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Microstructure and Mechanical Properties of Aluminium Based Metal Matrix Composite – A Review

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Abstract : *Aluminum based metal matrix is widely used nowadays in automobile, aerospace and other industry. Aluminum matrix Composite are gaining popularity due to high strength to weight ratio, good mechanical properties, light weight and inexpensive.. The performance of composite depends on type, percentage, size and shape of the reinforcement. The addition of reinforcement into aluminum improves mechanical properties such as like tensile strength, strain, hardness, wear and fatigue. . This paper attempts to review the effect of addition of different reinforcements and their effects on mechanical properties, along with the optimization techniques used to optimize the various process parameters.*

Keywords: *Stir casting, scanning electron microscope, Aluminium, Metal matrix composite, Microstructure, Mechanical Properties*

INTRODUCTION

There has been growing demands of advanced materials in the field of engineering which has led to an increased rate in development of composite materials. Number of different materials are being used to reinforce aluminum alloy matrices. The increasing demands have resulted in the research in the field of composites. Metal composites have significantly improved properties including high tensile strength, toughness, hardness, low density and good wear resistance compared to base metal There has been an increasing interest to manufacture composites at low cost. composite materials are engineered from two or more constituent materials with different physical and chemical properties .The constituents retain their identities do not dissolve or merge completely into one another although they act in concert .Most composites have two constituent materials: a binder or matrix (polymers, metals, or ceramics) and reinforcement (fibers, particles, flakes, and/or fillers). The reinforcement is usually much stronger and stiffer than the matrix, and provides composite good mechanical property.

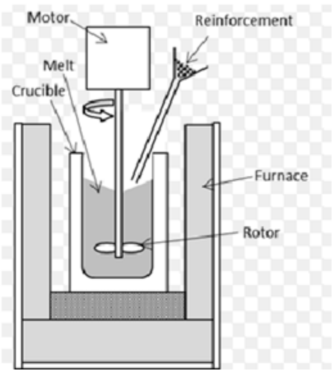

FIG 1:Stir casting apparatus[Sozhamannan et al]

LITERATURE REVIEW

Aluminium is one the very important matrix to fabricate composites. Because of low cost, lightweight material and good mechanical tribological properties in various filed it is widely used **[2][3]** Composite materials when compared to unreinforced composite showed that mechanical and tribological properties have increased and the properties directly depend on reinforcement **[6]**. The hardness of the aluminium matrix composites (AMCs) reinforced with Graphite particles decreased with a linear increase in the graphite (Gr) **[4–8]**.

Many researchers had reinforced aluminum metals and their alloys with ceramic particles to improve their properties. Their work is on the effect of graphite particles as reinforcement in aluminum. The composite was manufactured using stir casting. The reinforcement that was graphite was varied from 0% to 12% in a step of 3%. . There was decrease in hardness is a due to increased brittle nature of Gr reinforcement particles. At 12% Graphite as reinforcement it was observed that there was a very poor distribution of Graphite particles and less cluster of particles was observed than other workpiece (3, 6, 9% Graphite reinforced composites) .it was observed that as percentage of graphite increased the non-uniform distribution and decreases the hardness of composite **[9]**

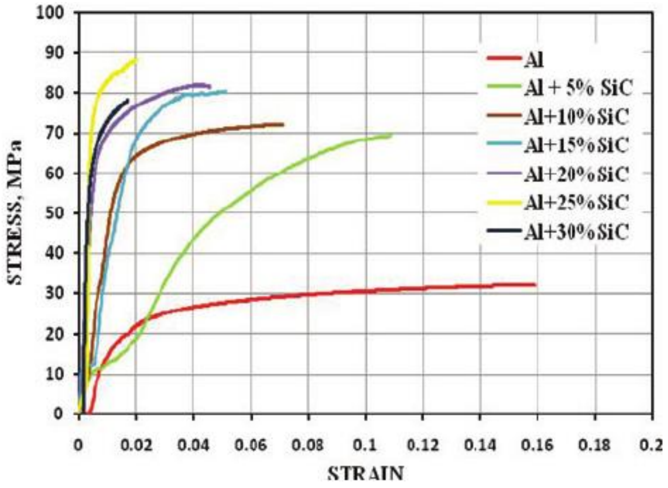

FIG 2:Relationship of stress and strain as Sic percentage is increased **[10]**

The use of B4C, TiB2 and ZrSiO4 as reinforcement and studied changes in mechanical properties of aluminium matrix composites.Then using the experimental data model named Levenberg-Marquardt Algorithm (LMA) neural networks was constructed .the result shows that maximum improvement was achieved through adding ZrSiO4 and TiB2, 52% and 125% increase in tensile strength and hardness, respectively**[11]**.The performance and properties of the AMCs depend on various factors such as uniform distribution of reinforced particles, bonding between the aluminium and reinforcement **[12]**. Therefore, it is difficult to produce a good AMCs having uniform distribution and good bond. Powder metallurgy and stir casting are used to produce AMCs. But, the common defects of casting such as porosity, clustering and segregation of particles are always there **[13–17].**

Reinforced aluminium matric composite with Boron Carbide (B4C) with an average particle size 25 µm and different weight percentages using stir casting method.the results showed with the increase in weight percentage of B4C particles the tensile strength and hardness has increased**[18]**

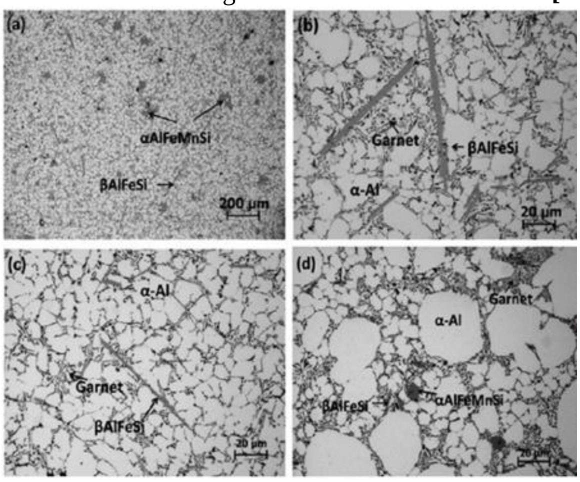

FIG 2: Microstrucrure of aluminum (LM24),3 wt% of garnet, 9 wt% of garnet, 15 wt% of garne **[19]**

The casted matrix using groundnut shell ash (GSA) and silicon carbide, silicon carbide with different ratios (10:0, 7.5:2.5, 5.0:5.0, 2.5:7.5 and 0:10) constituted 6 and 10 wt. % were used as reinforcing agent while the matrix material was Al–Mg–Si alloy. The groundnut shell was procured and then burned to obtain groundnut shell ash the results showed that with increasing percentage of reinforcing agent the hardness, ultimate tensile strength and specific strength of the composite decreased slightly**[20]**.

The AMC reinforced with alumina, rice husk ash (RHA) and graphite. Then properties such as. Hardness, tensile properties, scanning electron microscopy, and wear test were tested .With increase in weight ratio of rice husk ash and graphite the hardness decrease significantly. When the percentage of rice husk ash was increased to 50 % there was no much effect of graphite on hardness. The composites without graphite exhibited greater wear susceptibility in comparison to the composite grades containing graphite. However the wear resistance decreased with increase in the graphite content from 0.5 to 1.5 weight%**[21]**When AMC was tested aluminum matrix composite using selected cutting parameters such as cutting speed, feed per tooth and different kinematics (up milling and down milling) on surface properties. As cutting speed increased (up to 200 m/min) which resulted in a reduced void formation and higher absolute values of compressive residual stresses. As feed per tooth increased which resulted in higher surface roughness**[22]**

Casted aluminum matrix composite using Silicon carbide and Titanium di boride as reinforcement .mechanical test were carried such as hardness using Vickers hardness testing instrument,wear test and tensile test .The casted specimens were carefully machined(turning operation). The effect of machining parameters such as cutting speed, feed rate, depth of cutand weight percentage of TiB2 on surface roughness were observed.The analysis using variance method showed that 38.86% of TiB2 reinforcement is the most influential parameter which largely affects surface quality**[22]**.

Dinaharan casted aluminum matrix using various ceramic particles, such as SiC, Al2O3, TiC, B4C and WC .test such as The microstructure, micro hardness and tensile strength were carried on casted material SiC, TiC, B4C and WC reinforced particles had fragmentation during FSP because of plastic deformation and contact with the rotating tool. The fragmented particles mixed well with aluminum. All types of reinforcement enhanced the UTS of aluminum**[23].**

Casted aluminum matrix using fly ash as reinforcement varying its percentage 14.3 % and 13.2%by volume .mechanical properties such as tensile properties, compression strength were observed**[24]**.The effect of addition of magnesium of aluminum based metal matrix using FSP, Grain refinement, improved hardness, wear resistance, mechanical behavior, improved bioactivity and corrosion resistance are the common observations**[25].**

casted aluminum matrix using Friction stir processing (FSP) using quartz as reinforcement. The specimen had volume fraction of quartz particles between 0 to 18 vol.% and in steps of 6 volume %. The speciemen was studied using optical, scanning and transmission electron microscopy. The quartz particles were distributed uniformly in the aluminum matrix. The quartz particles changed their size and shape due to high strain rate due to FSP**[26]**

CONCLUSIONS

In this paper aluminum based metal matrix are discussed using various different reinforcements such as fly ash, rice husk, coconut husk, ceramics etc. Different machining such as milling, turning, drilling and effect of changing parameters on aluminum based metal matrix is also discussed. Nowadays majority of aluminum based metal matrix are casted using stir casting .The reinforcements used are industrial waste thus saving cost of reinforcement. The future scope is to find other methods for making aluminum based metal matrix which are less expensive and a lot of work is already done using different reinforcements ,but still we do not have a specific percentage of reinforcement for optimum aluminum based metal matrix

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