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A Review Paper on Aluminium Metal Matrix Composite

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ABSTRACT: A metal matrix is strengthened by adding a reinforcing element to create MMCs. One of the greatest engineering structural elements is commonly considered as metal matrix composites based on aluminium because of their high strength, stiffness, resistance to wear, thermal stability, and numerous other advantages that differ according to the type and quantity of reinforcements utilised.

The analysis is done by using several research papers by various writers. Much of the quality of the AMCs is dependent on the manufacturing technique, which can provide good qualities to meet the need of industries.

KEYWORDS: Metal Matrix Composites(MMC), Aluminium Metal Matrix Composite(AMMC).

I. INTRODUCTION

The need for affordable, effective, and lightweight stiff materials has led to a transition in research from base alloys to composite materials, which is discussed in the text. It is underlined that Metal Matrix Composites (MMCs) have a nice combination of qualities that are challenging to achieve with monolithic materials. Aluminium metal matrix composites are now frequently used in technical fields. It has exceptional qualities that no existing solid material can match. Currently they are in great demand in the aerospace, car, and other technical applications. Aluminium composite matrix are becoming increasingly popular in the transportation industry since they use less fuel and produce less noise than other materials. Johnny James.S et al [1] reviewed that A new class of materials known as metal matrix composites (MMCs) displays excellent mechanical and physical qualities. The use of MMCs has increased significantly in various engineering applications, including aerospace, automotive, and electronic industries, due to their high strength, stiffness, and wear to resistance and corrosion. Hybrid AMC with SiC and TiB₂ is the most suitable MMCs.[3] Composites are mixtures of two or more materials that have qualities like durability, more strength, stiffness, ductility, and toughness as well as hardness that are difficult for a single material to achieve. The reinforcement provides the composites with the desired mechanical strength while the matrix transfers the load placed on it. Depending on the shape, the reinforcement material can be categorized as fibers or particles. Typically, composite materials, such as polymer matrix, metal-matrix, and ceramic composites, are categorised based on the physical or chemical properties of the matrix. Moreover, some data suggest that carbon-matrix and intermetallic composites are starting to appear. The other component, which is typically non-metallic and frequently ceramic-like SiC and Al₂O₃, serves as reinforcement and is integrated in this aluminium alloy matrix. By changing the type of ingredients and their volume percent, AMC properties can be adjusted. These are some of the main benefits of AMCs over unreinforced materials like it has better strength, good stiffness, improved high temperature properties, less density, enhanced electrical performance, good wear strength and damping ability.

There is currently no monolithic material that can compete with the superior mix of properties (profile of properties) offered by AMC material systems. AMCs are mostly used in a variety of applications like structural, non-structural, and functional over the years. In several engineering fields. Performance, economic, and environmental advantages are the driving forces behind the use of AMCs in various domains. Less fuel consumption, reduced noise, and lower airborne emissions are the main advantages of AMCs in the transportation sector. The usage of AMCs in the transportation industry will be necessary and desirable in the next years due to tightening environmental restrictions and a focus on increased fuel efficiency. [2] The development made in aluminium-based MMCs employing various manufacturing methods to attain desired material qualities, with liquid state processing being one of these methods are also mentioned. Aluminium matrix composites (AMCs) are a type of lightweight, high-performance material system



that is aluminium-centric. In AMCs, reinforcement may take the shape of whiskers, particles, or continuous or discontinuous fibres in volume fractions which ranges till 70%. AMCs properties can be adjusted to meet the needs of various industrial applications by choosing the right combination of the matrix, reinforcement, and processing method.

II. FABRICATION METHODS OF MMC

The two main types of composite fabrication processes are solid-state processing and liquid phase processing. In liquid phase processing procedures, the continuous metal matrix phase and discontinuous reinforcement phase are combined while still in a liquid condition, and the proper shapes are then typically cast using the molten metal. MMCs were created using the solid-state processing method below its melting point. Reactive processing (also known as in-situ processing) is an additional technique in which chemical reactions are used.

2.1. Liquid state processing method:

Stir casting entails mixing liquid aluminium melt with ceramic particles and letting the combination set up. Here, it's essential to get the liquid aluminium alloy melt and the particle reinforcement well-wetted. The vortex technique or stir-casting technique is the most basic and widely utilised method. The vortex approach involves introducing pre-treated ceramic particles into the revolving impeller's molten alloy vortex. According to Lloyd (1999), the vortex-mixing process was first created at the Indian Institute of Science by Surappa & Rohatgi (1981) for the manufacture of ceramic particle distributed aluminium matrix composites. Later, a number of aluminium businesses improved and altered the procedure, which is now used to create a number of AMCs on a large scale.[2]

Karbalaei Akbari et al.[4] created A356/TiB₂ and A356/TiO₂ nanocomposites using the stir casting method with various volume fractions of reinforcements. As the matrix material, an aluminium alloy (A356) with the chemical composition shown in Table 1 was used. TiO₂ and TiB₂ nanoparticles (20 nm) with high purity were used to provide reinforcement. Figure 1 depicts the morphology of TiO₂ nanopowder. A resistance furnace with a graphite stirring system and an inert gas injection tool was used to create the composite materials. TiO₂ and TiB₂ nanopowders were added in concentrations of 0, 0.5, 1.5, 3, and 5 vol% to the molten alloy to create the composites. TiB₂ and TiO₂ powders have densities that are higher than the density of molten aluminium (2.7 g/cm³), causing ceramic particles to drop to the bottom of the crucible. Stir casting was performed in an inert environment of argon gas at a steady speed of 450 revolutions per minute for 8 minutes. The casting temperature was 800C. The stirring process' requirements were modified in light of the findings of earlier studies. Samples were formed into cylinders with an outside diameter of 14 mm and a height of 140 mm using a cast iron mould and composite slurry. Figure 2 depicts the graphical layout of the fabrication process.

Chemical Composition of A356 Aluminium Alloy (wt%)

Composition	Al	Si	Mg	Zn	Cu	Fe
Wt%	91.99	7.5	0.38	0.02	0.001	0.106

Table 1. Behaviour of wear and friction [4]

MWCNT was purchased from Redex Technologies Pvt. Ltd. in Ghaziabad, Uttar Pradesh, and nanoSiC was obtained from Mahalakshmi Scientific, a chemicals company in Chennai. To fit inside the graphite crucible, the ingot-shaped Al 6061 alloy was divided into smaller pieces. By using the stir casting process, Padmavathi and Ramakrishnan [3] developed nano-composites of hybrid Al/SiC + MWCNT that outperformed in terms of dry abrasive wear resistance for mono Al/SiC composites. Al/SiC demonstrates better hardness when compared to Al/SiC + MWCNT. Hardness increases as hybrid ratio does. In an electric furnace, aluminium alloy was first melted. The preheated MWCNT and SiC, which had reached a temperature of around 620 °C, were continuously mixed in with the 750 °C molten metal as they were added. To guarantee even inclusion of the SiC and MWCNT particles into the Al6061 matrix, the stirring was done for 5 minutes at 450 rpm using a dual blade mild steel impeller. To prevent iron from contaminating the molten Al metal, an alumina powder coating was applied to the dual-blade mild steel impeller. The impeller was placed 20 mm above the base of the graphite crucible, and when turned, its blades, which were inclined at a 45° angle, covered a sizable portion of the crucible base. This design kept the SiC and MWCNT nanoparticles from settling until the melted slurry was agitated for 5 minutes. Al-SiC-MWCNT metal matrix nanocomposites' toughness was evaluated using the Rockwell hardness test. The sliding wear behaviour of the composites was assessed using a pin-on-disc wear

testing system. According to ASTM G99-95, the wear tests were conducted under dry sliding circumstances in air at 30°C with a relative humidity of 59–69%. From the machined samples, pin specimens with dimensions of 8 mm in diameter and 50 mm in height were cut and polished. Dead weights were used to apply a standard load of 0.5, 1 and 1.5 kg at 636 rpm for 5 minutes, and the pins were then meticulously cleaned with alcohol and weighed using a precise electronic scale. Every test was carried out at room temperature.

To improve interfacial bonding and uniform reinforcement distribution, stir-cast MMCs can be extruded. To reduce their porosity and enhance particle dispersion within the Al matrix, the cast composites were heated extruded at 420 C with an extrusion ratio of 27 at a speed of 1 m/min. After being heated at 400 °C for two hours and cooled in a furnace, hot extruded composites of 10 mm diameter bar were treated to remove the extrusion effect.

Shorowordi et al. [5] processed Al/B₄C, Al/Al₂O₃, and Al/SiC composites in range of 6-20 vol% reinforcement. It can be seen that aluminium with no SiC has quite big grains. The grain size is reduced by the addition of SiC particles. Moreover, as more SiC particles are added to the cast composites, the number of pores visible as a dark area increases. This is because air is added when particles are added while stirring liquid Al because particles often enter melts in groups that trap air between them. Interfacial reaction products have been identified at the Al/SiC contact for a long time in treated composites, but not at the Al/B₄C or Al₂O₃ interfaces. Apart from the Al/B₄C interface in the aluminium matrix, two secondary phases, Al₂O₃ and Al₃BC, were discovered. Al/B₄C AMCs have better interfacial bonding than Al/SiC and Al/Al₂O₃ AMCs do.

Schobel et al. [7] produced Al composites reinforced with carbon diamond and SiC particles created using the liquid metal infiltration technique. When the matrix metal is melted between the SiC particles in AlSi7/SiC/70p, after being heated to 650 C, the original void volume percentage of 1 vol% is reduced to zero. Continuous scanning of the sample was carried out at a rate of 3 K/scan, or 1 min/scan, while the sample was being cooled from 650 C at a rate of 3 K/min. At 577 C, AlSi7/SiC/70p suddenly exhibits 0.5 vol.% voids. The void volume percentage continues to rise throughout additional cooling, reaching a final value of 1.2 vol.% at RT, which is comparable to their initial state prior to cycling. AlSi7/CD/60p exhibits an initial void volume fraction of 2.5 vol% that closes during heating as the matrix metal becomes liquid in the space between the diamond particles. The liquid matrix material is injected into the gaps in the porous reinforcement preforms using the infiltration technique, with or without vacuum or pressure. This technique can produce products with superior wettability that are suited for mass production; it also limits excess interfacial reactions by reducing the contact time between the reinforcement and matrix during the fabrication of structural shapes like tubes, beams, and rods that require uni-axial directional qualities.

Johny James.S [1] suggested that various techniques have been used for the fabrication of hybrid AMCs composite strengthened with SiC and TiB₂, including stir casting, powder metallurgy, and in-situ synthesis. The stir casting technique is the most popular technique for the fabrication of the composite due to its simplicity, cost-effectiveness, and ability to produce large-scale components. However, the powder metallurgy and in-situ synthesis techniques are more suitable for producing high-performance composites with superior mechanical properties. The powder metallurgy technique produces a particles homogeneous distribution, while in-situ synthesis enhances the interfacial bonding between the matrix and the reinforcing particles.

According to Lai and Chung [6], the reaction between matrix Al and the reinforcement SiC produced a non-uniform distribution of the reaction product Si in the Al/SiC composites made using the liquid metal infiltration method. The infiltration temperature and increased SiC whisker volume percentage both contributed to the non-uniformity. The SiC whisker volume % and consumption fraction were inversely related during the reaction. Reactivity index is the two-fraction product that characterises the Al-SiC reactivity. SiC whiskers had a better index than SiC particles, and it dropped as the infiltration temperature dropped. Due to agglomeration and segregation, the reinforcing material distribution is not uniform during liquid phase processing. It reacts with molten material at a higher temperature during liquid phase processing and produce undesirable phases. One of the most popular reinforcement materials for the fabrication of lightweight, very durable, and highly elastic composites is SiC. Aluminum carbide was created because of a SiC and aluminium interaction at higher temperatures. (Al₄C₃). When compared to pure aluminium matrix, the Al-Si matrix's low ductility led to low strength of composites. By using an Al-Si matrix containing more than 7% Si and controlling temperature, the reaction of SiC and aluminum can be controlled.

2.2 SOLID STATE METHOD:

Zan et al. [9] developed AA6061/B4C composites utilising the powder metallurgy technique and various hot-pressing temperatures. B4C-Al neutron absorber materials with high strength, low cost, and good stability at high temperatures are required for the dry storage of spent nuclear fuel. The interfacial interactions lead to the development of compounds like Al₃BC and Mg(Al)B₂ and improved mechanical behaviour of the composites with higher temperatures from 560 C to 630 C. As can be seen in Fig2., the sample hot-pressed at 630 C had a tensile strength that was 4059% higher than that at 560 C, both at room temperature and when heated up. This is due to the Mg(Al)B₂ nanorods' ability to prevent dislocation movement. B4C-Al neutron absorber materials with low cost, high strength, and good stability at high temperatures are required for the dry storage of spent nuclear fuel.

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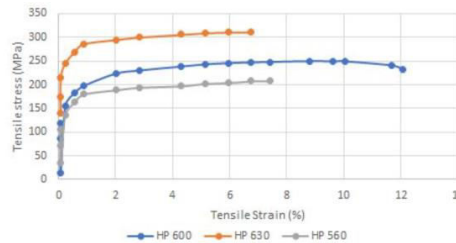


Fig. 1. Composites tensile stress-strain curves.[9]

Azam et al. [7] reinforced considering the requirements of composite materials for demanding tribological applications, 10, 20, and 30% wt% Ni-coated and uncoated (cBN) i.e cubic boron nitride, spark plasma particles created a nano-alumina matrix and tested the tribological characteristics of dry sliding against Al₂O₃, and Si₃N₄materials. Increased cBN contentsignificantly enhanced the wear resistance and coefficient of friction of the nano-alumina composites with uniformly distributed particles. Because the nickel coating produced superior interfacial bonding, cBN particles with a nickel covering showed greater wear resistance. The sample with 30% cBNNi reinforcement performed well mechanically and tribologically, which was recommended in harsh environments, such as wear pads, seal rings, cutting tools, aircraft brakes, and bearing components.

Zhou et al. [8] created an AA6061/26 wt% B4C composite utilising powder metallurgy and hot-pressed temperatures of 560 C and 620 C to study the function of the Cu microalloying element in composites made of AA6061 and B4C. Al₃BC and MgB₂ are produced by the reinforcement-matrix processes, and Cu was separated at the precipitates-matrix interfaces and increased precipitate nucleation at 620 C. These days, the nuclear sector is particularly interested in B4C particles-reinforced aluminium matrix composite (AMC) because of its light weight, high stiffness, and particularly its specialised ability for neutron absorption. They have been extensively employed in the storage and transportation of spent nuclear fuel as neutron absorber materials.

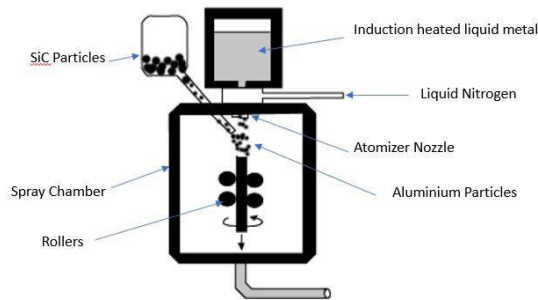
Al-Mg-Si (6xxx series) alloys are frequently employed in industrial applications to create B4C-reinforced AMCs. It has been demonstrated that adding a little quantity of Cu, known as microalloying, to these alloys will boost their peak hardness and thermal stability. Previous studies have shown that the addition of Cu mostly modifies the kinetics of precipitation and hardening. Microscopic analyses have discovered different forms of Cu-contained precipitates in Al-Mg-Si-Cu alloys.

Pulkit Garg et al.(2019)[11] Metal Matrix Composite can be manufactured by a primary process known as Deposition Process.

Deposition Process:Physical vapour deposition procedure is used to make MMC's which is often a procedure at a leisurely rate. The fibre is continuously brushed aside over zone of very prominent partial pressure of metal which is been deposited in this procedure.In which condensation occur to produce bit dense layer over fibre. To generate vapours strong beam of electron is focused at the end of sturdy bar input stock. Rate of Deposition range between 5

and 10 metres/minute. To create the final composite material, the fibres which are coated are joined together into bunch or collection and solidified in a heated press.

Spray Deposition: There are two main types of spray deposition procedures, based whether the molten bath is used to create droplet stream or uninterrupted cold metal feeding on region of fast injection of heat is used. Figure below shows Spray Deposition Process.



Spray formation, sometimes acknowledged as Osprey procedure, an effective path for producing components known near-net shape. The technique is divided into two steps: the first includes to atomize the liquid which is melted into small droplets utilizing inert gas like atomizing agent, in second tiny drops are being deposited on a metallic substrate. Rate of deposition length of flight (From nozzle-substrate), spraying angle, atomizing pressure and gas atomizing these are all essential spray forming production characteristics.

The outcome of processed factors on the mechanical characteristics of aluminium metal matrix composite:

The elasticity modulus, fracture strength, and compressive strength of metal matrix composites (MMCs) are all quite high. They have better heat, wear and corrosion resistance. The below factors have a substantial influence on powder metallurgical characteristics produced metal matrix composites:

- Reinforcement Percentage
- Structural properties that are affected by the parameters used for processing and schedule of heat treatment.
- Dispersoids as well as matrix are bonded together.

Yashpal Kaushik et al.(2017)[12], studies on fabrication of MMC's using Particulate(less effective) Reinforcement. Aluminium metal is used as a matrix in AMMCs. Material which are augmented together with other materials, primarily ceramics such as SiC, Al₂O₃, B₄C, TiB₂, and others. AMMCs has multiple uses in aircraft, ground and marine transports, such as airframes, pistons, propellers. submarines and so on. AMMCs are in great demand because of less weight, very high strength-weight ratio, Corrosion resistability, wear resistability, excessive thermal conductivity. Reinforcement could be continuous or discontinuous, such as whiskers, particles or threads. Particle reinforced AMMCs are reinforced using particle reinforcement in an aluminium matrix material.

Stir casting was used to create Al-TiB₂ composites. Three specimen of composites with AA 1100-4.5 wt.% Cu, AA 1100, AA 1100-4.5 wt.% Cu-3 wt.% reinforced with 15 Vf% TiB₂ were constructed. Moreover cast billets had been expelled out at 350 C at pace of 2.85 mm/s with an extrusion ratio of 12:1. Insertion of TiB₂ with AA 1100 enhances yield, tensile strength more than double as well as the modulus of elasticity by roughly 20% [9]. However, when compared to the matrix material, the ductility loss was observed to be 68%. Tensile and yield strengths rose thrice belonging with AA 1100-4.5 wt.% Cu, but these gains were hampered by ductility, which decreased by 84% when differentiated to material matrix. When AA 1100-4.5 wt.% Cu-3 was compared with matrix material, the yield and tensile strengths got better by 2.5 times, while the loss of ductility was observed as 27%. In TiB₂ particulates were used to strengthen an Al base (AA 1100) composite using stir casting procedure. The Al based material matrix (AA 1100), Al-10%Vf TiB₂, Al-5%Vf TiB₂, Al15%Vf TiB₂ are casted as billets and discovered a rise in tensile, yield strength, but a loss in ductility. To boost the strength of composites with 10% Vf TiB₂ reinforcement, 4% of Cu had been introduced to Al base matrix before casting.

SUMMARY

1. A356/TiB₂ composites achieved better particle distribution, wettability, and higher mechanical characteristics than A356/TiO₂ composites. Refinement in hardness as well as wear resistability was witnessed in composite named A356/1.5 vol% TiB₂. For reinforced samples, as the normal load rose, friction coefficient decreased due to an increase in wear rate.
2. In comparison to mono Al/SiC composite, nanocomposites of hybrid Al/SiC+ MWCNT revealed good dry abrasive wear resistability. Al/SiC exhibits greater toughness than Al/SiC + MWCNT.
3. Comparing with Al/Al₂O₃ and Al/SiC AMCs, Al/B₄C AMCs displayed superior particle dispersion along with bonding between two surfaces.
4. Non-uniform dispersion of the reaction product Si was created by the Al-SiC reaction alongside rising SiC whisker volume fraction along with infiltration temperature, SiC whiskers had a higher reactivity index than SiC particles, and it dropped when the infiltration temperature dropped.
5. Mg(Al)B₂ as well as Al₃BC compounds are created by interfacial reactions at higher hot pressing temperature of 630 C compared along with 560 C. The composites mechanical qualities were improved.
6. Most of the works suggested that strength and hardness of composites got better as involvement of reinforced material corresponding to SiC, B₄C, TiC, Al₂O₃, TiB₂, etc. B₄C provided rise in strength as well as hardness in contrast to others.
7. Deposition procedure has major advantage of producing a matrix microstructure with little segregation and too tiny grain size but it has numerous disadvantages. Technology can be employed only with discontinuous reinforcements, prices are prohibitively expensive, and products are restricted to basic forms achieved by extrusion, rolling, or forging. Physical vapour deposition may yield composites with constant fibre dispersion and fraction of volumes as high as 80%.
8. MMCs manufactured via spray deposition are generally affordable, with costs often falling in between stir casting methods. Spray deposition is explicitly beneficial for production of materials (metal matrix composites/alloys) that are hard for manufacturing using usual methods.

REFERENCES

- [1] Karbalaee Akbari, M., Rajabi, S., Shirvanimoghaddam, K., & Baharvandi, H. R. (2015). Wear and friction behavior of nanosized TiB₂ and TiO₂ particle-reinforced casting A356 aluminum nanocomposites: A comparative study focusing on particle capture in matrix. *Journal of Composite Materials*, 49(29), 3665-3681.
- [2] Surappa, M. K. (2003). Aluminium matrix composites: Challenges and opportunities. *Sadhana*, 28, 319-334.
- [3] Padmavathi, K. R., & Ramakrishnan, R. (2014). Tribological behaviour of aluminium hybrid metal matrix composite. *Procedia Engineering*, 97, 660-667.
- [4] Karbalaee Akbari, M., Rajabi, S., Shirvanimoghaddam, K., & Baharvandi, H. R. (2015). Wear and friction behavior of nanosized TiB₂ and TiO₂ particle-reinforced casting A356 aluminum nanocomposites: A comparative study focusing on particle capture in matrix. *Journal of Composite Materials*, 49(29), 3665-3681.
- [5] Shorowordi, K. M., Laoui, T., Haseeb, A. A., Celis, J. P., & Froyen, L. (2003). Microstructure and interface characteristics of B₄C, SiC and Al₂O₃ reinforced Al matrix composites: a comparative study. *Journal of Materials Processing Technology*, 142(3), 738-743.
- [6] Lai, S. W., & Chung, D. D. L. (1996). Consumption of SiC whiskers by the Al-SiC reaction in aluminium-matrix SiC whisker composites. *Journal of Materials Chemistry*, 6(3), 469-477.
- [7] Azam, M. U., Ahmed, B. A., Hakeem, A. S., Irshad, H. M., Laoui, T., Ehsan, M. A., ... & Khalid, F. A. (2019). Tribological behaviour of alumina-based nanocomposites reinforced with uncoated and Ni-coated cubic boron nitride. *Journal of Materials Research and Technology*, 8(6), 5066-5079.
- [8] Zhou, Y. T., Zan, Y. N., Zheng, S. J., Wang, Q. Z., Xiao, B. L., Ma, X. L., & Ma, Z. Y. (2017). Distribution of the microalloying element Cu in B₄C-reinforced 6061Al composites. *Journal of Alloys and Compounds*, 728, 112-117.
- [9] Zan, Y. N., Zhang, Q., Zhou, Y. T., Wang, Q. Z., Xiao, B. L., & Ma, Z. Y. (2019). Enhancing high-temperature strength of B₄C-6061Al neutron absorber material by in-situ Mg (Al) B₂. *Journal of Nuclear Materials*, 526, 151788.
- [10] Pulkit Garg, P., Jamwal, A., Kumar, D., Sadasivuni, K. K., Hussain, C. M., & Gupta, P. (2019). Advance research progresses in aluminium matrix composites: manufacturing & applications. *Journal of Materials Research and Technology*, 8(5), 4924-4939.
- [11] Chandla NK, Yashpal, Kant S, Goud M, Jawalkar C. Experimental analysis and mechanical characterization of Al 6061/alumina/bagasse ash hybrid reinforced metal matrix composite using vacuum-assisted stir casting method. *Journal of Composite Materials*. 2020;54(27):4283-4297.



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