International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., Issue.4., 2015
(July-Aug)

RESEARCH ARTICLE

ISSN: 2321-7758

MANUFACTURING OF FLYASH REINFORCEDAL356 ALLOY METAL MATRIX USING STIR CASTING METHOD

OMKAR PANSARE[1],S.G.KULKARNI[2],S.S.KULKARNI[3]

[1]PG Student,[2,3]Associate Professor

Department of Mechanical Engineering,

SKN Sinhgad College of Engineering, Pandharpur, India

OMKAR PANSARE

ABSTRACT

Aluminium Matrix Composites (AMC's) are having wide use in advanced applications like structural, aerospace, marine, automotive etc. Stir casting method is used for manufacturing of AMC's which is cost effective. Stir casting method is also useful to increase the mechanical properties of AMC's. By using good quality and low cost reinforcement of industrial waste production of composite material is need of future. In current work pure reinforcement of as received fly ash is used. This paper gives idea about stir casting process, manufacturing of AMC containing Al356 alloy as metal and fly ash as reinforcement.

Keywords: Aluminium Matrix Composite, Metal matrix composite, Reinforcement, Stir casting

I.INTRODUCTION

Al 356 alloy as Matrix Material

Aluminium is found wide range of applications for rail coaches, aircraft industry, bearing materials, piston material, transmission lines etc. But due to their low melting point and low hardness they will wear and deformed easily [1]. The metal Aluminium cannot meet all the required properties suitable for various engineering applications. So it is necessary to develop the Aluminium based materials that could have all combinational properties satisfying all our engineering requirements. SiC, Si, Cu and Mg etc can be considered as reinforcements, due to their high strength, high aspect ratio and thermo-mechanic properties [2-3]. However, until now the main obstacle is to obtain a homogenous dispersion of the Reinforcement in the desired matrix. [4] The most common particulate composite system is an aluminium alloy (AA) reinforced with Si, Mg, Zn, Cu and SiC and some hybrid reinforcements such as fly ash, Al_2O_3 in powder forms.

Aluminium is most abundant metal in earth's crust and third most abundant element after Oxygen & Silicon. It makes up about 8% by weight of Earth's solid surface[11]. They are widely used due to easy availability, high strength to weight ratio, easy machinability, durable, ductile & malleable. Further, Aluminium based Metal Matrix composites (MMC) have received increasing attention in recent decades as engineering materials due to their enhanced high strength, hardness and wear resistance over conventional Al alloy [2]. A metal matrix composite (MMC) is composite material with at least two constituent parts in which a metal used as matrix. The other material may be ceramic or organic compound. Generally, a MMC is composed of reinforcement (fibbers, particles, flakes) embedded in a matrix (metals).The matrix is monolithic material into which reinforcement is embedded & which is completely continuous. The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. A good matrix should possess ability to deform easily under applied load, transfer the load onto the reinforcement and evenly distributive stress concentration [6]. Here, matrix material Aluminium has advantage of lighter weight &major silicon content of alloy may helps to improve castability.Typical composition of Al 356 alloy is given in the table [9].

Table-1Chemical composition of Al356 alloy

Element	Si	Cu	Mg	Mn	Fe	Zn	Ni	Ti	Al
% wt	7.20	0.02	0.29	0.01	0.18	0.01	0.02	0.11	Balance

Processing of AMC's

Primary process for manufacturing of AMC's at industrial scale can be classified into two main groups [10].

1) Liquid state processes:

a) Stir casting b) Infiltration process c) Reactive processing

d) Spray deposition

2) Solid state processes:

a) PM processing b) Diffusion bonding c) Physical vapour deposition.

The major advantages of AMCs compared to unreinforced materials are as follows [10]:

a) Greater strength

b) Improved stiffness

c) Reduced density (weight)

d) Improved high temperature properties

e) Controlled thermal expansion coefficient

f) Thermal/heat management

g) Enhanced and tailored electrical performance

h) Improved abrasion and wear resistance

i) Control of mass (especially in reciprocating applications)

j) Improved damping capabilities.

Fly ash-As reinforcement

Fly ash particles (usually of size 0-100micron) which are extracted from residues generated in the combustion of coal can be used as reinforcement material. As Fly ash has low density, chances of having good wettability between fly ash & matrix Al alloy. Particulate reinforced aluminium matrix composite are gaining importance because of their low cost with advantages like isotropic properties and the possibility of secondary processing.

The high electrical resistivity, low thermal conductivity and low density of fly-ash may be helpful for making a light weight composites. Also production of Al may be significantly reduced by fly ash substitution [2]. Typical composition of fly ash being used is given in the table [8].In current study 4, 8 and 12% of fly ash is used.

Table-2Chemical composition of Fly Ash

Element	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	LOI
Content % wt	59.00	21.00	3.70	6.90	1.40	1.00	0.90	4.62

(a) (b)

Fig1: The fly ash powder used (a) as received condition (b) After heat treatment condition

II. Stir Casting

This 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. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies. Stir Casting is the simplest and the most cost effective method of liquid state fabrication. [12] Stir Casting is characterized by Amount of Reinforcement is limited (usually not more than 30 vol. %), Mixing is not perfectly homogeneous, There are local clouds (clusters) of the reinforcement molten materials. The technology is relatively simple and low cost.

Distribution of reinforcement may be improved if the base metal is in semi-solid phase. High viscosity of base metal enables better mixing of the dispersed phase. In stir casting technique (look at figure 3 for demonstration) of production of metal matrix composites, a melt of the selected matrix material is produced by heating the material in a furnace. In the molten matrix material, the reinforcing particles are then added followed by stirring of the melt to make the reinforcement particles homogenous to the melt. After stirring, solidification of the melt containing suspended particles takes place to obtain the desired product. For a homogenous distribution of reinforcing particles in the matrix material by stir casting route, the following factors play important role [12].

- Metallurgical properties play an important role in the reinforcement settling rate.
- Tribological particles determine the ease or difficulty of wetting.
- The reaction of the reinforcing particles with each other and with matrix melt influences the rheological behavior of the slurry.
- During particle addition or stirring, gas entrapment takes place leading to poor distribution of particles due to attachment of particles to gas bubbles and also increase in porosity in the composite.
- Mixing parameters should be so adjusted that particle distribution in axial and radial directions must be uniform.

The holding time of melt is approximately 15-20 min at temp 750-800°C.The settling time should be as minimum as possible during solidification of melt.

Experimental Procedure and Setup

Stir casting procedure starts with placing empty graphite or cast iron crucible inside the furnace. The heater temperature of induction furnace is then gradually increased up to 800°C. (90 to 120 min approximate)Al alloy 356 is cleaned neatly and then placed inside the crucible. Required amount of reinforcement and hexachloro ethane powder and scum powder is measured by weighing machine. Hexachloro ethane powder reduces impurities and entrapped gases inside melt. Scum powder reduces impurities of melt.1% of pure Magnesium powder is added in semisolid form of matrix at 650°C. Magnesium increase wettability of reinforcement and matrix. After 5-10 min measured quantity of scum powder is added. This forms a layer of scum on top surface of melt which is then removed. As furnace temperature is reached 800°C the stirring is gradually started from 0 to 400 rpm for 8 min with speed control unit. Preheated reinforcement is gradually added during stirring. Reinforcement is poured manually with the help of conical hopper. The constant flow rate of 0.5 gram per second of reinforcement is maintained throughout. The stirrer speed is gradually lowered to zero. The melt is hold at 800°C for 5 min inside crucible. The melt is then directly poured in the metallic mould without giving time for reinforcement to settle down. The MS mould is heated at 500°C to increase the fluidity of composite before pouring melt in the mould. A constant rate of pouring is maintained to avoid trapping of gas. The distance between crucible and mould should be as minimum as possible to increase quality of casting.

The following diagram shows the schematic set up of stir casting.

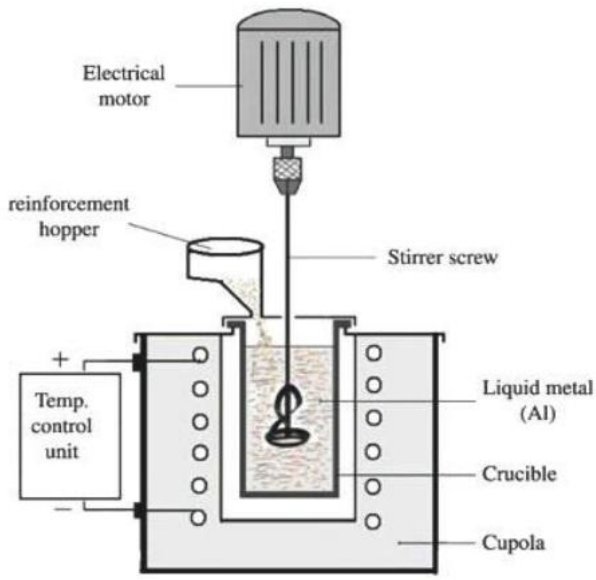

Fig 2: Schematic view of stirring mechanism for the fabrication of MMC.

Fig3: Experimental setup of stirring mechanism for the fabrication of MMC.

III. Process parameters

a) Stirring Speed and Time:

Stirring speed is the important process parameter as stirring is necessary to help in promoting wettability i.e. bonding between matrix & reinforcements. Stirring speed will directly control the flow pattern of the molten metal. Parallel flow will not promote good reinforcement mixing with the matrix. Hence flow pattern should be controlled by turbulence flow. Flow pattern, from inwards to outwards is the best. During thesis work, we will keep speed from 300rpm to 600rpm. As solidifying rate increases (with rise in stirring speed), the percentage of wettability and corresponding Compressive Strength will also increase [12]. The Stirring Time can be varied in between 5mins to 20mins [3]. It was found from the hardness test that the stirring speed and time directly influence the Hardness of the composite. Higher stirring speed and stirring time gives better Hardness and Strength to MMCs as compared to as-cast conditions [13].

b) Stirring Temperature:

It is an important process parameter and is related to the melting temperature of matrix i.e.aluminiumA356 alloy. Aluminium generally melts at 650^{o}C. The processing temperature mainly influences the viscosity of Al matrix. The viscosity of liquid decreases with rise in the processing temperature. It also accelerates the chemical reaction between matrix and reinforcement. In our experimental work, we will have to keep the operating temperature from 610°C to 630°C for better wet ability, by keeping Aluminium alloy in semisolid state. The Hardness and Strength values will increase linearly with further rise in processing temperatures from 650°C to 800°C (at holding time of 15mins) [13].

c) Reinforcement preheat temperature:

Reinforcement was preheated at a specified 500^{o}C temperature 30 min in order to remove moisture or any other gases present within reinforcement. The preheating of also promotes the wettability of reinforcement with matrix [7].

d) Addition of Mg:

Addition of Magnesium enhances the wettability. However increase in the content above 1% of wt increases viscosity of slurry and hence uniform particle distribution will be difficult [6].

e) Stirring time:

Stirring promotes uniform distribution of the particles in the liquid and to create perfect interface bond between reinforcement and matrix. The stirring time between matrix and reinforcement is considered as important factor in the processing of composite. For uniform distribution of reinforcement in matrix in metal flow pattern should from outward to inward.

f) Blade Angle:

The blade angle and number of blades are prominent factor which decides the flow pattern of the liquid metal at the time of stirring. The blade with angle 45° & 60° will give the uniform distribution. The number of blade should be 4. Blade should be 20mm above the bottom of the crucible [8].

Blade pattern drastically affect the flow pattern.

g) Preheated Temperature of Mould:

In casting porosity is the main defect. In order to avoid these preheating the permanent mould is good solution. It will help in removing the entrapped gases from the slurry in mould It will also enhance the mechanical properties of the cast AMC. While pouring molten metal keep the pouring rate constant to avoid bubble formation.

h) Powder Feed Rate:

To have a good quality of casting the feed rate of powder particles must be uniform. If it is non-uniform it promotes clustering of particles at some places which in turn enhances the porosity defect and inclusion defect, so the feed rate of particles must be uniform.

IV. Conclusion

In current study we successfully fabricated the AL-Fly Ash Composites by using Stir Casting arrangement with proper distribution of ash particles all over the specimen.

[1]. Wettability of melt goes on increasing as Mg weight % increases.

[2]. Preheating of mould increases the proper distribution of melt and increases fluidity and reduces porosity in casting.

[3]. As reinforcement percentage increases the density of AMC decreases rapidly hence low density composites can be easily manufactured.

[4]. Stir casting is cost effective process and easy to carry.

V. REFERENCES

[1] Adhithan B.,et al,"Contemplation of mechanical and thermal properties of Aluminum (1100) with Silicon Carbide" International Journal of Engineering and advanced technology,2012, Vol-2, No-2.

[2] Henri, R.W., et al, "Principle of metal casting" Tata McGraw-hill education, 2014.

[3] Dwivedi, S.P., et al, "The Effect of Process Parameters on Mechanical Stir Casting Process" NIET Journal of Engineering & Technology, 2014, Vol. 1, No. 2.

[4] Mathur S., Barnawal A. (2013), "Effect of Process Parameter of Stir Casting on Metal Matrix Composites" International Journal of Science and Research Vol. No.12.

[5] S.G.Kulkarni,et al,"Effect of Fly Ash Hybrid on Mechanical Property And Density Of Aluminium 356 Alloy", Procedia Materials Science 5,2014.

[6] K V Mahendra, "Fabrication of al–4.5% cu alloy with Fly Ash metal matrix composite and its characterisation."Material Science Journal, 2007, Vol 25.

[7] Pradeep Sharma, et al, "production of AMC by stir casting-an overview", International Journal of Contemporary Practises, Vol.2 Issue1.

[8] Khairul Nizar Ismail et al, "Physical, chemical and Mineralogical properties of fly ash "Journal of Nuclear and Related Technology", Vol 4, Special Edition 2007.

[9] Z. Mišković et al, "The Structure and Mechanical Properties of an Aluminium A356 Alloy Base Composite With Al2O3 Particle Additions", Tribology in industry, Volume 28, 2006.

[10] MKSurappa,"Aluminium matrix composites: Challenges and opportunities", Sadhana Vol. 28, Parts 1& 2, February/April 2003.

[11] D. Mohana Rao, Bapi Raju Bandam, "Preparation and characterization of Al-Fly ash metal matrix composite by stir casting method", IJISME,2014, Volume-3 Issue-1

[12] Hashim J. et al., "Metal matrix composite: Production by stir casting Method", journal of material processing Technology, 2005.

[13] Prabhu, S. B., "Influence of stirring speed and stirring time on distribution of particles in cast metal matrix composite", Journal of Materials Processing Technology, 2006, Vol. 171.