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Review on Various Aluminum Based Metal Matrix Composite

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***Abstract* -Aluminium matrix composite which are new in the category of metal matrix composites have wide potential of satisfying present industrial needs. Aluminium has low density and has capability to resist corrosion hence its matrix composites have become significant matter of concern in the field of metallurgy. The reinforcing materials for the fabrication of aluminium matrix composites could be in the form of whiskers, particulates or fibres, their volume fabrications ranging up to 70%. Different properties of the composites can be obtained depending upon the industrial applications by following different processing routes and reinforcements. Certain combinations of reinforcements and processing routes have also been conceptualized for the design of AMC's. These have wide range of applications including defense, aerospace, sports, automotive due to their low density and highly precise mechanical properties.This paper attempts to review the various aluminium metal matrix composites.**

Key words: Aluminium matrix composites, reinforcements, processing techniques.

i. INTRODUCTION

Composite is a material in which two materials with different physical and chemical properties are combined together to produce a material having distinguishing characteristics from its individual constituents [2]. Composites can be classified as: metal matrix, polymer matrix, and ceramic composites on the basis of physical and the chemical properties of the metal matrix. This paper emphasis on metal matrix composites and more explicitly on aluminium matrix composites. AMC's are made by reinforcing non-metallic or ceramic materials like Aluminium Oxide (Al_2O_3) and silicon Carbide (Sic) into the matrix phases i.e. aluminium or its alloy. The ratio of reinforcements and their distribution into the matrix plays an important role in determining the properties of the AMC's. For example: reinforcements of 60% volume of aluminium fibre increase the elastic modulus to 240GPa from 70GPa of pure aluminium. Similarly; hardness, tensile strength and density of AMC's are increased by reinforcing Sic particulates into the aluminium matrix.

Current engineering applications require lighter as well as stronger material i.e. major focus is given on strength to weight ratio. Modern manufacturing sector demands for materials with broad range of properties like high thermal resistance, minimum wear rate, good damping properties, high specific stiffness etc. Hence the high performance and light-weight aluminium matrix composites can be one of the viable solutions for fulfilling various demands of the industry. In this review paper, overview is given on the various aluminium metal matrix composites.

ii. ALUMINIUM OXIDE REINFORCED AMC

Park et al. [1] investigated the effect of Al_2O_3 in Aluminium for volume fractions varying from 5-30% and found that the increase in volume fraction of Al_2O_3 decreased the fracture toughness of the MMC. This is due to decrease in inter-particle spacing between nucleated micro voids. Park et al. [2] investigated the high cycle fatigue behaviour of 6061 Al-Mg-Si alloy reinforced Al_2O_3 microspheres with the varying volume fraction ranging between 5% and 30%. They found that the fatigue strength of the powder metallurgy processed composite was higher than that of the unreinforced alloy and liquid metallurgy processed composite. Tjong et al. [3] compared the properties of two aluminium metal matrix composites, Al-B_2O_3-TiO_2system and Al-B-TiO_2systems. It was found that the reactive hot pressing of the composites resulted in the formation of ceramic Al_2O_3 and TiB_2 particulates as well as coarse intermetallic Al_3 Ti blocks. Al-B-TiO_2had higher Al_3Ti content and showed high tensile strength, but tensile ductility. Al-B_2O_3- TiO_3had more fatigue Strength than Al-B-TiO_2. Kok [4] fabricated theAl_2O_3 particle reinforced 2024 Al alloy composites by vortex method and studied their mechanical properties and found the optimum conditions of the production process with a pouring temperature of 700 NC, preheated mould temperature of 550 NC, stirring speed of 900 rev/min, particle addition rate of 5 g/ min, stirring time of min and with a applied pressure of 6MPa. The wettability and the bonding between Al alloy/Al_2O_3 particles were improved by applied pressure but porosity will be decreased by this pressure. Abhishek Kumar et al. [5] experimentally investigated the characterization of A359/Al_2O_3 MMC using electromagnetic stir casting method. They found that the hardness and tensile strength of MMC increases and electromagnetic stirring action produces MMC with smaller grain size and good particulate matrix interface bonding. Abouelmagd [6] studied the hot deformation and wear resistance of powder metallurgy aluminium metal matrix composites. It was found that the addition of Al_2O_3 and Al_4C_3 increases the hardness and compressive strength. The addition of Al_4C_3 improved the wear resistance of the MMC. Kannan and Kishawy [7] conducted orthogonal cutting tests to study the effect of cutting parameters and particulate properties on the micro-hardness variations on the machined Al_2O_3 particulate reinforced AMC. They found that the micro- hardness is higher near the machined surface layer. Micro-hardness variations were higher for low volume fraction and coarse particles.

iii.BORON CARBIDE REINFORCEDAMC

Bo Yao et al. [7] investigated the trimodal aluminium metal matrix composites and the factors affecting its strength. The test result shows that the attributes like Nano-scale dispersoids of Al_2O_3, crystalline and amorphous AlN and Al_4C_3, high dislocation densities in both NC-Al and CG-Al domains, interfaces between different constituents, and nitrogen concentration and distribution leads to increase in strength. Vogt et al. [8] studied the cryomilled aluminium alloy and boron carbide nano-composite plates made in three methods,
(1) hot isostatic pressing (HIP) followed by high strain rate forging (HSRF), (2) HIP followed by two-step quasi-isostatic forging (QIF), and (3) three-step QIF. The test results showed that the HIP/HSRF plate exhibited higher strength with less ductility than the QIF plates, which had similar mechanical properties. The increased strength and reduced ductility of the HIP/ HSRF plate is attributed to the inhibition of dynamic recrystallization during the high strain rate forging procedure. Mahesh Babu et al. [9] investigated the characteristics of surface quality on machining hybrid aluminium-B_4C-SiC metal matrix composites using taguchi method. It was found that feed rate was the most important parameter followed by the cutting speed. Moreover it was concluded that the feed rate does not have a significant effect on surface quality. Barbara Previtali et al. [4] investigated the effect of application of traditional investment casting process in aluminium metal matrix composites. Aluminium alloy reinforced with SiC and B4C were compared and the experiments showed the wear resistance of SiCreinforced MMC is higher than that of B4C reinforced MMC.

iv.FLY ASH REINFORCED AMC

Fly ash particles are potential discontinuous dispersoids used in metal matrix composites due to their low cost and low density reinforcement which are available in large quantities as a waste by product in thermal power plants. The major constituents of flyash are SiO_2, Al_2O_3, Fe_2O_3, and CaO. Rajan et al. [41] compared the effect of the three different stir casting methods on the properties of fly ash particles reinforced Al-7Si-0.35Mg alloy. The three stir casting methods are liquid metal stir casting, compocasting, modified compocasting followed by squeeze casting. The compression strength of the composite processed by modified compocasting cum squeeze casting is improved compared to the matrix alloy. However, the tensile strength was found to be reduced. The modified compocasting cum squeeze casting process has resulted in a well dispersed and porosity free fly ash particle dispersed composite. Zuoyong Dou et al. [12] studied the electromagnetic interference shielding effectiveness properties of the 2024 Alloy-fly ash composites. The composite have effective shielding property in the frequency range of
30.0 KHz -1.5GHz. But the addition of fly ash particulate decreases the tensile strength of the composites. Ramachandra and Radhakrishna [13] experimentally found that the wear resistance of Al MMC increases with the increase in fly ash content, but decreases with increase in normal load and sliding velocity, and also observed that the corrosion resistance decreases with the increase in fly ash content.

v. SUMMARY

- The optimum conditions for fabricating Al_2O_3 reinforced Al MMC as pouring temperature-700 NC, preheated mould temperature-550 NC, the stirring speed-900 rev/min, particle addition rate-5g/min, the stirring time - 5 min and the applied pressure was 6MPa.
- The wear resistance and compressive strength of Al MMCs increase with the addition of Zircon sand reinforcement.
- The addition of flyash reinforcement in Al increases the wear resistance but decreases the corrosion resistance.

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