MECHANICAL CHARACTERISTICS OF FLY ASH REINFORCED ALUMINIUM METAL MATRIX COMPOSITE-ART OF REVIEW

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ABSTRACT

Composites are widely utilized in the industries like automobile, aircraft, space craft, transport, generation of wind-power and so on due to its lightweight and inexpensive. Recently, dissimilar physical and chemical features of materials are intercorporate to produce an innovative composite material. Many researches had performed research on those composite materials. In this research, fly ash materials are utilized in the form of reinforcement due to their improved mechanical characteristics like enhanced UTS, impact and compressive strength, toughness and low intensity and ductility. Fly ash is also known as fuel ash. In this research fuel ash is reinforced with aluminium metal matrix composites. MMC are prepared by using the fabrication techniques of solid and liquid stage.

Keywords: Fly ash, MMC, Mechanical Characteristics

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1. INTRODUCTION

The potential for widespread application of cast composite materials is very great in India particularly in fields of transport, power engineering, and electrical and mechanical equipment. Expanded use of composite materials could lead to great investments in substances, energy and in various areas diminish environmental contamination. Significant progress was made in the areas of cast MMC since cast aluminum-graphite particle composites were first synthesized in 1965. Stir casting and pressure infiltration have emerged as the two major processes to make composites. Generally, MMC is made up of discontinuous or continuous fibers, particulates or whiskers scattered in a metal alloy matrix. This strengthening offers composite materials with characteristics that are not feasible in monolith alloys.

2. FUEL AND FLY ASH

Fuel ash, being a complete waste substance resulting from burning coal in power stations there is a need for environmental handling in order to prevent its dumping on the waste grounds or waste disposal sites. The fuel ash may be a very attractive material as the reinforcing phase in metal matrix composites through an economic and environmental perspective and perspective of a mixture of physical and chemical characteristics. MMC produced by the diffusing coal fuel ash in alloys of aluminum has led to enhanced mechanical characteristics and durability.

Babu Rao et al (2010) presented that fuel ash can be divided into two kinds namely the cenosphere and precipitator. Monochromatic spherical particulates of fuel ash are referred to as precipitator fuel ash and the hollow particulates of fuel ash that contain densities not more than 1.0 g/cm^3 are referred to as cenosphere fuel ash. The addition of precipitator fuel ash particles in aluminium alloy improved the stiffness, strength, and durability. However, adding fuel ash decreased the density of composites. Cenosphere fuel ash consisting of hollow fuel ash particulates may be utilized for the synthesis of ultra-light composite parts because of its lower density. Fuel ash primarily includes elements like silicon, oxygen, iron, aluminium, calcium, sodium, magnesium, titanium, and potassium. Integration of fuel ash particulate matter in the Al alloy promotes the usage of fuel ash and has the ability to conserve energy-consuming aluminium, thus lowering the cost of products of aluminium.

Rohatgi et al (2006) reported that the incorporation of fuel ash into aluminium castings decreased the content of energy and material, expense and mass. Fly ash was incorporated in the Al alloy matrix using techniques of pressure infiltration and stir casting. The sand and persistent mold castings demonstrated sufficient actability of aluminium molten contains up to 10 % by volume of fuel ash particulate matter. The thickness and the factor of growth of heat of castings has been reduced with growth in the content of fuel ash. Toughness and resistance to wear increased as the content of fuel ash increased. UTS of heat-treated composites (T6) containing not more than 8 vol% fuel ash was similar to that of the aluminium alloy.

LI Yue-ying et al (2007) examined the mechanical behaviors of aluminium fuel ash particles synthesized through squeeze casting method. The hardness of the composite materials was greater in comparison to the Al matrix and augmented with increased fraction of volume of fuel ash particulate matter. The tensile strengths and elongation of composites are lower than that of the Al matrix and decreased with increase in volume fraction of fly ash particles.

Rohatgi et al (2005) observed that the availability of fuel ash cenospheres in pure aluminium matrix has reduced the coefficient of enlargement in heat. Growth in pressure

applied and the time of infiltration decreased the coefficient of thermal expansion. The rise in the pressure of infiltration and temperature improved the infiltration and decreased the entrapment of atmospheric cavities.

3. MMC

The materials of MMC have a grouping of better characteristics when compared with an unreinforced matrix-like enhanced strength, more elevated modulus of elasticity, elevated service temperature, enhanced resistance to wear, excessive electrical and heat conduction, lower coefficient of heat enlargement and the high vacuum ecological durability. These qualities can be achieved with the correct selection of the reinforcement and matrix.

4. WEAR BEHAVIOUR OF ALUMINIUM COMPOSITES

Aluminum-based MMC has discovered the application in producing different engine components of automobiles like piston insert rings, engine blocks, and pistons in which adhesive wear is a prevalent procedure. Materials that possess the high durability (under the conditions of dry sliding) are linked to the stable tribo layer on the surface of wearing and the creation of fine equiaxial debris of wear. The impact of load exerted, morphology, speed of sliding, the hardness of the surface, strengthening fracture strength were key factors for adhesive wear compared to the wear mode experienced by the matrix material.

Rohatgi and Guo (1997) observed that the abrasion of aluminium alloy which contains 5vol% fuel ash was better in comparison to the base alloy of A356 under an 8 N of load at a 1 m/s of velocity of sliding. Reduction in the specific rate of wear with the rise in the load was due to the accumulation of debris of wear in the interstices among abrasive particulates and observed sub surfaces under the surfaces of rubbing of composites and the base alloy.

Samrat Mohanty and Chugh (2007) embedded fuel ash composites in automobile brake pads friction composite materials. The components like Phenol formaldehyde resins, glass fiber, aramid pulp, aluminium fiber potassium titanate, copper powder, and graphite have been utilized in compound development stages by adding fuel ash. Industrialized brake pads composite materials have demonstrated a coherent coefficient of friction and wear rates.

Mahendra and Radhakrishna (2005) produced aluminium 4.5% copper alloy fuel ash particles bush by a method of stir casting. The bush constructed from the compound has demonstrated more wear resistance than the aluminium alloy under lubricated conditions for 200 hours. The cylindrical liner was cast from the compound and then analyzed in a two-stroke gasoline engine. No seizure was detected in the cylinder liner even after 400 hours of testing.

5. TRENDS OF MECHANICAL PROPERTIES AND DISTRIBUTION FLY ASH - REINFORCEMENT IN ALUMINIUM COMPOSITE MATERIALS

The materials of MMC have a grouping of better characteristics when compared with an unreinforced matrix-like enhanced strength, more elevated modulus of elasticity, elevated service temperature, enhanced resistance to wear, excessive electrical and heat conduction, lower coefficient of heat enlargement and the high vacuum ecological durability. These qualities can be achieved with the correct selection of the reinforcement and matrix.

Manoj Singla et al. (2009) increased the rigidity, strength of impact and displacement of normalization through increasing the formulation of SiC in aluminium matrix. Standardized

dispersion of particles SiC in the Al matrix showed a growing trend in the tests made by the two-step technique of stir casting.

Tamer Ozben et al (2008) examined the effect of SiC reinforcement in aluminium (Al/7Si/2Mg) and noted that increasing SiC has increased the UTS, hardness, and density of Al/SiC composites, the impact toughness decreased with increase in SiC particles. The machinability of MMC was very less compared to traditional materials because of the abrasive reinforcement element.

Bayraktar et al (2008) examined the damage mechanism of aluminium silicon carbide composite materials in as received and conditions of heat-treated of the composites fabricated with various production methods. The rupture was started in the interface (matrix /SiC) with large debonding interfacial the matrix and particles SiC causes reduced fatigue strength. The mechanical performance of these composite materials was associated with particulate geometric shapes, deployment and the number of reinforcement molecules in the matrix.

Chennakesava Reddy and Essa Zitoun (2010) reported that the strength of yield, UTS, and the plasticity of aluminium silicon carbide MMC are in the reverse order of Al 6061, Al6063 and Al7072 matrix alloys. The entire contents of alloy components like Fe, Si, Cu, and Mg play a significant role in mechanical performance of SiC /Al composite materials. Mg enhanced wetness among the particles SiC and Al by lowering the layer of SiO₂ on the SiC surface. Fractured modes of composites are ductile in nature.

Veeresh Kumar et al (2010) were successful in adopting the liquid metallurgical techniques in preparing Al7075-Al₂O₃ and Al6061-SiC composites and found that composites of Al6061-SiC exhibited excellent UTS performance in comparison of composites of Al7075-Al₂O₃. The resistance to wear of the composite materials are larger, SiC significantly improved the abrasive resistance of composite materials in comparison to composites of Al₂O₃.

Neelima Devi et al (2011) found that weight to the power proportion of Al SiC composite was approximately three times that of mild steel. The composite material of Al SiC was twice less on the mass in comparison to aluminium for equal size.

Anilkumar et al., (2010) described the results of an empirical study of the mechanical characteristics like hardness, ductility, compressive and UTS of reinforcement of fly ash with samples of Al 6061 composites. The plain Al6061 composites have also been tested with similar characteristics. It was established that there is a reduction in the hardness, compression strength and UTS of Al 6061 composites when the improvement in the grain size of reinforced fly ash.

Admille et al., (2014) reviewed several kinds of literature about the overall efficiency of reinforcement of fly ash particles with composites by a technique of stir casting. As per fundamental factors, literature is being examined and produce a clear view of the utilization of fuel ash is in the form of reinforcement in various aluminum alloy in the form of matrix together with its characteristic performances.

Ramnah et al., (2014) examined the mechanical characteristics of reinforcement of aluminum alloy, alumina (Al₂O₃) and boron carbide metal matrix composites. Here, the technique of stir casting was utilized for fabrication. After hardening, specimens are manufactured and tested in order to discover different mechanical characteristics like hardness, impact, bending and tensile.

Ravesh et al., (2012) attempted to develop a traditional low cast procedure of establishing MMC by developing the reinforcement of Al-based SiC with particles of MMC. These

developed techniques lead to the attainment of homogenous scattering of ceramics and there is an improvement in the value of toughness, hardness and UTS by improving the w% of SiC.

Kulkarni et al.,(2014) examined the mechanical performance of reinforcement of mixed fly ash with aluminum carbonate by a technique of stir casting. Results demonstrate that mixed composite provides excellent characteristics with relatively lower concentrations.

Senthilkumar et al.,(2016) examined the reinforcement of Al-based boron carbide with various proportions of fly ash particles by a technique of stir casting. As a result, frictional coefficient, loss of wear, rate of wear with various mixtures are attained by performing the test with a different testing machine like wear testing machine, dilatometer and an apparatus pin on the disc.

Malhorta et al., (2013) examined the impact of mechanical characteristics on the reinforcement of samples of Al 6061 composites with Zirconia and fly ash particles by a technique of stir casting. The estimated characteristics of the specimens were % elongation, hardness and UTS. The categorization of the best-attained specimens had been performed by SEM.

Mohammed Razzaq et al.,(2017) examined the impact on mechanical characteristics of Al-based alloy was reinforced with fly ash particles and these composites were utilized in many different areas like aircraft, spacecraft and automobile industries due to its fine mechanical characteristics and lower intensity. Findings demonstrated that an enhancement in the content of fly ash in a molten form improves the porosity and microhardness in the composites.

Canute et al.,(2018) attempted to produce mixed composites with A356 A alloy based fly ash reinforced boron carbide powder by the technique of stir casting. The method of ANOVA was utilized to discover the influence of factors of wear on the rate of wear. As a result, there is an improvement in the rate of wear when the temperature and applied load was increased. The rate of wear decrease when the distance of sliding increases.

Kassim et al (1999) examined two-body abrasion performance of Al-based composite materials of SiC particles with mean sizes of 10 μm , 27 μm and 43 μm fabricated by a powder metallurgical route. The abrasive wear resistance of composite materials against an abrasive paper augmented with increased proportion by volume and dimensions of silicon carbide particulates. The resistance to abrasion diminished with an increase in relative depth of abrasive penetration as long as threshold, resistance to abrasion has been independent of the depth of penetration.

Singh et al (2002) researched two-body abrasion performance of Al alloy/10 wt% sillimanite (Al_2SiO_5) particulates a compound against sandpaper of required sizes of abrasive that is attached on the wheel. The rate of wear has been reduced with distance of sliding and augmented with a rise in size of abrasive and enforced load regardless of the substance.

Sug Won Kim et al (2003) examined the impacts of alloying elements and HT of Al/Si/Cu/Mg/Ni alloy composite material reinforced with SiCp prepared by the duplex procedure of squeeze infiltration and by the casting of squeeze. The solidity of the composite material augmented with a reduction in the size of SiCp and also with adding Ni. Aluminum composite strengthened by 10 μm of SiCp has the lowest abrasion volume in comparison to composites with SiCp composites ranging 3 μm and 5 μm .

Hayrettin Ahlatci et al (2001) examined the abrasive wear performance of pure Al composite materials strengthened with 13 μm and 37 μm diameter SiC particles produced by a technique of pressure infiltration. He tests of Abrasive wear was performed against Al_2O_3 has shown that the impact of SiC particles dimension on the resistance to wear of compacts

dependent upon the dimension of the aluminium oxide abrasive particles being scraped. The compact that had 13 μm of particles of SiC demonstrated a higher rate of wear in comparison to compact with 3 μm of particles of SiC.

Sudarshan and Surappa (2008) manufactured Al alloy (A356) composite material with a slender range in size (53 μm –106 μm) and a broad range in size (0.5 μm –400 μm) fuel ash particles. Composite Materials reinforced with a thin range in size of fuel ash particulate matter exhibited better mechanical performance in comparison to composites with extensive particles of range in size. At higher loads abrasion of composites reinforced with a thin range in size from fuel ash composites was better to that of composite materials with extensive fuel ash composites.

6. CONCLUSION

Recently, the developed industries utilize lightweight compounds with improved stiffness, strength and hardness. In this study, the fly ash particles were reinforced with Al alloys to produce improved mechanical and physical characteristics. The factors like hardness, UTS and compression strength are increased by increasing the percentage of content of fly ash. Studies revealed that wear and frictional coefficient of composite materials are affected by the content of reinforcement, speed of sliding and load exerted. The particle size of reinforcement was also a factor influencing the wear and mechanical properties of MMCs.

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