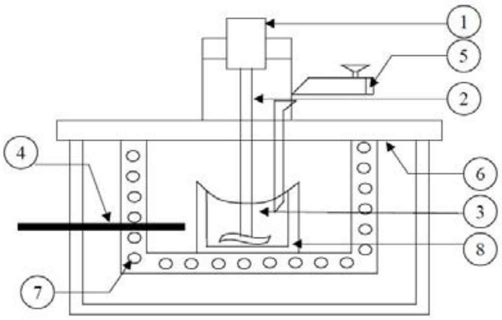


**Figure:** Schematic view of setup for Fabrication of AMC via stir casting technique.

1. Motor.
2. Shaft.
3 Molten aluminium.
4. Thermocouple.
5. Particle injection chamber.
6. Insulation hard board.
7. Furnace.
8. Graphite crucible.

Distribution of dispersed phase throughout the matrix is not perfectly homogeneous. There are local clouds(clusters) of the dispersed particles(fibers). There may be gravity segregation of the dispersed phase due to a difference in the densities of the dispersed and matrix phase. The technology is relatively simple and low cost.

## III. Process variables and their effect on properties.

In Preparing Metal Matrix Composites by the stir casting method, there are process variables that need considerable attention are:

**i) Speed of Rotation:** The Control of speed is very important for successful production of casting. Rotational speed also influences the structure, the most common effect of increase in speed being to promote refinement and instability of the liquid mass at very low speed. It is logical to use the highest speed consistent with the avoidance of tearing.

**ii)Pouring Temperature:** Pouring temperature plays a major role on the mode of solidification and needs to determined partly relation to type structure required. Low temperature is associated with maximum grain refinement and equiaxed structure while higher temperature promotes columnar growth in many alloys. However practical consideration limits the range. The pouring temperature must be sufficiently high to ensure satisfactory metal flow and freedom from collapsed whilst avoiding course structures.

**iii)Pouring Speed:** This is governed primarily by the need to finish casting before the metal become sluggish. Although to high rate can cause excessive turbulence and rejection. In practice slow pouring offers number of advantages. Directional solidification and feeding are promoted whilst the slow development of full centrifugal pressure on the other solidification skin reduces. Excessively slow pouring rate and low pouring temperature would lead to form surface lap.

**iv)Stirring Temperature:** It is an important process parameter. It is related to the melting temperature of matrix i.e., aluminium. Aluminium generally melts at 650◦C. The processing temperature mainly influences the viscosity of Al matrix. The change of viscosity influences the particle distribution in the matrix. The viscosity of liquid decreases when increasing processing temperature. It also accelerates the chemical reaction between matrix and reinforcement.

**v)Mould Temperature:** The use of metals produces marked refinement when compared with sandcastle mould temperature is only of secondary importance in relation to the structure formation. Its principal signification lies in the degree of expansion of the die with preheating. Expansion diminishes the risk of tearing in casting. In Non Ferrous castings, the mould temperature should neither be too low or too high. The mould should be at least 25 mm thick with the thickness increase with size and weight casting.

**vi)Mould Coatings:** Various types of coating materials are used. The coating material is sprayed on the inside of the metal mould. The purpose of the coating is to reduce the heat transfer to the mould. Defects like shrinkage and cracking that are likely to occur in metal mould scan be eliminated, thus increasing the die life. The role of coating and solidification can be adjusted to the optimum value for a particular alloy by varying the thickness of coating layer.

## IV. Literature Survey :

**H. Joardar,N.S.Das and G**. Sutradhar**et et a**l.[1] examined the influence of depth of cut, the cutting speed and Weight percentage of SiC in the metal matrix on surface roughness in plain turning of LM6Al/SiC metal matrix composites. A functional relationship between the surface roughness and the cutting parameters using the principles of Response Surface Methodology and following conclusions were established. The best surface finish is associated with the lowest level of weight percentage of SiCp, the lowest level of depth of cut and highest level of the cutting speed. The surface roughness is most sensitive to variation in the cutting velocity and the depth of cut.

**Serajul Haque, Akhtar Hussain Ansari and Prem Kumar Bhartiet et al** .[2] investigated the effect of stirring speed and pouring temperature on wear rate and microstructure of Al6061- Cu reinforced SiC MMC by stir casting technique. The dependent variable is wear rate by pin on disc wear method while the independent parameters are five level of stirring speed and five level of pouring temperature. The optimal values of wear rate are observed between ranges of 200 to 600 rpm stirring speed, at high speed(800 rpm)the wear rate increases drastically. The wear rates are stable in range of 700˚C to 750˚C of pouring temperature, except at 800 rpm stirring speed and concluded that wear rates are optimal at range of 200 rpm to 600rpm for Al6061-4%Cu-5%SiC MMC. Optimum values of wear rates are obtained between ranges of 700˚C to 750˚C for Al6061-4% Cu-5% SiC MMC. At low pouring temperature 675˚C near melting point of metal matrix, wear rates are high for Al6061-4%Cu-5%SiC MMC. Wear rates are also high at high pouring temperature(775˚C)forAl6061-4%Cu-5%SiC MMC. Wear rates are high at high stirring speed above 600rpmand also wear rates high when stirring speed is low i.e., 50rpm.

**Shubham Mathr and Alok Barnawaet a**l.[3], studied the properties of aluminum based silicon carbide particulate metal matrix composite with low cost method of producing MMCs material. Desired improvement in properties including specific strength, hardness and impact were achieved by intelligently selecting the reinforcement materials, their size and shape and volume fraction and they concluded that hardness of the composites found increased with increased grit size of SiC. Impact (Izod) of the composites found increased with increased grit size of SiC. The tensile strength of the composites found increased with increased grit size of SiC. The pouring temperature at725˚C which gave the best optimum value of hardness, impact strength and ultimate tensile strength.

**Serajul Haque , P. K. Bharti and Akhtar Hussain Ansari et a**l.[4], In their study, a attempt was made to find out the processparametersatwhichbestmechanicalpropertiesofAl6061,4%Cuand reinforced 5%$SiC_p$ ceramic MMC can be obtained. An analysis of Variance(ANOVA) was used for analysis of data with the help of SPSS (Version-17.0) software. Independent parameters are three levels of pouring rates (1.5cm/s,2.5cm/sand3.5cm/s),material type(Al6061+4%Cu alloy and Al+4%Cu, reinforced 5%$SiC_p$MMC processed using stir casting technique)and dependent parameters are hardness and impact strength, which was found that at different pouring rates material hardness and impact strength are highly significant. At pouring rate of2.5cm/sand700±5˚C pouring temperature, optimum values of hardness and impact strength are observed as compared to other values of pouring rates(1.5cm/s and 3.5cm/s). With reinforcement of 5%SiC trend of mechanical properties is same, but hardness and impact strength of MMCs are increased by 25%and20%respectively.Alsoitisobservedfrom scanning electron microscopy(SEM)that atpouringrate2.5cm/s a better homogeneity can be obtained and following concluded that reinforcement of SiCp increases the Impact strength and Hardness. Increase in pouring rate increases the impact strength and hardness of material up to a certain limit after that these properties decrease drastically. It was observed from SEM study that at pouring rate 2.5cm/s better homogeneity can be obtained and reason of improved mechanical properties of the composites compare to matrix alloy may be the stir casting technique of production and reinforcement of SiCp.

**Ajay Singh Verma, N.M. Suri and Suman Kantet a**l.[5]investigated various parameters using various tests MMCofaluminium6063reinforcedwithfly ash particles was fabricated by using stir casting process. Fatigue strength and vickers hardness of fabricated samples was observed by vickers hardness tester and fatigue testing machine. Effect of varying temperature, composition flyash stirring speed on these properties studied using Taguchi method. They concluded that, hardness of Al6063/Fly Ash composite increased with increase in Flyash percentage but decrease in fatigue strength with increase in flyash content. It has been observed that mainly fly ash is responsible for the increase in micro hardness value. Based on the results of experiments carried out, they also suggested that though hardness value found to be maximum for 9% but due to substantial reduction in fatigue strength flyash composition of near about 9% at 720ºC with 400rpm stirring speed is not recommended for fabrication.

**Tamer Ozben, Erol Kilickap and Orhan Cakret a**l.[6], Carried out a study on mechanical and machinability properties of Silicon Carbide particle reinforced aluminium metal matrix composite. The influence of reinforcement ratios 5, 10, 15 wt% of Sic-p on mechanical properties were examined. The of effect process parameters such as cutting speed , feed rate and depth of cut on tool wear and surface roughness were studied. They concluded that increase of reinforcement resulted in better mechanical properties such as impact toughness and hardness. But tensile strength showed different trend, increased up to 10 wt% of Sic-p reinforced and then decreased when 15 wt% of Sic-p reinforcement. Machinability properties of the selected material were studied and higher Sic-p reinforcement produced a higher tool wear surface roughness affected by feed rate and cutting speed.

**Rajeshkumar Gangaram Bhandare, Parshuram M. Sonawane et al**[10], Carried out a study on various operating parameters of stir casting process upon preparing Al 6061 as matrix phase and Sic, Alumina and Graphite as reinforcing materials and concluded that for uniform dispersion of material the blade angle should be $45^0$ or $60^0$ and the number of blades should be 4 ,for better wettability the operating temperature should be at semisolid stage i.e. 630 for Al (6061) , ) Preheating of mould helps in reducing porosity as well as increases mechanical properties.

## V. CONCLUSION.

The Current Literature review reveals that, extensive work has been reported to improve properties of different aluminium based MMC by forming their composites being reinforced with various materials such as Fly Ash and Sic etc., and at same time process parameters playing important role on properties of Al based MMC. Process parameters especially stirring rate, blade angle and number of blades in stirrer has to be maintained to achieve better properties of MMC. For manufacturing of composite material by stir casting, knowledge of its operating parameters is very essential. As there are various process parameters if they are properly controlled can lead to the improved properties in composite material.

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