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# Review of Aluminium Composites and Its Reinforcements

Prashanth B[1*], Yogesh B[2], Dr. N B Doddapattar[3], Vijaykumar M Patil[4]
[123]*Department, of Mechanical Engineering, Cambridge Institute of Technology North Campus*
[4]*Department, of Mechanical Engineering, Nagarjuna College Engineering and Technology*

***Abstract***: The demand for better, improved and efficient materials has increased many folds over the recent years. In this regard, Aluminium Metal Matrix Composites have gained considerable traction as an alternative for conventional materials. Reinforced AMMCs have been researched extensively with an additive to improve specific properties based on the application. The main applications of AMMCs are in Engineering sectors like automotive, aerospace, marine and electronics. Based on the application, the mechanical and tribological properties of the AMMCs are improved by the addition of commercially available reinforcements like Al2O3, SiC, TiC, SiO2, B4C and other silicon-based reinforcements. A review of the Aluminium composites, methods of manufacturing and reinforcements used are discussed with an account of the research work done by other researchers.
***Keywords***: AMMC, Stir casting, Wear

## I. Composite materials

A rapid growth in the technology used in the industry has given way to a new generation material called composites. They are made up of two or more physically and chemically different materials arranged in a specific order to meet the required application. The main constituent is called as the matrix and the additive is known as reinforcement. Out of the many composite materials available, Aluminium composites are gaining headway into the new generation as the most versatile matrix material.

### 1.1 Properties of al composites materials

Microstructure, volume fraction isotropy and homogeneity of the system are the factors that determine the properties of a composite. These properties are influenced by the proportions and properties of the matrix and the reinforcement.

#### 1.1.1 Physical Properties

Density plays a very important role in the study of composite materials. This is because every application requires the material to be lightweight with improved properties. Low density with improved properties is achieved by using additives to the aluminium alloy.

#### 1.1.2 Mechanical Properties

Improvements in the mechanical properties of the composite materials are a major attraction for the composite materials. Properties such as Tensile strength, hardness, wear resistance, youngs' modulus etc are studied extensively. These properties are easily modified in a composite material by using reinforcements.

#### 1.1.3 Tribological Properties

Better tribological properties such as wear-resistance are also studied extensively in the composite materials research as the composites will be subjected to wear during everyday use. Commonly, the wear resistance of a material is tested using Pin-on-Disc, Pin-on-Flat, Pin-on-Cylinder, thrust washers, Pin-into-Bushing, Rectangular Flats on a Rotating Cylinder and such others.

## II. METALMATRIX COMPOSITES

The potential advantages of the MMCs have piqued the interests of several researchers to do extensive research on them and have pushed the research on materials into a new era. Application of advanced composite materials in structural components is attractive due to their good stiffness/strength-to-weight ratios. The increasing demand for lightweight, energy-saving, materials, in the transportation industries, has steered the research in the direction of aluminium MMCs.

Aluminium MMCs have proven to be of high strength-to-weight ratio that has already replaced many of the conventional Fe-based materials. AMMCs can be modified easily to fit the needs of the application. Particle reinforced metal matrix composites (PRMMCs) have great potentials for various applications ranging from defence, automotive and aerospace industries because of their high specific strength and modulus, low thermal expansion and isotropic properties [36].

Aluminium-matrix composites (AMCs) reinforced with hard ceramic particles have emerged as a potential material especially for wear-resistant and weight critical applications such as brake drums, cylinder liners, pistons, cylinder blocks, connecting rods, and so on. [3][29]

Production of defect-free bulk and surface composites with a good distribution of the reinforcing material has been reported aluminium matrix composites like Al/SiC, Al/$Al_2O_3$ Al/NiTi, Al/ CNT Al/Fullerene, Al/Ni, Al/$TiO_2$. Various aluminium metal matrix composite systems, with reinforcing phases such as $B_4C$, SiC, $Al_2O_3$, BN, and AlN. These materials can be prepared by using different types of AMCs with different reinforcements such as $Al_2O_3$, **Error! Reference source not found.** SiC, [10] $SiO_2$, [11] $B_4C$, [16] ZrSiO4 [28] and Graphite [35] and has been studied in detail. In addition, metal matrix composites (MMCs) show good performance at high-temperature environments **Error! Reference source not found.**-[28].

## III. Processing of AMMCs

Liquid state and solid-state processing have emerged as the two primary processing methods for AMCs. In liquid state process, the reinforcement used is distributed in the molten aluminium base matrix. The mixture is mechanically stirred to achieve an even distribution of reinforcement. Recently many other techniques have emerged for liquid state processing of AMCs. Some methods are discussed below.

Squeeze casting process uses pressure on the solidifying liquid metal. Initially, a known quantity of the molten metal is poured into the die cavity and pressure is applied till the molten composite solidifies. When the casting cools down, it is taken out of the die and prepared for further processing.

Ultrasonic Assisted Casting combines solidification processes with ultrasonic cavitation-based dispersion of nanoparticles in metal melts has been developed. Ultrasonic cavitation can produce transient (in the order of nanoseconds) micro ‘hot spots’ that can have temperatures of about 5000ºC, pressures above 1000atms, and heating and cooling rates above 1010 K/s.

In solid-state processing, the matrix is used in the powder form and then this powdered matrix is mixed with the reinforcement and blended. The final mixture is compacted using mechanical means and the compacted AMCs are sintered to achieve a solid block of the AMC with the reinforcement. Further processing can be done on the sintered AMCs to achieve further improvement in its properties.

## IV. Reinforcements

Reinforcements can come in all shapes, sizes and materials. Following are some of the naturally occurring reinforcements that are being studied.

### 4.1 Rock Dust as a Reinforcement

In a study performed by K. Surya Prakash et al., [34] AMC composites with rock dust reinforcements of particle size of 10, 20 30um and mass fraction 5%, 10%, 15% using a stir casting process. The process parameters of Rock dust particle size, Mass fraction of rock dust, applied load, sliding velocity and sliding distance are considered as an influencing parameter on wear. Dry sliding wear tests conducted on AA6061-rock dust composites based on Taguchi orthogonal array L27. Orthogonal array using pin-on-disk wear test carried out using pin-on-disk wear test over a load range of 10-20N and sliding velocity of 2-4m/s for a various sliding distance of 1-2km. From the results, it is observed that the wear resistance of Aluminium composite decreases with increasing rock dust particle size, due to small size rock dust particles filling the gaps in the composite, and it forms the strong bonding strength, and wear resistance decreases with increasing the mass of rock dust particles, and due to strong bonding strength at 5% rock particles, and it decreases with increasing rock dust particles. As the load and sliding distance increases, the wear resistance increases and it decreases with increasing sliding velocity.

### 4.2 Quarry Dust as a Reinforcement

M. Ramesh, et al. [31] studied the effect of varying weight percentage of reinforcement in the A-356 alloy. The composite was reinforced with a weight percentage of 0, 5, 7.5, and 10 of quarry dust by the stir casting process. Dry sliding wear tests conducted on Aluminium metal matrix composites using pin- on –disc wear testing equipment overloads of 19.62, 29.43, 39.24N and constant sliding speed of 1m/s, and sliding distance 1500m. Mechanical tests conducted on the aluminium metal matrix composites. From the results, it is observed that the hardness and tensile strength of the A356-quarry dust composite increase with increasing the weight percentage of quarry dust, due to the presence of hard quarry dust particles. The wear resistance of Aluminium metal matrix composites increases with increasing the quarry dust particles, due to strong bonding between the quarry dust and A-356 alloy. The wear of the aluminium metal matrix composites increases with increasing the load from 19.62 to 39.24N.

In his study, M. Ramesh. [32], reinforced A-356 alloy with 5 weight percentage of quarry dust by the stir casting process. Dry sliding wear tests conducted on Aluminium metal matrix composites using pin-on-disc wear testing equipment over a load of 20-60N and at a constant sliding velocity of 0.5m/s, and sliding distance 500m. The wear rate of Aluminium metal matrix composite was compared with the Gray Cast Iron disk. From the results, it is observed that the wear resistance of the Aluminium Metal matrix composite is more than that of the Gray Cast Iron disc, due to the presence of hard quarry dust particles. The wear rate of the Aluminium Metal matrix composite decreases with increasing the load and at higher load, the wear rate of the AMC disc is equal to the Gray cast iron. At constant applied load on AMC disc and Gray Cast Iron disc, the coefficient of friction of Gray Cast Iron disc is lower than that of the AMC due to presence of graphite. The graphite act as a solid lubricant in Gray Cast Iron.

### 4.3 Wet Grinder Stone Dust as a Reinforcement

"Wear behaviour of Aluminium Metal matrix composites prepared from Industrial Dissipate" by L. Francis et.al. [37] In this study, AA6063 alloy reinforced with a weight percentage of 10, 20 of wet grinder stone dust by two-step stir casting process. In the first step, wet grinder stone dust particles preheated for removing the moisture and improving the wettability. AA6063 metal matrix produced by the addition of preheated wet grinder stone dust to the semi-solid state alloy. Dry sliding wear tests conducted on Aluminium metal matrix composites using pin-on-disc wear testing equipment over a load range of 9.81-29.43N at a sliding velocity of 1.57-4.71m/s for a various sliding distance of 1-3km. The mechanical tests conducted on the AA6063 metal matrix composites. The results indicate that the hardness, Yield behaviour and strength of the AA6063 alloy are improved with the addition of wet grinder stone particles due to reason that, wet grinder stone dust possess hard $Al_2O_3$ particles. The wear resistance of Al6063 metal matrix composite is more than that of the AA6063 alloy, due to due to the formation of the oxide layer by transfer of materials in dry sliding of steel pin surface against the Aluminium metal matrix composites. The oxide layer act as a protective layer. The oxide layer thickness increases by adding more wet grinder stone dust particles, and it enhances the wear resistance of the base matrix.

## V. Inexpensive Reinforcements for AMMCs

### 5.1 Rock Dust

Rock dust is obtained from crushing of rock. It is a dissipate material and it is reused as reinforcement in the fabrication of Aluminium metal matrix composites. The addition of rock dust to the aluminium alloys increases the wear resistance.

### 5.2 Quarry Dust

Quarry dust is obtained from cutting and crushing of rock. It is a dissipate material, and dumping in the air, it may cause air pollution. Now a day's, quarry dust is used for road construction and fabrication of lightweight bricks and tiles. It is a dissipate material, and it is reused as reinforcement in the fabrication of Aluminium metal matrix composites. The addition of rock dust to the aluminium alloy(A356) increases the wear resistance and hardness.

### 5.3 Wet Grinder Stone Dust

Wet Grinder stone dust is obtained from the processing of Quarry rock. It is a dissipate material and dumping in the environment, it may cause environmental pollution and health problems. Therefore, it can be re-used as reinforcement in the manufacturing of Aluminium Metal matrix composites, to reduce environmental pollution. The addition of wet grinder stone dust to the Al6063 alloy increases the wear resistance.

## VI. Conclusions

An exhaustive literature survey is presented in this paper on AMCs and natural reinforcements. The most common process used for preparing AMCs is stir casting process although new and highly efficient techniques are being discovered. Powder metallurgy has proven to be the better alternative when compared to the other processes of manufacturing AMCs because of its simple operation and is also cost-effective since it does not require heavy machinery or complicated processes. Natural reinforcements from dissipate materials like Rock Dust, Quarry dust, Wet grinder stone dust, Red mud, Bore sand, Jute bast Ash and Bamboo leaf Ash can be used as an alternative to the comparatively more expensive synthetic reinforcements.

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