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– A REVIEW

AN OVERVIEW ON THE EFFECT OF PARAMETERS IN CHARACTERIZATION OF HYBRID ALUMINIUM METAL MATRIX COMPOSITE

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ABSTRACT

Aluminium metal matrix composite displays enhanced materialistic and abrasive materialistic properties. Apart from space and automotive applications, metal matrix composites (MMC) finding its position in prototyping, electronics substrates components, space vehicles, sports equipment due to its upgraded properties and improved performance. Certain design properties such as quality, cost reduction, uniform distribution, mechanical properties, and tribological properties of the composites depends on fabricating method adopted, fiber orientation and type of particles used. The association of pertinent reinforcements with the MMC have shown attractive mechanical properties. Influence of better embedded particles on metal matrix composite improves corrosion, friction behaviour and wear resistance with modified specific strength possessing exceptional tribological properties. Distinctive attainment of properties can be remarkably attained by fabricating the composite specimen by stir casting method. Right selection and combination of parameters influence the processing of composites decide the performance of the materials. Metallographic investigations examined by Scanning Electron Microscope (SEM) ensures the existence and fine dispersion of particles within the matrix element beyond the clustering the particles. Aluminium composite exhibits improved wear resistance and enhanced mechanical properties suitable for automobile and space craft applications. Wear characterization is mostly measured with the weight loss of samples, by varying the conditions such as sliding distance, sliding velocity and loading conditions.

Key words: Aluminium, Hybrid composite, Mechanical properties.

INTRODUCTION

Abundant existence among the alloy available in earth is the conventional aluminium alloy. Continuous embedding of reinforcements into monolithic matrix upgrade overall mechanical properties of the metal matrix composite[1]. Combination of insoluble

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constituents having dissimilar chemical composition constitutes a material system. The chosen reinforcement materials should be an alternative reinforcement for improving properties with reduction in particle size influences toughness and ductility with combination of materials. Individual property of reinforcements decides the final property of the composite. Availability and accessibility of reinforcements must be considered beyond the suitable reinforcing material. Certain parameters like % volume, size, type, nature of the reinforcements have their effect on the composite. Twinning effect of particles with good lubricating medium possess exceptional characteristic composite. Synthetic reinforcements and other individual waste reinforcements can also used as particulates instead of other fiber materials. Fiber clustering hardly affects the strength of the aluminium matrix composites. Processing a reinforced composite with exceptional load bearing capacity, acceptable interfacial reaction between the matrix and reinforcements should exists[2]. Bonding between the reinforcements and matrix show sewn properties on the matrix composite[2,3]. Even load distribution between matrix and reinforcements may results in uniform distribution of stress[4]. Process parameter possesses a greater effect in the fabricating of the favourable characteristics composites. Wettability is important in intermolecular interactions between two materials for intermolecular bonding within the composite. During the fabrication of composites graphite, and magnesium ribbons were used for improving the wettability.

Infiltration of discrete constituents as filler phase in the aluminium alloy satisfied enormous growing requirements. Variation in chemical composition and reinforcement proportion depends upon the functional requirement of the application[3]. Higher specific modulus, prominent strength and distinct hardness, and isotopic mechanical properties can be generated by processing of particulate reinforced hybrid aluminium composites. Upgraded properties can be obtained by reinforcing unreinforced matrix alloy with exceptional reinforcements. Requiring the best suited materials with higher performance is the most ultimate aim of current engineering trend[5]. MMC admits lot of application, advantages in the field of automobile, aerospace, etc. for replacement in pistons, brake disks, cylinder blocks, piston rings as a result of the pervasive properties[1]. Beyond the automotive application, extended applications in replacing the conventional materials are more important.

Processing techniques

Processing of composite always depends on the relating weight and volume fraction of the matrix and reinforcements by the rule of mixture. It demonstrates that the hardness of the composite mixture directly relates to the hardness and volume fraction of the matrix and the reinforcements[6]. Powder metallurgy and liquid metallurgy are generally used methods for the production of reinforced metal matrix composites. Powder metallurgy concentrates towards the wettability and clustering of particulates. Cold working is rarely used for strengthening the composite by reducing the porosity in the casting component. Even though stir casting remains flexible, it concerns with little metallurgical complication and also depends upon certain parameters influencing it. Fine distribution of particles in the final composite depends upon position of the stirrer inside the crucible, stirrer geometry, casting temperature, preheating temperature and properties of reinforcements.

Conventional stirring is replaced by two step stir casting method due to fine and uniform microstructure. Three step stir casting is accomplished by three steps such as initial prevention of particulate clustering by ball milling, mechanical stirring and additional adequate stirring using ultrasonic probe for better distribution of particles[7].

Significance of mechanical properties

Metal matrix composites with high performance at reduced cost with improved properties is the most ultimate aim of processing of composite. Strengthening mechanism depends on load transfer within the composite and thermal disparity between the matrix alloy and reinforcement particles. Homogenous distribution of particles also improves the strengthening mechanism within the fabricated composite[8]. Beyond the reduction in strength, hybrid reinforcements exhibits improved wear resistance. Effective load distribution between the reinforcement and matrix achieved by augmented interfacial strength. Strength of materials depends on the diminished size of the reinforcement of composite and fine dispersion of particles within the composite. Exceptional properties can be achieved by fine dispersion of particles and interfacial bonding between the matrix and reinforcement. Hardness of the composites will be higher, when comparing the base alloy.

Density is measured based on the ASTM: D792.66 test method and hardness measurement using Brinell's, Rockwell's, Vickers hardness testers. Decrease in size of the particle, improves the tensile strength of Al6061+ fly ash composite casted by stir casting process[5]. Comparatively aluminium composites with fly ash as reinforcements shows slight decrease in the tensile strength than the Al_2O_3 reinforcements. The percentage of reinforcements added has its effect on the composite and it depends on the type of the particles used. Al+10% SiC shows better tensile strength than Al+5% fly ash[9]. Exceptional tensile property in Al+SiC+fly ash composite shows that hybrid metal matrix composite 10% greater tensile strength than Al+SiC than Al+SiC and Al+fly ash composites. Clustering of reinforcement phase occurs due to increase in volume fraction and it may decrease the tensile strength of composites. Addition in weight fraction of reinforcements leads to improve the hardness Al6061. Maximum hardness can be achieved by hybrid composite materials than common matrix composite[10]. Reduction in impact strength results in the increase in tensile strength and hardness of the composite. Stir casting exhibit superior properties with improved tensile and yield strength with reduction in ductile property. Al + TiB_2, Al2024/Al_2O_3, Al2024/nano Al_2O_3 particles, Al/SiC/Gr, Al7075 + B_4C composites remarkably ensures that mostly all types of aluminium alloy composites synthesized using stir casting exhibits significant mechanical properties relevant for numerous applications.

Wear characteristics

Superior wear resistance of Al-matrix composite has drawn attention among the researchers to involve into the assorted applications. Increase in sliding distance and size of particles may lead to excessive wear loss of the material, apart from reciprocating velocity. When the material loss due to relative motion between contacting surfaces is progressive, then the material is said to be undergone wear[11]. Wear of material depends on the contact surface, load acting, speed and temperature. Significant parameters for determining the tribological behaviour can be fixed by applying ANOVA among the selected parameters. Sliding conditions should be well defined for effective evaluation of wear rate. Fracture toughness outcome of the particles depends upon the ultimate load that can be carried by the composite. Wear rate has a greater influence by the surface roughness due to the coarseness of the contact surface[12].

Reinforcement provides better stress to strain ratio, superior resistance to elastic deformation, substantial intermolecular bonds, by maintaining average grain size; thereby, strengthening the materials can improve the hardness[13]. Wear resistance directly depends upon the dispersion of particles, within the matrix. Al356+TiC, Al6061, Al5083+B_4C, TiB_2 particles+ Al-4Cu composites shows greater wear resistance with significant enhancement. Wear resistance improves with greater volume fraction of reinforcement due to the prior composition of mixture. The bonding between matrix phase and dispersed phase has a critical part in the wear behaviour. Wear resistance improves with decrease in the coefficient of friction as wettability of matrix phase enhances the fine distribution of particles. In aluminium matrix, effective stress can be reduced by good durability and ductileness of aluminium matrix. Precipitation hardening improves yield strength so that plastic deformation is resisted to a greater extent. Better load carrying capacity comes with greater wear resistance and low coefficient of friction.

Microstructure analysis

Microstructure analysis ensures the presence and fine dispersion of particles within the matrix element. Study of effect of wear on the contact surface can be examined by Scanning Electron Microscope[13]. The chemical configuration between the surface and infiltrated particles of compound matrix can be investigated by microstructure analysis. All technological properties of materials such as strength, hardness, fatigue, corrosive, thermal, and tribological characteristics precisely depend on microstructure. Few among these properties can be altered dramatically by minor variation in the microstructure. Metallographic investigations are done for the analysis of fracture surfaces, extensive phase analyses, profile determination and chemical concentration interface.

Concluding remarks

This review paper views the effect of reinforcements, interfacial bonding, tensile strength, wear characteristics, factors enhancing and influencing the wear in the tribological behaviour of the aluminium matrix composite. Volume fraction has a greater impact on the processing of composites but it has its effect only up to certain extent. However, the addition of reinforcements can improve the mechanical properties, most economical and extensive method for fabrication should be preferred. Even though reinforcements provide better significant property to the alloy, but when exceeding the range of volume fraction, it may lead to downgrade in the property. Reinforcing aluminium composites by stir casting method can exhibit desired tribomechanical properties. Infilteration of hybrid ceramic particles, organic reinforcements and nano reinforcements into the matrix aluminium alloy have displayed convincing enhancement in mechanical as well as tribological properties. Importance of interfacial bonding and its outcome on the enhancement of wear resistance can be remarkably inferred. During wear tests, increasing in loading conditions, results in decrease in coefficient of function. Hardness of matrix composite was reviewed with respect to strength and the individual material properties. High hardness may result in low wear rate and thereby composite shows better properties than pure aluminium. For the outlook and the convenience of experimenters investigating the tribological properties can be more convenient by using the detailed review. Various combination of reinforcement with the matrix element shows remarkable performance than the composite with single reinforcement and unreinforced alloy.

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