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Manufacturing Methods of AMMCs and Their Application in Auto Motive Industry

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***Abstract:*- To meet the ever increasing demand of man's needs and comforts composites are versatile materials used for various engineering and industrial applications.Among the various MMCs, aluminium alloy based composites (AMMCs) are widely considered by the researchers because of their high strength-light weight combination along with good corrosion resistance. As a result, AMMCs are increasingly finding their application in the fields of electronics, aerospace and automobile etc .Aluminium metal matrix composites (2618) is reinforced with hard ceramic particles Tic has emerged as a potential material for wear – resistance and weight critical applications, such as brake drums, cylinder liners, pistons, cylinder blocks, connecting rods and so on.**

Keywords: AMMCs,Stir casting process, Applications

I. INTRODUCTION

Now days with the modern development need of developments of advanced engineering materials for variousengineering applications goes on increasing. To meet such demands metal matrix composite is one of reliable source. Composite material are composed of two or more distinct phases (matrix phase and reinforcing phase) and having bulk properties significantly different from those of any of the constituents. Many of common materials (metals, alloys, doped ceramics and polymers mixed with additives) also have a small amount of dispersed phases in their structures,Favorable properties of composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc.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.[2]

The commonly usedmetallic matrices include light metals such as aluminium, magnesium, titanium and their alloys.The incorporation of ceramic reinforcements like SiC, A1203, B4C, TiC etc., in the form of either continuous / discontinuous fibres, whiskers or particulates improves the strength & stiffness of the metals & alloys.Al-2618 is reinforced with hard ceramic particles Tic has emerged as a potential material for wear – resistance and weight critical applications, such as brake drums, cylinder liners, pistons, cylinder blocks, connecting rods and so on [1]. These new materials offer promising perspectives in assisting automotive engineers to achieve improvement in vehicle fuel efficiency. Several engineering applications require enhanced friction and wear performances. The basic reason of metals reinforced with hard ceramic particles or fibres are improved properties than its original material like strength, stiffness etc. Aluminium alloys are widely used in aerospace and automobile industries due to their low density and good mechanical properties, better corrosion resistance and wear, low thermal coefficient of expansion as compared to conventional metals and alloys. The excellent mechanical properties of these materials and relatively low production cost make them a very attractive. This materials to suit different engineering applications has gained considerable interest among the researchers. Technique involves incorporating the ceramic particles into the melt is stirring by means of a mechanical impeller.

Al2618 is selected as a matrix material because of excellent physical and mechanical properties.

Table 1.Composition of Al2618 alloy

Component	**%Composition**
Aluminium	93.7
Copper	2.30
Iron	1.1
Magnesium	1.6
Silicon	0.18
Titanium	0.07

Table2:shows the mechanical and physical properties of Al 2618 alloy

Mechanical and Physical Properties	**Value**	**Units [SI]**
Density	2.6- 2.8	gms/cm^3
Poisons ratio	0.33	BHN
Ultimate Tensile Strength	440	Mpa
Yield Strength	370	Mpa
Melting Point	510	^0C
Thermal Conductivity	146	$Mm/mm/^0C$
Elongation	10	%

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2. MANUFACTURING METHOD FORALUMINIUM METAL MATRIX COMPOSITE (AMMCS)

Accordingly to the temperature of the metallic matrix during processing the fabrication of MMCs can be Classified into two categories
(a)Liquid phase processes,
(b) Solid state processes, and

a. Liquid state processes:
Liquid state processes include stir casting, compo casting and squeeze casting spray casting and in situ (reactive) processing, ultrasonic assisted casting.

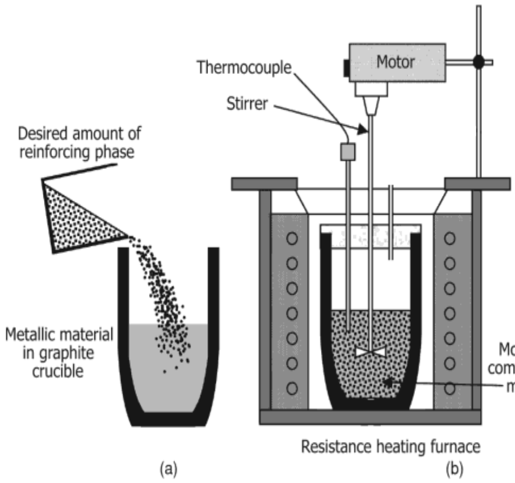
b. Solid state processes:
Solid state processing include Powder blending followed by consolidation (PM processing), high energy ball milling, friction Stir Process, diffusion bonding and vapours deposition techniques. The selection of the processing route depends on many factors including type and level of reinforcement loading and the degree of micro structural integrity desired.

2.1 Stir Casting Method

Stir casting of metal matrix composites was initiated in 1968, when S. Ray introduced alumina particles into an aluminium melt by stirring molten aluminium alloy containing the ceramic powders. Mechanical stirring in the furnace is a key element of this process. The resultant molten alloy, with ceramic particles, can then be used for die casting, permanent mold casting, or sand casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement. This process involves a liquid state fabrication technique which requires the incorporation of reinforcing phase (discontinuous form) into a molten matrix metal (continuous form) to obtain a uniform distribution through stirring as shown in Figure 1.

Stir casing is the simplest and economical technique used commercially for processing of AMCs, but the crucial thing is to create a good wetting between particulate reinforcement and the aluminium alloy melt. [2] 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. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies [3].The reinforcement in AMCs could be in the form of continuous/discontinuous fibres, Whisker or particulates, in volume fractions ranging from a few percentage to 70%.

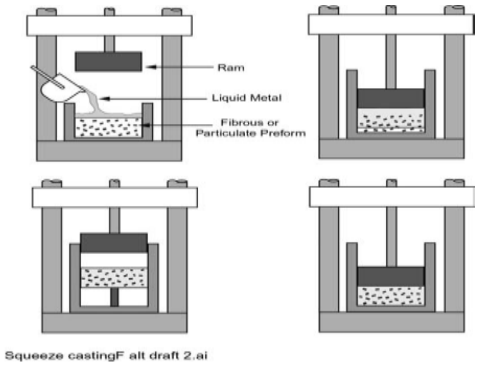
The main advantages lie in its simplicity, flexibility and applicability to large quantity production. It is also attractive because, in principle, it allows a conventional metal processing route to be used, and hence minimizes the final cost of the product. This liquid metallurgy technique is the most economical. Applications in the field of aerospace, automotive, biomedical, military defence and sports industries. The development of this promising technique evolved as a result of modern technological advancement in material application and the demand for light weight materials with improved mechanical and thermal properties.



2.2 Squeeze casting

Squeeze casting process is the combination of gravity die casting and closed die forging. The technique in which metal solidifies under pressure within closed die halves. The applied pressure and the instantaneous contact of molten metal with the die surface produces rapid heat transfer that yields a porous free casting with mechanical properties approaching the wrought product . Squeeze casting offers high metal yield, nil or minimum gas or shrinkage porosity, excellent surface finish and low operating costs. Squeeze casting (also known as extrusion casting, squeeze forming, liquid forging) was developed to produce high quality components. In this process, pressure is applied on the solidifying liquid metal. Due to the intimate contact between the liquid metal and the mold and hence higher rate of heat removal across the metal mold interface, premium quality castings are obtained[3].

The steps involved in this process are: (i) pouring of metered quantity of liquid metal with adequate super heat in to the die cavity, (ii) application of pressure on the liquid metal and maintaining the same till the solidification is complete and (iii) removal of the casting and preparation of the die for the next ycle. These steps are illustrated bellow Fig schematically

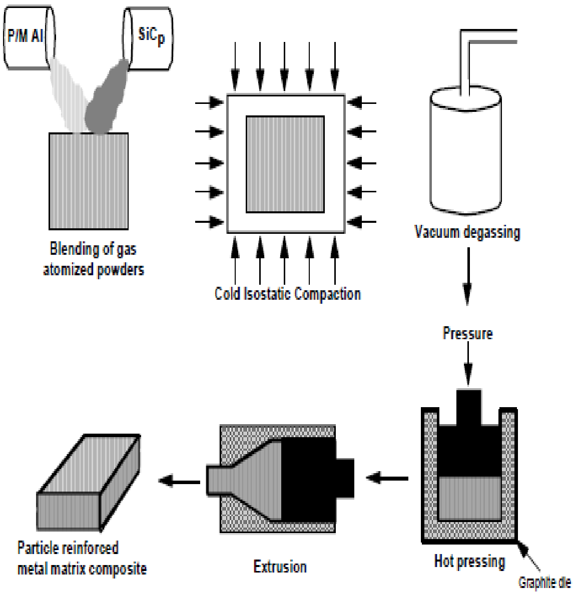


2.3 Powder Metallurgy

Powder metallurgy is the process of blending fine powdered materials, pressing them into a desired shape (compacted), and then heating the compressed material in a controlled atmosphere to bond the material (sintering). The powder metallurgy process generally consists of four basic steps [3]

(1) Powder manufacture,
(2) Powder mixing and blending,
(3) Compacting,
(4) Sintering.

The P/M process is a unique part fabrication method that is highly cost effective in producing simple or complex parts at, or close to, final dimensions. P/M processing provides the following advantages. Production of complex shapes to very close dimensional tolerances, with minimum scrap loss and fewer secondary machining operations. Physical and mechanical properties of components can be tailored through close control of starting materials and process parameters. Powder metallurgy may not be an ideal processing technique for mass production.



3. TYPES OF REINFORCEMENT:

There two types of reinforcing materials for Aluminum matrix composites. The first and most widely used is ceramic. The other is metallic/ Intermetallic Ceramic particles are the most widely studied reinforcement for Aluminum matrix composites. Some common properties of ceramic materials make them desirable for reinforcements. These properties include low-density and high levels of hardness, strength, elastic modulus, and thermal stability [4].

They also have some common limitations such as low wettability, low ductility, and low compatibility with a Aluminum matrix..The shape of reinforcement is another factor affecting the reinforcing effect. In a Aluminum matrix composite, the most commonly used reinforcements assume a shape of short fiber/whisker, or particle, or a mixture of these two configurations. Short fiber/whisker reinforced Aluminum alloys usually show better mechanical properties than the particle reinforced Aluminum alloy with some degree of anisotropic behaviors. To overcome the barriers of relatively high cost and the anisotropic properties associated with fiber reinforcement, some recent efforts have been made to reduce the fiber cost by developing a new fibrous material and using hybrid reinforcements that incorporate particles into fibers.

Because of metallic solids will generally have a much better wettability with liquid metals than ceramic powders, the reinforcing of a Aluminum matrix with metallic/intermetallic particulates has recently been examined. The advantages of the metallic reinforcements lie in their high ductility, high wettability and high compatibility with the matrix as compared with ceramics, and their great strength and elastic modulus as compared to the Aluminum matrix.

4. APPLICATION OF AL MMCS IN AUTOMOTIVE INDUSTRY

Basic requirements in engine industry, which are major driving forces for developing and implementing new materials, are reduction of fuel consumption and vehicle emissions. Aluminium andother light metals have lower density compared with the standard materials used in engine industry (grey cast iron and steel). Their utilization reduces mass, and increases the efficiency, and thus satisfies the basic requirements on fuel economy and vehicleemissions.

Unfortunately their Tribological properties are not satisfactory, which limits their application in manufacturing the tribomechanical components. One of the possible solutions for this problem is use of Aluminium Metal Matrix Composites (Al MMCs). These materials, although being primarily developed for the needs of airplane and space industry, find an increased application in automotive industry, where they are utilized for manufacturing pistons, cylinders, engine blocks, brakes and power transfer system elements

Toyota Motor Co. developed in 1985 a diesel engine piston, in which a discontinuous fibre preform of Al2O3, was infiltrated by squeeze casting into aluminium matrix .

Similar process, since 1990, is employing for producing the Honda Prelude 2,3 litre engine,in which the cylinder liners, consisting of a hybrid of graphite and alumina fibres, were infiltrated during casting of the engine block. Wear resistance is superior to cast iron with a 20 % weight reduction of the engine block [6].

optimization of a space truss toreduce the weight and vibration transmission ina 100HZ bandwidth was performed by resizing the cross sections of truss members ,the selected material wasAl-6061 T6-10%Gr Also the optimum values of tube cross sections obtained as R = 0.71 cm, R = 1.5 cm respectively. It was demonstrated that the filtering capability of new design has been improved for the whole 100 HZ frequency range. The averaged vibration filtering capability of new design is increased equal to 7.2 *dB*. Also the new design constructed of tubes made of Al-6061 T6-10%Gr is considerably lighter than the initial structure made of aluminum rods. The weight reduction of the optimum design is 42% [7]

Aluminium MMC brake drums and rotors have been used in light-weight vehicles such as Lotus Elise, Volkswagen Lupo 3L, Chrysler Plymouth Prowlerand General Motors EV-1. Advantage of weight savings (50 - 60 %), higher wear resistance, and higher thermal conductivity was achieved [6].

Some global market studies show that, in 1999, the overall MMC market (not just aluminium-based) grew by 62 % of the volume in ground transportation applications.

CONCLUSION

Aluminium Metal matrix composites, (AMMCs) are gaining much importance in the field of aerospace and Automotive industries due to their high strength to weight ratio, high elastic modulus, high specific stiffness, high temperature resistance and good wear resistance.

Aluminium alloys are widely used in aerospace and automobile industries due to their low density and good mechanical properties, better corrosion resistance and wear, low thermal coefficient of expansion as compared to conventional metals and alloys. The excellent mechanical properties of these materials and relatively low production cost make them a very attractive. This materials suit different engineering applications has gained considerable interest among the researchers.Developing new design modification with advanced materials andmanufacturing processes prolong the life cycle of the MMC.Reviewing the present development gives opportunity for further improvementof the aluminium matrix composite.

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