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Fabrication of Aluminum Magnesium Composite Material: A Review

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Abstract: **This review paper represents the fabrication procedure of making aluminum magnesium composite material by use powder metallurgy method. In this method we make this composite material by doing reinforcement process. Composite material is less in weight, high in strength, or also less coastly.composites have many different properties like high thermal conductivity, high tensile strength. Composite material is generally a mixture of two or more same or different metlas.we can use composite metal in different mechanical sector, because of their multipurpose uses. In composite material we can easily find two metals properties in one metal. . The new material may be preferred for many reasons. Composite materials are generally used for buildings, bridges, and structures such as boat hulls, swimming pool panels, race car bodies, shower stalls, bathtubs, storage tanks, imitation granite and culture marble sinks and countertops. The most advanced examples perform routinely on spacecraft and aircraft in demanding environments. Surface metal matrix composites (MMCs) are a group of modern engineered materials where the surface of the material is modified by dispersing secondary phase in the form of particles or fibers and the core of the material experience no change in chemical composition and structure.**

Keywords: **Stir Casting, Aluminum Cast Composites, Effect of Composition on Mechanical Properties of Cast Composites, "Al2O3" Particulates.**

1. INTRODUCTION

A composite material is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. In addition, higher fatigue and wear resistance also can be achieved Aluminum, copper, magnesium and titanium are a few examples for matrix materials and SiC, SiO2, Al2O3, TiB2, WC are a few examples for secondary phase materials. The potential applications of metal matrix composites (MMCs) can be found in automobile, aerospace, marine and power generation industries. Stir casting squeeze casting , spray deposition *in situ* fabrication powder metallurgy diffusion bonding and vapor deposition methods are a few examples for manufacturing techniques commonly used to fabricate bulk MMCs Recently, magnesium and its alloys have proven as excellent candidates for constructing structures in automobile, aerospace, marine and electronic industries because of their low density, high specific strength (158 kN-m/kg), good castability, weldability and machinability .The density of magnesium (1.738 g/cm3) is substantially less than aluminum (2.7 g/cm3) But magnesium is brittle in nature compared with aluminum. Magnesium based MMCs are an upcoming new class of materials in non-ferrous metals that address the problems associated with brittleness of magnesium

Aluminum Matrix Composites (AMCs):

Aluminum is the most popular matrix for the metal matrix composites (MMCs). The Al alloys are quite attractive due to their low density, their capability to be strengthened by precipitation, their good corrosion resistance, high thermal and electrical conductivity, and their high damping capacity. A*luminum matrix composites* (AMCs) have been widely studied since the 1920s and are now used in sporting goods, electronic packaging, amours and automotive industries.

Mahindra boopathi.M et al [20] offers a large variety of mechanical properties depending on the chemical composition of the Al-matrix. They are usually reinforced by Al2O3, SiC, C but SiO2, B, BN, B4C, AlN may also be considered.

Metal matrix composite:

Metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal necessarily, the other material may be a different metal or another material, such as a ceramic or organic compound. When at least three materials are present, it is called a hybrid composite. An MMC is complementary to cermets.

Composition:

MMCs are made by dispersing a reinforcing material into a metal matrix. The reinforcement surface can be coated to prevent a chemical reaction with the matrix. For example, carbon fibers are commonly used in aluminum matrix to synthesize composites showing low density and high strength. However, carbon reacts with alum

Matrix:

The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. This means that there is a path through the matrix to any point in the material, unlike two materials sandwiched together. In structural applications, the matrix is usually a lighter metal such as aluminum, magnesium, or titanium, and provides a compliant support for the reinforcement. In high-temperature applications, cobalt and cobalt–nickel alloy matrices are common.

Reinforcement:

The reinforcement material is embedded into a matrix. The reinforcement does not always serve a purely structural task (reinforcing the compound), but is also used to change physical properties such as wear resistance, friction coefficient, or thermal conductivity. The reinforcement can be either continuous, or discontinuous. Discontinuous MMCs can be isotropic, and can be worked with standard metalworking techniques, such as extrusion, forging, or rolling.

Types of reinforcement:

Two types of reinforcing materials have been investigated 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 .However; they also have some common limitations such as low wetability, low ductility, and low compatibility with a Aluminum matrix reinforcements lie in their high ductility, high wetability and high compatibility with the matrix as compared with ceramics, and their great strength and elastic modulus as compared to the Aluminum matrix.

2. LITERATURE REVIEW

Venkatraman and Suundararajan [1], conducted research on 7075 aluminum alloy and AMMCs reinforced with SiCp using powder metallurgy method. They correlate mechanically mixed layer and wear behavior with 7075 aluminum alloy and AMMCs. They observed that precipitation hardening of AMMCs gave positive response in improving in mechanical properties. However, they did not investigated the effect of "Al2O3" particles in 7075 aluminum alloy using simple conventional stir casting method

H.B.Bhaskar and Abdul Sharief in [2] conducted research on the Tribological properties of Al 2024 alloy. Al2024-beryl composites were fabricated by liquid metallurgy route by varying the weight percentage of reinforcement from 0 to 10 wt.% in steps of 2 wt.%. Dry sliding wear tests were conducted to test the wear behavior of Al2024 alloy its composites. Their results indicated that the wear rates of the composite was lower than half of the matrix alloy and friction coefficient was minimum when compared to monolithic alloy. Further beryl particles as reinforcement improved Tribological characteristics.

Suresha and Sridhara [3] conducted research on the hardness of hybrid composites reinforced with SiC and Graphite particles increased up to reinforcement contents of 2.5 wt.% (equal for both reinforcements) and then decreased. The increase was due to the addition of SiC particulates and the decrease was attributed to the overriding effect of soft graphite particles. The addition of graphite particles reduces the hardness value due to the increase in porosity levels

In [4], **JothiSudagar** et.al. Conducted research on Dry sliding wear properties of a 7075-T6 Al alloy coated with Ni-P (h) in different pretreatment conditions. Dry sliding behavior of electro less nickel-prosperous (EN) coating of thickness ~35μm deposited on a 7075-T6 Al alloy was studied. Their results suggested that the wear behavior of EN mostly depended on the pretreatment conditions. Heat treatment at temperature of 400oC can enhance the wear resistance properties for all types of pretreatment conditioned samples.

Lakshminarayanan A. K. et al. [5] conducted research on AA2219 aluminum alloy at spindle rotation of 500–1600 RPM and frictional speed of 0.37‒2.25 mm per sec. They found that defect free FSW on AA2219 metals produced under a wide range of rotational speeds and welding speeds

Hashim, et. al. [6], conducted research on porosity in stir castings is produced as a result of gases entrapped in melting and during stirring/mixing, which form gas bubbles, causes large porosity. However the causes of porosity and their control are well documented in literature.

N.Radhika et al [7]. Conducted research on tribological behavior of aluminum alloy reinforced with alumina and graphite this are fabricated by stir casting process. The wear and frictional properties of the hybrid metal matrix composites was studied by performing dry sliding wear test using a pin – on- test wear test. Experiments were conducted based on the plan of experiments generated through taguchi's technique. AL27 orthogonal array was selected for analysis of the data. Investigation to find the influence of wear rate sliding speed applied load sliding distance, as well as the coefficient of friction. The results show that sliding distance has the highest influence followed by load and sliding speed. Finally confirmation test were carried out to verify the experimental results and scanning electrons microscopic studies were done on the wear surfaces. The incorporation of graphite as primary reinforcement increases the wear resistance of composites by forming a protective layer between pin counter face and the inclusion of alumina as a secondary reinforcement also has a significant effect on the wear behavior. The regression equation generated for the present model was used to predict the wear rate and coefficient of friction of HMMC for intermediate conditions with reasonable accuracy.

Balasivanandha prabu et al [8]. Investigated that better stir process and stir time. The high silicon content aluminum alloy –silicon carbide MMC material, with 10% SiC by using a variance stirring speeds and stirring times.

The microstructure of the produced composite was examined by optical microscope and scanning electron microscope. The results with respected to that stirring speed and stirring time influenced the microstructure and the hardness of composite also they investigate that at lower stirring speed with lower stirring time, the particle group was more. Increase in stirring time and speed resulted in better distribution of particles. The mechanical test results also revealed that stirring speed and stirring time have their effect on the hardness of the composite. The uniform hardness valued was achieved at 600 rpm with 10min stirring. but above this stir speed the properties degraded again. This study to establish the trend between processing parameters such as stirring speed and stirring time with microstructure and hardness of composite

Jokhio, Panhwar & Mukhtiar Ali [9]. Conducted research on the effect of elemental metal such as Cu-Zn-Mg in aluminum matrix on mechanical properties of stir casting of aluminum composite materials reinforced with alpha "Al2O3" particles using stir casting they found increase in tensile strength. Also they found that Mg has pronounced effect on aluminum cast composites up to 2.77% Mg contents which increases wetability, reduces porosity and develops very good bonding with Al2O3

Boopathi et al. [10] conducted research on the microstructures of aluminum alloy (Al 2024) reinforced with different compositions of fly ash, SiC and their mixtures. It has been observed that the particles were not uniformly distributed in single reinforced composites and segregation of particles was clearly visible. This was attributed to the gravity-regulated segregation of the particles in the melt

Uvaraja and Natarajan [11] conducted research on the influence of addition of SiC (0–15 wt.%) and B4C (3 wt.%) particle son the hardness of Al-7075 alloy. Fig. 5 shows that the hybrid composites with higher hardness than unreinforced alloy could be achieved by reinforcing the Al-matrix with multiple reinforcements. This may be due to the fact that silicon carbide and boron carbide particles are harder than the alloy matrix and act as obstacles to the motion of dislocation. The Al/5 wt.%SiC/3 wt.B4C composite and the unreinforced alloy possessed similar hardness values. But, Al/15 wt.%SiC/3 wt.%B4C composite possessed slightly higher hardness and low toughness as compared to theAl/10 wt.%SiC/3 wt.%B4C composite.

Balasivanandha [12] conducted research on stirring speed and stirring time on distribution of ceramics particles in cast metal matrix composites using SiCp reinforced in A348 aluminum matrix. They recommended that 600 rpm stirring speed and 10 minutes stirring time gave best results on properties of cast aluminum composites.

Nakata et al. [13] conducted research on the optimal processing conditions for FSW of 2-mm AZ91D thixomolded sheet. An increase of 38~50% of the tensile strength in the weld could be obtained over base material with rotational speed between 1240 to 1750 rpm and a transfer speed of 50 mm/min. They contributed the increase of strength to the fine recrystallized structure of 2~5 µm grain sizes.

Prasad and Shobha [14] conducted research on the micro structural characteristics of hybrid composites reinforced by SiC and rice husk ash (RHA) particles. The uniform distribution of reinforcing particles was revealed during the examination .The presence of RHA and SiC particles was also confirmed in the micrographs of hybrid composites

Rajmo-han et al. [15], According to another investigation conducted by these authors the hybrid reinforcements (SiC and mica particles) were uniformly distributed in Al356 alloy. The aluminum, carbon, silicon and oxygen particles were clearly visible in the energy dispersive X-ray spectroscopy (EDS) pro-file

Sozhamanna et al [16]. Conducted research on the methodology of microstructure based elastic-plastic finite element analysis of PRMMC. This model is used to predict the failure of two dimensional microstructure models under tensile loading conditions. Hence analyses were carried out on the microstructure of random and clustered particles to determine its effect on strength and failure mechanisms. The FEA models were generated in ANSYS

Using SEM images. The percentage of major failures and stress-strain responses were predicted numerically for each microstructure. Here the mixture material Al alloy, SiC

Rohatgi et al [17]. Conducted research on A356-fly ash chemosphere composites can be synthesized using gas pressure infiltration technique over a wide range of reinforcement volume fraction from 20 to 65%. The densities of Al356-fly ash chemosphere composites, made under various experimental conditions, are in the range of 1250-2180 kg/m3 corresponding to the volume fraction of chemosphere in the range 20-65%. The density of composites increased for the same chemosphere volume fraction with increasing size of particles, applied pressure and melt temperature. This appears to be related to a decrease in voids present near particles by and enhancement of the melt flow in a bed of chemosphere. The compressive strength Plateau stress and modulus of the composites increased with the composite density.

Venkat prasat et al [18]. Conducted research on tribological behavior of aluminum alloy reinforced with alumina and graphite this are fabricated by stir casting process. The wear and frictional properties of the hybrid metal matrix composites was studied by performing dry sliding wear test using a pin – on- test wear test. Experiments were conducted based on the plan of experiments generated through taguchi's technique. AL27 orthogonal array was selected for analysis of the data. Investigation to find the influence of wear rate sliding speed applied load sliding distance, as well as the coefficient of friction. The results show that sliding distance has the highest influence followed by load and sliding speed. Finally confirmation test were carried out to verify the experimental results and scanning electrons microscopic studies were done on the wear surfaces. The incorporation of graphite as primary reinforcement increases the wear resistance of composites by forming a protective layer between pin counter face and the inclusion of alumina as a secondary reinforcement also has a significant effect on the wear behavior. The regression equation generated for the present model was used to predict the wear rate and coefficient of friction of HMMC for intermediate conditions with reasonable accuracy.

Keshavamurthy et al [19]. Conducted research on Al6061 matrix composite reinforced with nickel coated silicon nitride particles were fabricated by liquid metallurgy. Microstructure and tribological properties of both matrix alloy and developed composites have been evaluated. wear tests and dry sliding friction were carried out using pin on disk type machine over a load range of 20-100N and sliding velocities is 0.31-1.57m/s. Results revealed that, coated of nickel in silicon nitride particle are uniformly distributed throughout the matrix alloy. Al6061-Ni-p-si3N4 composite exhibited lower wear rate and coefficient of friction compared to matrix alloy. The coefficient of friction decreased with increased in load up to 80N. Further increase in the load, also increasing coefficient of friction and sliding velocity

Mahendra boopathi.M et al[20]. Conducted research on to Development of hybrid metal matrix composites has become an important area of research interest in materials science. In view of this, the present study was aimed at evaluating the physical properties of aluminum 2024 in the presence of fly ash, silicon carbide and its combinations. Consequently aluminum MMC combination the strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties not available in any single conventional material. Stir casting method was used for the fabrication of aluminum MMC. Structural characterization was carried out on MMC by x-ray diffraction studies and optical microscopy was used for the micro structural studies. The mechanical behaviors of MMC like density, elongation, hardness, yield strength and tensile test were ascertained by performing carefully designed laboratory experiments that replicate as nearly as possible the service conditions. In the presence of fly ash and silicon carbide [sic (5%) + fly ash (10%) and fly ash (10%) +sic (10%)] with aluminum, the result show that the decreasing the density with increasing harness and tensile strength was also observed but elongation of the hybrid MMC in comparison with unreinforced aluminum was decreased. The hybrid metal matrix composites significantly differed in all of the properties measured. Aluminum in the presence of sic (10%)-fly ash (10%) was the hardest instead of aluminum –sic and aluminum-fly ash composites.

3. CONCLUSIONS

This review presents the views, theoretical and experimental results obtained and conclusions made over the years by varies investigators in the field of aluminum alloy -MMCs. A considerable amount of interest in Al- MMCs evinced by researchers from academics and industries has helped in conduction of various studies and has enriched our knowledge about the processing of Aluminum alloy composites, their physical properties, mechanical properties .Several techniques are followed by researchers for the processing of Aluminum alloy reinforced MMCs.

(1) An optimized combination of surface and bulk mechanical properties may be achieved, if Al-MMCs are processed with a controlled gradient of reinforcing particles and also by adopting a better method of manufacturing . However processing of aluminum nano composites with high volume friction of reinforcement with hard particles is really challenging task. There is no clear relation between mechanical properties of the composites, volume fraction, type of reinforcement and surface nature of reinforcements, the reduced size of the reinforcement particles is believed to be effective in improving the strength of the composites.

(2)It has been studied and concluded that the density of the composites increases with the Addition of the hard ceramic reinforcement into the matrix material. In view of the above conclusions on density, experiments were conducted on the Al6061-SiC and Al7075-Al2O3 to determine the density by weight to volume ratio and by rule of mixture. The experimental and theoretical densities of the composites were found to be in line with each other. There is an increase in the density of the composites compared to the base matrix.

(3) The hardness of the composites was reviewed and on conclusion, it is discovered that as the reinforcement contents increased in the matrix material, the hardness of the composites also increased. Further, the tests conducted to determine the same indicated the (Vickers and Brinell's hardness) increased hardness with increased reinforcement contents when compared with the base matrix. The mechanical properties were reviewed with respect to strength. It is evident that the structures and properties of the reinforcements control the mechanical properties of the composites. The reported literature regarding the variations of the compression strength of ceramic filled aluminum composites are meager.

(4) In general, the Al-MMCs are found to have higher elastic modulus, tensile and fatigue strength over monolithic alloys In case of heat treatable Al-alloys and their composites, the yield strength of composites increase after heat treatment by reducing the cracking tendency and improving the precipitation hardening.

(5) The fracture toughness of the composite decreases with increase in the reinforcement content and size. Fracture will occur when the crack tip strain et. exceeds over some micro structurally significant characteristic distance , ahead of the crack tip .

(6) Creep does not become significant until temperatures of the order of 0.3 Tm for metals and 0.4 Tm for alloys is reached. creep resistance increases by the precipitation hardening. The increase of creep resistance is attributed to the decrease of grain size through the Hall–Petch effect.

(7) Ductility is one of the important aspects in the mechanical properties of composites. The tensile elongation during the past few years, materials design has shifted emphasis to pursue light weight, environment friendliness, low cost, quality, and performance. Parallel to this trend, metal-matrix composites (MMCs) have been attracting growing interest. [1-4].MMCs' attributes include alterations in mechanical behavior (e.g., tensile and compressive properties, creep, notch resistance, and tribology) and physical properties (e.g., intermediate density, thermal expansion, and thermal diffusivity) by the filler phase; the materials' limitations are thermal fatigue, thermo chemical compatibility, and low- transverse creep

resistance. The need for advanced engineering materials in the areas of aerospace and automotive industries had led to a rapid development of metal matrix composites (MMC) [1-2]. For applications in the automotive, transportation, construction, and leisure industries, affordable cost is also an essential factor. Apart from the emerging economical processing techniques that combine quality and ease of operations, [6-8] researchers are, at the same time, turning to particulate-reinforced aluminum-metal matrix composites (AMCs) because of their relatively low cost and isotropic properties[4,6,9] especially in those applications not requiring extreme loading or thermal conditions (e.g., automotive components). Also, the processing problems and commercial difficulties associated with continuously reinforced AMCs[9-10]are contributory to the recent interest in their particulate counterparts; the use of aluminum alloys for the matrix is preferred because of its commonly ceramic such as SiC and Al2O3 Properties of AMCs can be tailored by varying the nature of constituents and their volume fraction. The major advantages of AMCs compared to unreinforced materials are the major disadvantage of metal matrix composites usually lies in the relatively high cost of fabrication and of the reinforcement materials. The cost-effective processing of composite materials is, therefore, an essential element for expanding their applications. The increasing demand for lightweight and high performance materials is likely to increase the need for Aluminum matrix composites .The availability of a wide variety of reinforcing materials and the development of new processing techniques like ultrasonic assisted casting, powder metallurgy, high energy ball milling, friction stir casting are recently being used for the production of Aluminum matrix nano composites are attracting interest in composite materials.. This paper reviews recent studies on the processing, microstructure, and mechanical properties of Aluminum- matrix composites.

The conclusions are given below after the load cell testing...

(i) Aluminum composite material having good mechanical properties while we increasing the %age of magnesium.

(ii) Results show that "Al2O3" particles up to 10% Increase the tensile strength 237 MPa and elongation 17% in aluminum alloy matrix containing Cu-Zn -Mg in aluminum.

(iii) The results state that Cu contents in small quantity in the metal matrix composite i.e. less than 2.7% Cu increases the strength and ductility along with Mg and Zn contents in aluminum matrix as in case of alloy 1

. (iv) In this composite materials Mg has pronounced effect on aluminum cast composites up to 3.5% Mg contents which increases wet ability, reduces porosity and develops very good bonding with "Al2O3" particles, and aluminum matrix 1 and 3 yields superior properties

(v) When we take an sample with an amount of 2-3% Mg in combination with 4.5% Zn in aluminum matrix reinforced with 10% of "Al2O3" alloy number 1 and 3 particles yields best Combination of strength and ductility in case of a heat treated conditions.

(vi) In this composite material development in last we found that the overall mechanical properties of the composite material found to be good.

4. FUTURE OF SCOPE

The importance of composites as engineering materials is reflected by the fact that out of over 1600 engineering materials available in the market today more than 200 are composites. These composites initially replaced Cast Iron and Bronze alloys but owing to their poor wear and seizure resistance, they were subjected to many experiments and the wear behavior of these composites were explored to a maximum extent and were reported by number of research scholars for the past 25 years. In the present study, based on the literature review, the effect of Silicon carbide on Stir cast Aluminum Metal Matrix Composites is discussed. Aluminum Metal Matrix Composites with Silicon carbide particle reinforcements are finding increased applications in aerospace, automobile, space, underwater, and transportation applications. This is mainly due to improved mechanical and tribological properties like strong, stiff, abrasion and impact resistant, and is not easily corroded. In the present scenario, a review of different researchers have been made to consolidate some of the aspects of mechanical and wear behavior of Aluminum Metal Matrix Composites reinforced with Silicon carbide particles in both untreated and precipitation hardened condition.

Aluminum is used widely as a structural material especially in the aerospace industry because of its light weight properties however the low strength and low melting point of aluminum were always a problem. A cheap method of solving these problems was to use a reinforced element such as SiC particles and whiskers (1). The ceramic particle additions make it possible to increase the specific elastic modulus of aluminum and improve aluminum thermal properties

(2, 3). Using powder metallurgy (PM) method to produce aluminum composites reinforced with SiC particulates produce a homogenous distribution of reinforcement in the matrix. While other methods of production like casting and thixoforming have the problems of reinforcement segregation and clustering, interfacial chemical reactions, high localized residual porosity and poor interfacial bonding. The rest of the production methods such as spray deposition are very expensive which render its application. The main focus of this project is to analyze the importance of a composite material because such demands can only be met by development and processing of aluminum metal matrix composite materials. In future the biggest scope of work in the field of Aluminum magnesium composite material is because of-

- In modern technology we need some metal that have light weight high strength having good mechanical properties Composite material is lighter and stronger with compare to pure metal.
- It also having very good mechanical properties with compare to other. Composite material is based on the metal matrix or reinforcement.
- Composite material is an mixture of metal having lot of mechanical properties, such as high tensile strength, high melting temperature, much light in weight
- Aluminum composite material is widely used today in transportation, defense area, mechanical structure and power equipment also.
- Composite materials are generally used for buildings, bridges, and structures such as boat hulls, swimming pool panels, race car bodies, shower stalls, bathtubs, storage tanks, imitation granite and culture marble sinks and countertops

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