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Review on Aluminium Silicon Carbide Metal Matrix Composite

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***Abstract*—Good strength to weight ratio is always a interest of researchers to make the things more compact. Aluminium metal matrix composites are widely used in various industries ranging from house hold application to aerospace. Involvement of SiC in particulate form shows marginally increase in mechanical properties of Aluminium. Improvement in mechanical properties such as tensile strength, Hardness, toughness etc by varying the percent composition of SiC is being reviewed in this literature along with the fabrication techniques and effect of some alloying metals.**

Keywords— Stirr casting, Metal matrix composite, Al-SiC, Mechanical Properties.

INTRODUCTION

Aluminium and its alloys have gained vast and huge industrial significance because of the exceptional combination of physical and mechanical properties over the base metal. These properties include: high strength, high abrasion and wear resistance, high stiffness, low thermal expansion, improved damping capacity etc. but, the modern development in field of material science and technology demands advanced engineering materials which are which are strong, light and less expensive, posses good strength to weight ratio, and which can also be used in various engineering applications, especially in field of transportation, aerospace and military engineering related areas [1, 2].

Metal matrix composites (MMCs) are known to offer such tailored properties which are highly required in a wide range of engineering applications [3-5]. MMC is one marvelous example of an engineered combination of metal (usually the Matrix) and some hard particles (called Reinforcement) [6]. MMCs are the most promising materials in attaining enhanced mechanical properties such as: Hardness, ultimate tensile strength, Young's modulus, Yield strength, due to the presence of very fine (micro) sized reinforcement particles into the matrix [7,8]. MMC's also exhibit properties like: light weight, greater resistance to corrosion, oxidation and wear.

Huge leap in processing and enhancing properties of MMCs has been made on various composites in the past [9]. Metal matrix composites (MMCs), such as SiCp-Al composites; have been attracting more and more interest because of their outstanding dimension stability, low expansion coefficient, as well as high specific strength and stiffness with lesser cost [10,11]. A number of materials are being used as reinforcements, such as SiC [12], Al_2O_3 [13], B_4C [14,15], TiB_2 [16-18], ZrO_2 [19-21], SiO_2 [22], TiC [23] and graphite to improve the properties of Aluminium alloys [24].

However, the crucial challenge which lies in field of processing of these engineering materials is to control its microstructure, mechanical properties and product cost through optimization of its chemical composition, the processing method and heat treatment procedures [25]. Non homogeneous distribution of the reinforcement is one of the biggest problems faced during casting of metal matrix composites [26]. The homogeneous distribution of reinforced particles in the matrix alloy is influenced by various factors like: method used for particle incorporation, rheological behaviour of the matrix melt, the, interaction between matrix and particles before, during, and after mixing [27].

Many processing techniques, including melt infiltration and semi-solid stirring have been suggested to fabricate SiC particles reinforced MMCs. But, due to simplicity in processing, flexibility and lesser cost, semi-solid stirring is considered as the best method amongst all these techniques [28]. Another problem of unwettability between the metal matrix and reinforcement of SiCp-Al composites can be solved by using stirring technique, which also aids in enhancing the mechanical properties of the composites. During stir casting of SiCp-Al composites, addition of magnesium (Mg) into the aluminium melt improves the wettability of reinforcement with the matrix, by increasing the interface bonding strength and restraining the deleterious reactions at the interface [29–31].

The alloying elements, which are classified as major and minor elements and/or microstructure modifiers or impurities, can be selected on the basis of their effects and suitability [32]. For Aluminium and its alloys, major elements typically include Silicon (Si), Magnesium (Mg), and Copper (Cu).

Silicon (Si): is mostly used single alloying element in majority of aluminium alloys. It is solely responsible for good castability, increase in overall strength, along with corrosion and wear resistance. Adding Si to aluminium also enhances the thermal dimensional stability, elastic modulus, and

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thermal conductivity of the composite, but decreases the machinablity consequently [33]. Depending on its concentration by weight (%), It has been observed that with increase in Si content, ultimate tensile strength increases slightly (for 3-8% Si) with a linear increase later on (for 8-15% Si). It was also reported, that the hardness increases with increase in Si content (12%) to 70 MPa, whereas it then decreases to 60 MPa with a further addition (15% Si) [34].

Magnesium (Mg): provides better work hardening characteristics and extremely high strength without any significant reduction in ductility of aluminium. It also imparts good weldability and corrosion resistance [35, 36]. Silicon combines with magnesium to form a hardening phase Mg_2Si which provides the strengthening.

Combined Effect of Si & Mg: can help to improve the thermo-mechanical properties of the composite/alloy, especially the wettability. Shubin et al. [33], in their work observed good thermo-mechanical properties, for Si content lower than 12%wt and for Mg content in the range of 4-8%wt. However, a reduction in bending strength and thermal conductivity was significant for Si content rising beyond 12%wt, and higher levels of porosity was significant for Mg content beyond 8%wt.
Jamaluddin et al., concluded most of the literature available is based on composites such as: Al7075, Al6061, Al2214, Al2618, Al359, and Al357 [37].

PROCESSING TECHNIQUE OF METAL MATRIX COMPOSITES

Processing technique is important factor. It must ensure uniform distribution of SiC particle throughout the matrix material. Mechanical Stirr casting is one of the processing techniques for preparation of Al- SiC metal matrix Composites. However it has some constraint like wettability between two substances, porosity etc but it can produce wide range and also less expensive, without damage in reinforcement [38].Powder Metallurgy is also one of the processing technique that is used for Metal matrix Composites.[39]. Some researchers conclude that it is Expensive technique and there is chance of reinforcement fracture. Squeeze Casting is other technique for processing of matal matrix composites. It may cause damage to reinforcement materials [40]. Spray Casting [41] and electromagnetic Stirring [42] are also used for processing. Stirring time and Speed also influence the properties of Metal matrix Composites [43]. Prabhu et al. found better hardness on 600rpm at 10 min condition.

MECHANICAL PROPERTIES

TENSILE STRENGTH: Alaneme[44] et al. found the improved ultimate tensile strength from 112.93 MPa to 158.5 MPa by increasing the SiC volume percentage from 0% to 12% respectively, Yield strength was found to be improved from 80.75 MPa to 120.24 MPa of as cast alloys.

Rahman et al.[46] also found significance improvement in tensile strength by increasing the wt% of SiC in metal matrix Composite.
HARDNESS: Singla et al.[45] found improved in Hardness (BHN) from 28.5 to 45.5 when SiC was 0% and 25% respectively.
TOUGHNESS: Singla et al.[45] found increase in impact strength 12Nm to 34 Nm when SiC is 0% and 25% respectively. At 25% he found maximum value and further increase in SiC decrease in impact strength was found.
WEAR: Rahman et al.[46] concluded the reduction in cumulative mass losses while increasing the fraction of SiC in composite.

CONCLUSION

In this paper advantages of Aluminium- SiC metal matrix Composites are discussed along with different processing technique. Effect of other metals like magnesium and silicon are also discussed Study shows that the influence of reinforcement as SiC in particulate form is capable to tailored the properties of Aluminium upto some extent. Study also shows that Stirr Casting technique is being widely used and preferred over other processes. However there is concern about the wettability of reinforcement around the matrix material. Porosity is also a problem in Stirr Casting technique. Reinforcing Aluminum and its alloys with ceramics particles has shown an appreciable increase in its mechanical properties.

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