



ALUMINIUM-BASED METAL MATRIX COMPOSITES WITH LOW-COST REINFORCEMENTS: A REVIEW

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Abstract

Aluminium metal matrix composite (Al MMC) is most promising sector due to its extraordinary properties of great strength to weight ratio, low specific gravity, improved corrosion resistance, optimum wear resistance and low thermal expansion. Aluminium matrix composite is mainly used in automobile and aviation and now a day's used in construction site for making aluminium frames. Al MMC has two phases, one phase is parent aluminium phase makes impregnate structure network called matrix and second phase is reinforcement implanted in Aluminium matrix to meet the product requirement. Reinforcement usually is hard and stiff ceramic materials (Al₂O₃, SiC, B₄C) and heavy metals (W, Mo, Ti, Pb) which distributed the load of Al matrix and enhanced the mechanical and tribological properties of metal matrix composite materials. Characteristics of Aluminium metal composite can be tailored based on nature and weight proportion of reinforcement.

2020 Mathematics Subject Classification: 74A40.

Keywords: Aluminium metal composite, Reinforcement, Strength to Weight Ratio, Rice Husk.

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Received January 15, 2022; Accepted May 18, 2022

1. Introduction

Today's consumer markets are running by two types of institution, one is service based and second is product based. In product-based institution composite material contribute crucial role to achieve competitive market goals by altering or enhancing manufactured material characteristics. The main motivation for development a composite material having high strength to weight ratio with low specific gravity [1]. From the past Bronze Age to this Modern ere, human used this composite so many forms such as building blocks, archery, plywood, concrete etc where building block is made by clay mud with dried tree straw make suitable to with stand virtue of environment effect. Concrete material is mixture of stone aggregate, sand and limestone. From past few decades concrete strength is enhanced through reinforcing it by steel rods or wire which called reinforced concrete cement (RCC). Environment also have some natural composite like bone, wood, muscle etc where Bone is combination of protein collagen and durable outer covering of calcium phosphate, here protein character is soft and also present in nails and hair. Wood is also natural composite material having arrangement of polymeric cellulose fibre with lignin as reinforcement. Cellulose present in flower, grass and cotton etc. which is flexible in nature and with combination of nutritional fibre lignin make in strong enough to withstand the environmental adverse effect.

1.1 Context of Aluminium composites

Composite material is low-density high-performance material which enhances the mechanical and tribological properties of manufactured product by selecting suitable material as matrix and appropriate element as reinforcement for fulfil consumer requirements. Composite materials have following quality to meet consumer need: high strength to weight ratio, Optimum elasticity to mould into complex shape, high tensile strength and high rigidity, Optimum thermal and electrical specific conductance, Superior fatigue and impact strength at higher temperature, low specific gravity, high erosion and corrosion resistance [2].

1.2. Matrix and reinforcement

Composite have two phases one is matrix and second one is

reinforcement. Matrix phase is moderately elastic and bendable to achieve to complex shape and reinforcement are comparable durable and rigid phase having high tensile and flexural strength, high stiffness and rigidity to supply better load bearing capacity. Reinforcement is basically surrounded by matrix phase where matrix should attach and grip tightly this reinforcement to this particular structure. Matrix should choose wisely, which protects the material from atmospheric contamination and oxidation to prevents material from oxidation and abrasion. Matrix phase primarily form a new strain field embedded by reinforcement which restrict movement of dislocation density and supports the strengthening mechanism. Reinforcing phase should strong and stiff enough to afford better wear and fatigue resistance hence matrix phase offers adequate flexibility and reinforcing phase which withstand high load condition to fulfil the consumer and product requirement [3]. Selection of proper matrix and reinforcing element dependent upon following factor:

1. Mechanical and chemical characterization of matrix and reinforcement material.
2. Atomic bonding characteristics between matrix phase and embedded reinforcement.
3. Fractography and chemical composition about ingredient (matrix and reinforcement).
4. Size and volume of reinforcement element.
5. Manufacturing process involvement for development of new composite.
6. Surface treatment and atmospheric condition of ingredient.

2. Reinforcement Material for Al MMC

Reinforcement of Aluminium metal composite (AMC) enhances the mechanical strength and wear resistance with decreasing the specific gravity of composite material. So, reinforcement led to Reduce the overall cost of composite material by using light material high performance reinforced material. Properties of reinforcement can be altering by nature and weight proportion of reinforced constituent on matrix compound characteristics is mainly dependent upon shape, size, volume, treatment behaviour reinforcement and also chemical and thermal relationship between matrix and reinforcement play a vital role in selection of reinforcement [4]. From the previous research and development, it had seen that hard and brittle ceramic

material like SiC, Al₂O₃, B₄C, graphite, rutile etc enhanced the mechanical and wear properties [5] [6].

2.1 Red Mud

Red mud is basically bauxite ore residue from aluminium extraction through Bayer process. Around 30 to 40% ore processed into red mud. Approximately 15 million metric tons red mud processed from aluminium extraction worldwide yearly. Its disposal becomes tedious task due to high alkaline nature (pH 10-12), caustic behaviour for plants and living being, hygroscopic nature, toxicity [8]. Red mud also contains so many industrial compounds such as Fe₂O₃, Al₂O₃, TiO₂, CaO etc catch the attention of many researchers to use this waste material in building industries for making brick, tiles, cement material, absorbent material for removal of heavy metal as Arsenic, lead, sulphur etc and used as absorbent for removal of dye from water solution.

2.3 Rice husk ash

Rice husk is agricultural product used as bio sorbent material for removal of acid, heavy metal and methylene dye from waste solution. In India around 120 million tons rice produced every year. Outer hard face covering of rice grain is called husk and contribute approximately 30 to 40% weight of rice. High calorific value of rice husk (approx. 50% of coal) maintains to use as fuel in boiler for steam production and also in rice mill during parboiling. As per the data around 25 kg ash contain processed by burning of rice husk and its tiny small particle creates air pollution while exposed to open environmental space. Rice husk ashes are very rich in silica contain of around 90% which is basically hard and fragile ceramic matter [11].

2.4. Wheat husk ash

India is second most producer of wheat after than China as per the report around 110 million tons wheat produced yearly in India which is almost 20.31% of total production worldwide. Wheat husk is outer hard covering of golden wheat grain which extracted by milling from the grain wheat and occupied almost 35% of weight of wheat. Wheat husk have calorific value of almost 4000 Kcal with almost 10% ash ratio. Due to its high calorific value husk part can be used as fuel for captive power plant, in oil industries and

small industries for soaking and burning. As ash contain is almost 10% so by burning 100 kg of wheat husk, 10 kg of wheat husk ash generated. This ash contain creates some environmental issue to raising the smog at time of winter. So controlled burning and handling of this ash contain lead to utilized it for removal of heavy metals and contamination or use as bio sorbent material, for replacing Portland cement in building industries but very few research is done for reinforcing AMC material [13].

2.5 Coconut shell ash

Coconut is basically soft whitish fruit of coconut palm tree. In India around 10 million people were benefited by coconut production. As per the data in year of 2019 India produced around 14.20 million metric tons of coconut having third producer worldwide. Coconut shell utilized as adsorbent material for removing heavy metals and other contamination from waste water solution, in medical line for making medicine and also used for making activated carbon by burning it to high temperature in kiln. So, after burning around 8% of ash contain is remaining is called coconut shell ash [15].

2.6 Sugarcane baggase ash

India becomes second producer of sugarcane by producing almost 370 million tons sugarcane every year. Baggase is waste by product of sugarcane after extraction of juice from the fruit around 15% baggase converted by sugarcane which utilized in paper pulp industries and cattle field industries. The main uses of baggase are used as fuel in own sugar industries to overcome own requirement of coal and some fossil fuel.

4. Conclusions

The current evaluation effort is primarily concerned with assessing the feasibility of employing a mix of industrial waste and biosorbent materials as reinforcement in an aluminium metal matrix composite (AMC). Furthermore, the addition of industrial waste and biosorbent to Al MMC composites can have a favorable impact on the hardness, ultimate tensile strength, compressive strength, and dampening of mechanical vibrations of the material.

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