A Review on Utilization of Waste Material as Reinforcement in MMCs

Ajit Kumar Senapati1, Pratik Kumar Sahoo2, Akash Singh3, Shaktipada Dash4, Viplav Saumya Manas5

Associate Professor1, Students 2,3,4,5, Dept. Of Mechanical Engineering, GIET, Gunupur, Odisha, India
Email: pratik.sahoo94@gmail.com

Abstract- The application of waste material in Metal Matrix Composites has been getting more attention as they can reinforce particles in metal matrix which enhance the strength properties of the composites. In addition, by applying these wastes materials in useful way not only save the manufacturing cost of products but also reduce the pollutions on environment. This paper represents a literature review on a range of waste materials from different sources and their utilization in metal matrix composites. The paper describes the synthesis methods of waste filled metal matrix composite materials and their mechanical, wear, corrosion, and physical properties. It also highlights the application composites in aerospace, automotive and other construction industries.

Index Terms- MMC, Fly Ash, Rice husk, Coconut shell, Density, Hardness, Mechanical Properties, Wear.

1. INTRODUCTION

Composite materials are the materials made from two or more constituent materials with different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. Nowadays Composite materials are extending the horizons of designers in all branches of engineering. In composites, materials are combined in such a way that to enable us to make better use of their virtues while minimizing to some extent the effects of their deficiencies [1]. This process of optimization can release a designer from the constraints associated with the selection and manufacture of conventional materials.

MMCs are advanced engineering materials consisting of one or more reinforcements in a metal matrix to get a desired set of properties. Metal matrix composites (MMCs) possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys [2-4]. The MMCs provide much better physical, mechanical, and tribological properties as an advanced material w.r.t the conventional materials in their application field [5].

Aluminium metal matrix composites (MMCs) have gained importance in various industries because of their good Mechanical properties. Al-alloy is used as a matrix due to its good casting abilities, high corrosion resistance and low density [6]. Incorporating the various composite particles into the Al-alloy matrix, creates a significant increase in the hardness, tensile strength, fatigue strength, flexural, stiffness and wear resistance with low coefficient of thermal expansion and higher thermal conductivity [7].

There has been an increasing interest in composites containing low density and low cost reinforcements. Composites produced using waste as reinforcements helps not only clearing environmental issues but also helps in increasing mechanical properties of the composites. The growth of world population and increase of living standard due to technology development have increased the quantity of waste materials generated through industrial, mining and agriculture activities. The waste materials are hard to disposal and thus a major concern to environmental pollution. Therefore, recycling of waste material by converting it into green material for application in aerospace, automobile and construction industries is a prime concern among the current researchers [8-9].

One of the inexpensively available and also coming as waste form thermal power plant is fly ash [10-12]. Fly ash particles are discontinuous dispersions in the form of hollow spherical in shape used in MMCs, since they are low density and low-cost reinforcement available in large quantities as a waste in thermal power plants fabrication of MMCs is very promising for manufacturing near net shape components at a relatively low cost.[13]

Similarly other agro based wastes such as coconut shell and rice husk are potential materials for composites production. These wastes are not only found abundantly but also proved to be a good additive for composite material [14]. Use of these agro-wastes will solve but their storage and handling as a threat to the environment [15].
The use of the waste materials as composites can turn industrial waste into industrial wealth. This also solves the problem of storage as well as bring down the production cost giving an economical and eco-friendly solution.

This paper represents a literature review on a range of industrial wastes and their utilization in metal matrix composites. The paper describes the synthesis methods of agro-industrial waste filled metal matrix composite materials and their mechanical, wear, corrosion, and physical properties.

2. EXTENSIVE LITERATURE REVIEW

2.1 Review on Fly Ash as a reinforcement

A.K.Senapati et al. (2014) [16] conducted an experiment on the production of metal matrix composite by continuous stir casting method by taking LM6 as the base alloy along with two fly ash samples. Impact strength, Compressive strength and micro hardness were studied by using Charpy-V-Notched machine, Universal Testing Machine and Brinell hardness machine respectively. Here they found that addition of fly ash to Al-Si metal matrix composite improved the micro hardness, impact strength and compressive strength of LM-6.

G.N.Lokesh et al. [13] conducted study on Tensile and wear behaviour of Al-4.5%Cu alloy reinforced fly ash/SiC by stir and squeeze casting with rolled composites. The results indicate that the hardness and tensile strength increases with increase in percentage of fly ash and SiC by stir, squeeze and rolled composites. The squeeze cast composites exhibit 16% higher hardness, 12% higher tensile strength for 4% fly ash and 6%SiC composite when compared to corresponding stir cast composites. But the rolling composites exhibit better mechanical properties when compared to squeeze cast composites.

The rolled composites manifest higher wear resistance as compared to both vortex and squeeze cast composites. Microphotographs of rolled composites shows better bonding between matrix, fly ash and SiC with no fracture observed at matrix particle interface after 30% reduction. The test results showed that rolled specimens fabricated by stir casting technique have greater wear resistance than those fabricated by squeeze casting technique. Microstructure shows better bonding between matrix particle interface and no fracture observed in rolled composites. Chittaranjan.v et al. [17] has studied Thermal Properties of Aluminum-Fly Ash Composite, it showed metal composites possesses have improved thermal properties like thermal expansion, thermal cracking, thermal resistance compared to other metals. Incorporation of fly ash particles in Aluminum matrix causes reasonable decrease in Thermal conductivity. The strengthening of the composite can be due to dispersion strengthening as well as due to particle reinforcement. The density of the composites decreased with increasing ash content. Hardness of commercially pure aluminum is increased from 58BHN to 86BHN with addition of fly ash. Ultimate tensile strength has improved with increase in fly ash content. Whereas ductility has decreased with increase in fly ash content.

Arun.L.R et al. [18] conducted experiment on Aluminum alloy composite where they found these composites are hard, rigid, and tough and possess good mechanical properties their ductility will decrease and will gain better resistance to corrosion. The experiment was conducted on weight percentage basis SiC with 6 % and 9% and fly ash with constant 15 % and AL6061T6 alloy as matrix material. It was observed that Tensile strength of composite was enhanced and at 15% fly ash it is maximum when compared with Al6061 T6 it was increased by 23.26%.

Mr.Sharanabasappa R Patil et al. [19] did investigation on the mechanical properties of fly ash and Alumina reinforced aluminium alloy (LM25) composites samples, the Composite samples were having the reinforcement weight fractions of constant 3% fly Ash and varying %wt of 5, 10 and 15% Al2O3. The mechanical properties like Tensile strength and Hardness increases with increase in %wt addition of Al2O3,While at the other end ductility and impact strength will gets reduced .The poor wettability of the phases in the matrix is the major problem at higher weight fraction of reinforcement.
due to this problem the strength decreases after certain limit. But the problem can be overcome by adding small amount of Magnesium and by pre heating the composites and the die.

G.N.Lokesh et al. [20] studied effect of Hardness, Tensile and Wear Behavior of Al-4.5wt%Cu Alloy/Flyash/SiC Metal Matrix Composites. Here they were taking Al of 4.5wt%Cu alloy reinforced with Fly ash casted by liquid metal stirring casting technique. In this experiment they found that the hardness, tensile strength and wear resistance increased with increased in percentage of reinforcements also they found that Optical micro photographs shows better bonding between matrix, flyash and SiC with no fracture observed at matrix particle interface.

2.2 Review on Rice husk as a reinforcement

Kenneth Kanayo Alaneea et al. [21] studied the Corrosion and wear behaviour of rice husk ash Alumina reinforced and alumina as reinforcements has been investigated. Alumina added with 2,3, and 4wt. % RHA were utilised to prepare10wt.% of their reinforcing phase with Al–Mg Si alloy as matrix using double stir casting process Open circuit corrosion potential(OCP) and potential dynamic polarization measurements were used to study the corrosion behavior while coefficient of friction was used to assess the wear behavior. The corrosion and wear behavior of Al–Mg Si matrix composites containing 0:10, 2:8, 3:7 and 4:6wt.% RHA and alumina as Reinforcement was investigated and finally concluded that The corrosion resistance of the single reinforced Al–Mg–Si / 10 wt.%Al2O3 composite was superior to that of the hybrid composites in 3.5% NaCl solution ,the corrosion rates increased along with The coefficient of friction and consequently , the wear rate of the composites were observed to increase with increase in RHA wt %.

S.D.Saravanan et al. [14] studied the Effect of Mechanical Properties on Rice Husk Ash Reinforced with alumina as its reinforcement. A rice husk ash particle of 3, 6, 9 & 12 % by weight were used to develop metal matrix composites using a liquid metallurgy route. The surface morphology was studied using scanning electron microscope for analyze the distribution of RHA and derived the conclusion that the tensile strength increased with an increase in the weight percentage of rice husk ash in fig.1 due to the RHA particles act as barriers to the dislocations when taking up the load applied. D. Siva Prasad et al [22]. Studied the Production and Mechanical Properties of RHA Composites by vortex method .The ash was obtained by burning rice husk and was thoroughly washed with water to remove the dust and dried at room temperature for 1 day. Then it was heated to 200 ° C for 1 h in order to remove the moisture and organic matter. It was then heated to 600 ° C for 12 h to remove the carbonaceous material. The silica-rich ash, thus obtained, was used as a filler material for the preparation of composite. Here A356.2 alloy with the theoretic density of 2760 kg/m3 is used as the matrix material and RHA is used as the reinforcement having wt. % (4, 6 and 8) and observed that the hardness along with ultimate tensile strength increases and the density decreases with the increase in the RHA wt%.

Victor Sunday Aigbodion[23] studied the Development of Al-Si-Fe/Rice husk ash particulate composites synthesis by double stir casting method. The specimens were produced by keeping the percentage of iron and silicon constant and varying the rice husk particle (reinforced particles) in the range of 5-20%. And concluded that with the addition of rice husk ash particles to Al-Si-Fe alloy increases both the yield strength, ultimate tensile strength and hardness values up to a maximum values of 79.98, 106.12 Nmm2 and 67 HRB respectively at 15% rice husk ash addition.

S.D.Saravanan and M.Senthilkumar [24] have studied the mechanical Behavior of Aluminum (AlSi10Mg) in RHA Composite. Rice Husk Ash (RHA) of three different particle size ranges (50 – 75 µm), (75 – 100µm) and (100 – 150µm) in 3, 6, 9 and 12 % by weight was reinforced with the aluminium alloy using stir cast route. The result showed that there is a decrease in the tensile strength, compressive strength and hardness of the aluminum alloy composites with the increase in particle size of the (Stir Casting Method)

But the ductility of the composite decreases with the increase in the weight fraction RHA particles. This
result showed that this inevitably solves the problem of storage and disposal of RHA. The tensile strength, compression strength and hardness increases with the increase in the weight fractions of rice husk ash and decreases with increase in particle size of the rice husk ash. The enhancement in the mechanical properties can be well attributed to the high dislocation density. However, for composites with more than 12 wt % of RHA particles exhibits poor wettability.

Basavaraj Mathpathi and Bharat S Kodli [25] have studied the mechanical behavior of pure aluminium reinforced with Silicon Carbide and Rice Husk ash fabricated by liquid metallurgical (stir casting) method. The reinforcement silicon carbide and RHA were added in varying weight percentages of (3%-6%). The results were higher tensile strength with the increase in rice husk content and higher impact strength & hardness of the hybrid composite with increased SiC content. It was found that tensile strength increases with increase in rice husk whereas decreases with decrease in rice husk content. The impact strength and hardness of the composite increases with increase in SiC content while it slightly decreases with increase in rice husk content.

Ankit Mittal and Ramnarayan Muni [26] have studied the mechanical behaviour of aluminium alloy used as matrix and RHA and copper as reinforcements. RHA is the only agricultural waste that contains the larger amount of silica in it. For increasing wettability between metal matrix and reinforcing particles magnesium is used here. The rice husk ash were added in 8%, 16%, 24%, 32% by weight and copper 3% by weight to the molten metal. With the variation in weight fraction of reinforced particles with/without copper it was observed that the specimens containing copper showed improved values for hardness than those specimens containing only rice husk. This experiment results showed that a good hardness and strength of these composite can find application where light weight materials are supposed to be required. The hardness of prepared composites are increased by increasing rice husk ash and copper content.

Pallavi Deshmukh et al. [27] focused on the changes in the mechanical properties of the Al based MMC composites which were synthesized by reinforcing amorphous nano sized (32-56nm) rice husk SiO₂ particles and metallurgical grade SiO₂ particles (10 µm) in Al-Mg alloy by liquid metallurgical route with varying percentage of Mg. Improved mechanical properties was observed in the composite synthesized by the using Rice Husk Silica in comparison to metallurgical grade silica. The micro hardness of the Al-Mg- SiO₂ was found to be maximum for 2.5% of Mg and by using rice husk SiO₂ of nano structure dimension as reinforcement. Wear loss in this composition is found to be less.

2.3 Review on Coconut shell as a reinforcement

J.O. Agunsoye et al. [28] conducted dry sliding wear behavior and mechanical properties test on recycled aluminum metal matrix composite reinforced with 5 and 10 % coconut shell particles under varied loads and speed using pin on disc equipment and found that the strength and yield stress of the composite increased with the addition of the coconut shell particles to the waste aluminum can linearly which is due to hindrance offered by the coconut shell to dislocation of the aluminum particles. The addition of coconut shell improved the wear resistance of the composite at low speed.

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5-25% volume fraction of coconut shell particles. The result obtained to be is that hardness of the composite increases with increase in coconut shell content whereas the tensile strength, modulus of elasticity, impact energy and ductility of the composite decreases with increase in the particle content.

3. CONCLUSION

In last four decade, many researches had been done in order to reduce the cost of producing reinforced material. With the availability of waste material with possible use of combining with composites, the development kept on increasing with rapid experimentation for producing the Similar results as the existing material. With thorough extensive review, conclusions can be made that, addition of waste material such as fly ash, rice husk and coconut shell enhanced the physical, mechanical and tribological properties of the metal matrix composite. These MMCs can be utilized in automotive, industrial and construction as reinforce to produce better composites. An estimated value of particles content needed in order to increase the mechanical properties of existing material.

REFERENCES


