Fabrication of the Aluminum Graphite Composite Material: A Review

Gyanendra Singh[1], Himanshu Bharti[2]
[1]Asst. professor mechanical Eng. Department, Invertis university Bareilly,(U.P)
[2] Departments, Invertis University Bareilly, (U.P)

Abstract

This review paper represents the fabrication produce of making aluminum graphite composite material by use powder modular method. In this method we make this Composites material by doing reinforcement process. Composite material is lessen weight, height in strength, or also less costly. Composite have many different properties like high thermal conductivity, high tensile strength. Composite material is generally a mixture of two or more same or different metals. We can use composite metal in different mechanical sector; because of their multipurpose usages. In composite material can be easily find two metals properties in one metal. The material may be preferred of many reasons. Composite material are generally used for buildings, bridges and structure such as boat hulls,suming pull panels race car bodies shower stalls ,bathtubs ,storage tanks, imitations granite and culture marble sinks marbles and countertops. The most advanced examples perform routinely on spacecraft and aircraft in demanding environments. Surface metal matrix composites (MMC's) are a group puff modern engineered materials where the surface of the metals modified by dispersing secondary phase in the form of partials or fibers and the core of the material experience no change in chemical composition and structure.

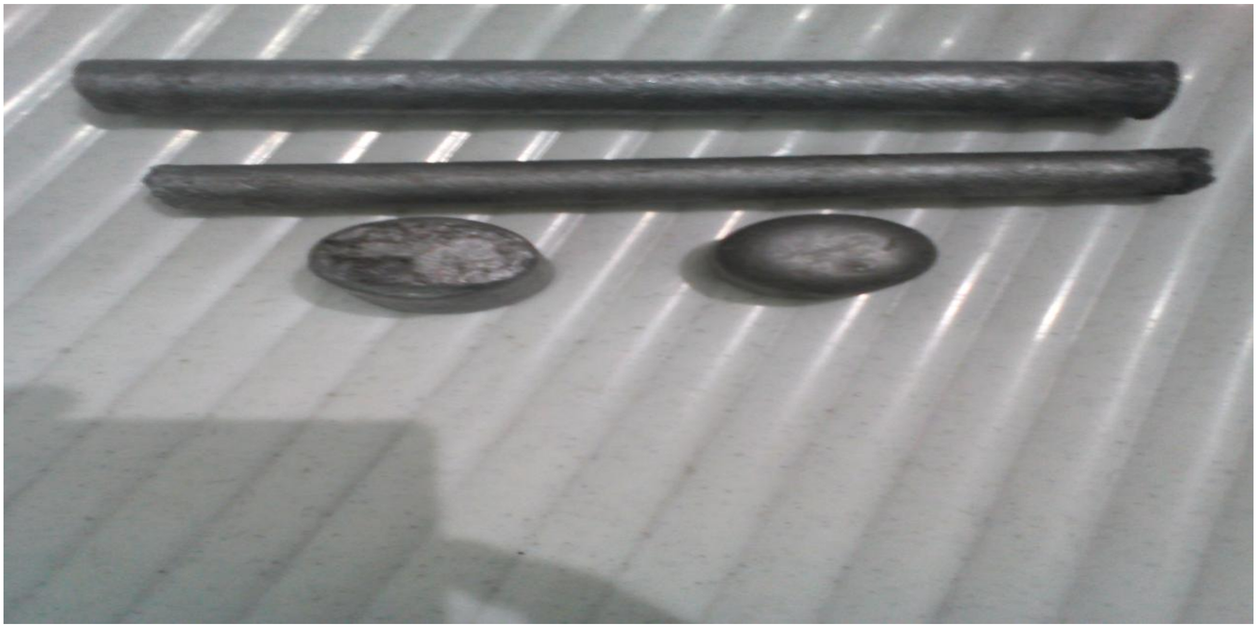
Keyworlds — *Aluminum cast composite, effect of composition on mechanical properties of the cost composite, metal matrix composites (MMC's), Casting.*

I. INTRODUCTION

A composite material is a material made from two or more constituent materials with significantly different physical or chemical priorities that when combined produce a material with characteristics different form the individual components. In addition, higher fatigue and wear resistant also can be achieved aluminum, copper graphite and titanium is the few examples for matrix material and SIC, SIO2, AL2O3, TIB2, WC are a few examples for secondary phase materials. The potential applications of material matrixes composite(MMC'S)can be found in automobiles,airspace,marine and power generation industries, Casting squeeze casting, spry deposition in situ fabrication powder metallurgy diffusion bonding vapor deposition methods are a few examples or manufacturing technique commonly used to fabricate bulk MMC's recently aluminum and its alloys have proven as excellent candidates for constructing structures in automobile,aircraft,marine and electronic industries because of their low density ,high specific strength (158kN-m/kg),good cast ability, weld ability and machanical.The density of graphite is substantially more than aluminum(2.7 g/cm3) but graphite is brittle in nature compared with aluminum. Graphite based MMCs are an upcoming new class of materials in materials in non-ferrous metals that address the problems associated with brittleness of graphite.

II. ALUMINIUM MATRIX COMPOSITE (AMCs)

The low density and high specific mechanical properties of aluminum metal matrix composites (MMC) make these alloys one of the most interesting material alternatives for the manufacture of lightweight parts for many types of vehicles. With wear resistance and strength equal to cast iron, 67% lower density and three times the thermal conductivity, aluminum MMC alloys are ideal materials for the manufacture of lightweight automotive and other commercial parts. The automotive industry recognizes that weight reduction and improved engine efficiency will make the greatest contribution to improved fuel economy with current power trains. This is evidenced by the increased use of aluminum alloys in engine and chassis components. Aluminum and magnesium castings in this sector have grown in leaps and bounds over the past five years to help engineers design and manufacture more fuel efficient cars.



Aluminium-Graphite Composite Material

III. METAL MATRIX COMPOSITES (MMCs)

Metal matrix composites (MMCs) composite possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various discontinuous dispersions used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. Hence, composites with fly ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications.

IV. COMPOSITION

MMC's desirable properties result from the presence of small, high strength ceramic particles, whiskers or fibers uniformly distributed throughout the aluminum alloy matrix. Aluminum MMC castings are economically competitive with iron and steel castings in many cases. However, the presence of these wear resistant particles significantly reduces the mach inability of the alloys, making machining costs higher due mainly to increased tool wear. As a result, the application of cast MMCs to components requiring a large amount of secondary machining has been somewhat stifled.

V. MATRIX

The matrix is the monolithic into which the reinforcements 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.

VI. REINFORCEMENT

The reinforcement material is embedded into a matrix. The reinforcement does not always serve p 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 metal working techniques, such as extrusion, forging, or rolling.

A. Types of reinforcement

Two types of reinforcing materials have been investigated for Aluminiummatrix 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 wet ability, low ductility, and low compatibility with a Aluminum matrix reinforcements lie in their high ductility, high wet ability and high compatibility with the matrix as compared with ceramics, and their great strength and elastic modulus as compared to the Aluminum matrix.

VII. LETRATURE REVIEW

C G Kang et al. [1] in their paper have described the one - dimensional heat-transfer analysis during centrifugal casting of aluminum alloy and copper base metal matrix composites containing Al_2O_3, Sic, and graphite particles. The model of the particle segregation has been calculated by varying the volume fraction during centrifugal casting, and a finite difference technique has been adopted. The results indicated the thickness of the region in which dispersed particles are segregated due to the centrifugal force is strongly influenced by the speed of rotation of the mould, the solidification time, and the density difference between the base alloy and the reinforcement. This study also indicated the presence of particles increases the solidification time of the casting.

J. Zhang et al. [2] have investigated the effect of Silicon Carbide and Graphite particulates on the resultant damping behavior of 6061 A1 metal matrix composites to develop a high damping material. The micro structural analysis has been performed using scanning electron microscopy, optical microscopy and image analysis. It was shown that the damping capacity of Al 6061 could be significantly improved by the addition of either Silicon Carbide or graphite particulates through spray deposition processing.

R.F. Cooper et al. [3] in their study have presented Silicon Carbide continuous fiber-reinforced glass and glass - ceramic matrix composites showing high strength and fracture toughness using thin-foil transmission electron microscopy and scanning transmission electron microscopy (AEM). The exceptional mechanical behavior of these materials is directly correlated with the formation of a cryptocrystalline carbon (graphite) reaction-layer interface between the fibers and the matrix. AEM results are used to comment upon a possible mechanism for the high - temperature embrittlement behavior noted for these materials when they undergo rupture in an aerobic environment.

L.C. Davis et al. [4] in their research thesis have explained the thermal conductivity of metal matrix composites, which are potential electronic packaging materials, has been calculated using effective medium theory and finite element techniques. It has been found that Silicon Carbide particles in Al must have radii in excess of 10μm to obtain the full benefit of the ceramic phase on the thermal conductivity. Comparison of the effective medium theory results to finite element calculations for ax symmetric unit cell models in three dimensions and to simulation results on disordered arrays of particles in two dimensions confirms the validity of the theory.

S CemOkumus, SredarAslan et al. [5] in their paper have studied on Thermal Expansion and Thermal Conductivity behaviors of Al/Si/Sic hybrid composites. It clearly highlights that Aluminum - Silicon based hybrid composites reinforced with silicon carbide and graphite particles has been prepared by liquid phase particle mixing and squeeze casting . The thermal expansion and thermal conductivity behaviors of hybrid composites with various graphite contents (5.0; 7.5; 10 wt.%) And a different silicon carbide particle size (45 µm and 53 µm) has been investigated. Results indicated that increasing the graphite content improved the dimensional stability, and there was no obvious variation between the thermal expansion behavior of the 45 µm and the 53 µm silicon carbide reinforced composites.

Na Chen, Zhang et al. [6]have review on metal matrix composites with high thermal conductivity for thermal management applications , it emphasizes that the latest advances in manufacturing process , thermal properties and brazing technology of Sic/metal , carbon/metal and diamond/metal composites has been presented . Key factors controlling the thermo-physical properties were discussed in detail. The problems involved in the fabrication and the brazing of these composites were elucidated and the main focus was put on the discussion of the methods to overcome these difficulties . This review shows that the combination of pressure-less infiltration and powder injection molding offers the benefits to produce near-net shape composites.

Venkartraman and Suundararajan [7] conducted research on 7075 aluminum alloy and AMMCs reinforced with SiC 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 "Al203"particles in 7075 aluminum alloy using simple conventional stir casting method.

H.B.Bhaskar and Abdul Sharief [8] conducted research on the Tribolical properties of Al 2024 alloy.Al2024-beryl composites were fabricated by liquid metallurgy route by varying the weight %o of reinforcement from 0 to 10 wt.% insteps of 2 wt.%.

LakshminarayananA.K.[9] conducted research on AA2219 aluminum alloy at spindle rotation of 500-1600RPM 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[10]conducted research on porosity in stir casting 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.

Rajmo-han [11] 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) profile.

Prasad and Shobha [12] The micro structural characteristics of hydroid composite reinforced by SiC and rice husk ash (RHA)particles. The uniform distribution of reinforcing particles was revealed during the examination. That pressure of RHA and Sic particles was also confirmed in the micrographs of hybrid composites.

Nakata [13] conducted research on the optimal processing conditions for FSW of 2-mm AZ 91D trio molded 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 grain sizes.

Balasivanandha[14] conducted research on stirring speed and stirring time on distribution of ceramics particles in cast metal matrix composites using Sic reinforced A348 aluminum matrix. They recommended that 600 rpm stirring speed and 10minutes stirring time gave best results on properties of cast aluminum composites.

Boopathi [15] conducted research on the microstructures of aluminum alloy (Al 2024)reinforced with different composites of fly ash ,Sic and their mixtures. It has been observed that the particles were not uniformly distributed in the single reinforced composites and segregation of particles was clearly visible. This was attributed to the gravity-regulated segregation of the particles in the melt.

Deravaju et al. [16] Studied the influence of SiC/Gr and SiC/Al2O3 on the wear properties of friction stir processed Al 6061-T6 hybrid composites. The authors reported uniform distribution of the reinforcing materials in the nugget zone of the hybrid AMCs. Similar report has been made by the authors on hybrid AMCs containing SiC and Al2O3. The hardness and wear resistance of the hybrid composites were superior to that of the matrix material. Furthermore, hardness of the composites containing SiC and Al2O3 was higher than that of the composites with SiC and Graphite due to the combined pinning effect of SiC and Al2O3 and the higher hardness of Al2O3 to that of the Gr. However, composite containing Al2O3 despite its hardness has inferior wear resistance to that of the composites containing Graphite because Graphite exhibits higher solid lubricating effect than Al2.

Rajmohan et al. [17] studied the influence of mica on the mechanical and wear properties of aluminum matrix composites reinforced with 10 wt% silicon carbide. The percentage of mica added to the 10 wt% SiC reinforced Aluminum composites was 6% in step of 3. It was reported that hybrid composites containing mica and SiC as reinforcements have superior hardness, tensile strength and wear resistance than the single reinforced silicon carbide aluminum composites. The superior wear resistance observed was ascribed to the formation of a stable mechanically mixed layer (MML) formed on the composites which reduces the wear loss. The hybrid composites with 3 wt% mica have the highest wear resistance, strength and hardness. These properties dropped as the mica content was increased to 6 wt%. The reason for this was not reported and still need further studies.

Ramnath et al. [18], Evaluated the mechanical properties of aluminum hybrid composites reinforced with Al2O3 and B4C. B4C was considered despite its high cost because of its high strength, low density, extremely high hardness, good chemical stability and neutron absorption characteristics. The hybrid composites exhibited superior hardness and impact strength than the unreinforced alloy. However, the unreinforced alloy had slightly higher tensile strength and superior flexural properties than the hybrid counterparts. Micro structural analysis revealed poor stirring and uneven distribution of the reinforcements in the matrix was responsible for this observation.

Ravindran et al. investigated the microstructure and mechanical properties of aluminum hybrid nano-composites with the addition of graphite as a solid lubricant. The composites had 5 wt% SiC with varied graphite content up to 10 wt%. It was reported that tensile strength, wear resistance and hardness increased with increasing reinforcement. The hybrid composites had superior mechanical properties than the single reinforced Al/5 wt% SiC composite with Al/5 wt% SiC/10 wt% Gr. having the highest strength and wear resistance.

Shiratori et al. [19] The encapsulation of exfoliated graphite - PMMA composite. This encapsulated exfoliated graphite composite can be directly molded by hot pressing. The electrical conductivity and the EMI SE of this molded product were superior to those of the exfoliated graphite-PMMA composite made by mechanical mixing. This is due to homogeneous dispersion of exfoliated graphite in the encapsulated composite.

Moorthy et al. [20] The dry sliding wear and mechanical behavior of Aluminum/Fly ash/Graphite hybrid metal matrix compos studied its using Taguchi method and reported that load was the most influencing factor affecting the wear rate of the composites followed by sliding speed and fly ash content respectively. There was an increase in the hardness of the hybrid composites as fly ash content increases. FA can also be used to suppress interfacial reaction that exists between matrix and the reinforcing particulate.

VIII. CONCLUSIONS

Composites the characteristically have a discontinuous fiber or particle phase that is stronger than the continuous phase matrix. the Composite materials which are being extensively used in day-to-day applications play a staggering role in the manufacturing sector for the fabrication of the highly the sophisticated the equipments and the Components. Predominantly in automotive industry, Metal Matrix Composites have been used commercially in fiber reinforced pistons and aluminum crank cases with strengthened cylinder surfaces as well as particle - strengthened brake disk . The composite materials usually divulge superior characteristics when compared to the characteristics of matrix material alone.
Particles Reinforced Aluminum Matrix Composites (PRAMC) have recognized supreme recognition in electronic packaging and thermal management such as power module base plates , printed wiring board cores , the microprocessor lids or the electric enclosures , for their flexible fabrication techniques ,the adaptable thermo - physical properties and reliable specific mechanical properties .the Particle Reinforced Matrix Composites (PMMCs) possess distinct advantages over fiber reinforced composites in terms of cost , the isotropic mechanical properties and the potentiality to be the processed using the technology similar to that used for the monolithic materials. Al/Sic/Graphite hybrid metal matrix composites exhibits better and the favorable thermal properties and are extensively used for aerospace application.

In this review paper represents the physical properties and the mechanical properties for the metal matrix composites. The conclusions of the aluminum graphite composite material are given below:-

[1] Aluminum composite material having very good mechanical properties while we increasing the %age of graphite.
[2] The graphite composite metal represents the mechanical and physical properties for the metal matrix composites.
[3] The ductility is important aspects in the mechanical properties of composites.
[4] The aluminum strength of the aluminum graphite composite metal is very good.

REFERENCES

[1] C G kang, "metal replacement by composite", JOM 2012, Vol 38 (03), p. 17.

[2] J. Zhang, "composite materials for aerospace applications, developments in ceramic and metal matrix composites"PA: TMS publications, 2012, pp. 3-24.

[3] R.F. Cooper, "Microstructure and deformation properties of an Al_2O_3-Ni_3Al composite from room temp to 1400^0C", High performance Composites for the 2013's Eds. S. K. Das, C. P. Ballard and F.

[4] [L.C. DavisManocha& A.R. Bunsell "Advances in composite materials", Pergamon Press, Oxford, 2011, Vol.2, p 1233-1240.

[5] S CemOkumus,SredarAslam, A. Nucleus, 8(5), 2010, (Nucleus A. Editeur, 1, rhe, Chalgrin, Paris, 16(e). Van suchetclan, Philips Res. Repts. Vol. 27. 2010, pp. 28.

[6] Na Chen, Zhang, "Analysis and performance of fiber composites" John Wiley & Sons, New York, 2014, pp.3-12.

[7] Venkartraman, the Mechanics of Plastics Reinforcement Tension, Mod. Plast: March 2014.

[8] H.B. Bhaskar in der Luft-und Raumfahrt, Kunststoffe, 60, Heft 10 (2009).

[9] Lakshminarayanan, ' GlasfaserverstarkteKunststoffe', SpringerVerlag, 2013.

[10] Hashim, IUNIDO's State-of-the-art series: "Advances in Materials Technology: MONITOR", Compiled by the Industrial Technology Development Division Department of Industrial Promotion, Vienna, Austria, No.17, Feb. 2014.

[11] Rajmo-han, "Reinforcement effects of Silicon Nitride in Silver and Resin Matrices", Powder Metallurgy, Vol. 7(14), 1964, pp 152-167.

[12] Prasad and Shobha, "Composites Go After Commercial Markets", Iron Age, Sept.5th, 1986, pp 35-38.
[13] Nakata, "Solidification processing of Metal Matrix Composites", JOM, Vol. 40(2), 1988, pp 12-19.
[14] Balasivanandha, "Microstructure and orientation effects on properties of discontinuous Silicon Carbide/ Aluminum Composites" NASA Tech. Pap. 2303, Cleveland, OH, 1984, pp 1-29.
[15] Boopathi, "Evaluation of low cost Aluminum Composites for Aircraft Engine Structural Applications", NASA Tech. Memo. No. 83357, Washington, DC, 1983.
[16] Deravaju, "The strength of MMCs Reinforced with Randomly oriented Discontinuous Fibers", Mett. Tran. Vol. 23A, Nov. 1992, pp 3045-3053.
[17] Rajmohan , "P/M Aluminium MMCs' Dispersion Strengthened Al Alloys", eds., PA, The Metallurgical Soc., 1988, pp 15-19.
[18] Ramnath, "The processing and properties of discontinuously reinforced Aluminium Composite", JOM, August 1991, pp 8-15.
[19] Shiratori, "Define the different-different types of composites"Vol. 3, 1987, p p. 662.
[20] Moorthy, "Mechanical Properties of Engg. Materials", 1986.