International Journal of Engineering Research And Advanced Technology (IJERAT)
ISSN: 2454-6135 **[Special Volume. 02 Issue.01, May-2016]**

EFFECT OF ALUMINUM (AL1100) AND SILICON CARBIDE ON THE MECHANICAL PROPERTIES OF METAL MATRIX COMPOSITES

Dhanya kumara N B [1] **Yerriswamy W [2]**

Department of Industrial Engineering & Management

JSS Academy of Technical Education

Bengaluru , KARNATAKA

INDIA

Abstract

Metal matrix composite (MMCs) are next generation materials. MMCs add higher strength and stiffness than the matrix alloy, excellent wear resistance and lower coefficient of thermal expansion (CTE). Additional functionalities can be designed into some MMCs through appropriate selection of constituents. One of the important objectives of metal matrix composites is to develop a material with a judicious combination of toughness and stiffness. It decreases the sensitivity to cracks and flaws and at the same time increases the static and dynamic properties. The reinforcement effect occurs due to the extraordinary high strength of whiskers with diameters below a few micrometers.

In general, Metal matrix composites consist of at least two components. One is the metal matrix and the second is reinforcement. In all cases, the matrix is defined as a metal, but a pure metal is rarely used as the matrix. It is generally an alloy. In the productivity of the composite, the matrix and the reinforcement are mixed together.

Advance composite materials like Al/SiC metal matrix composite is gradually becoming very important materials in manufacturing industries e.g. aerospace, automotive and automobile industries due to their superior properties such as light weight, low density, high strength to weight ratio, high hardness, high temperature and thermal shock resistance, superior wear and corrosive resistance, high specific modulus, high fatigue strength etc. In this study aluminum (Al100)/SiC ,Silicon carbide reinforced particles metal matrix composites (MMCs) are fabricated by Melt stirring technique. The MMCs bars and circular plates are prepared with varying the reinforced particles by weight fraction ranging from 2%, 4%, 6%. The average reinforced particles size of SiC are 220 mesh, 300 mesh, 400 mesh respectively.

Key Words: Aluminum alloys, silicon carbides, magnesium, tensile, compression, hardness, impact strength.

INTRODUCTION

In today's world, requirement of light, inexpensive and quickly processed materials has increased to a great extent. The Al/SiC metal matrix composites have light weight, wear resistance and high elastic modulus. The Al/SiC metal matrix composite has applications in many industries. In the present investigation, Aluminum based metal matrix composite are prepared using stir casting method. The weight percentage of silicon carbide varies from 10% to 30%. The main objective is to evaluate the ultimate tensile strength, hardness, density and the microstructure of Sic particulate reinforced Al matrix composites as a function of volume of Sic The specimens made were tested on universal testing machine.

Metal Matrix Composites (MMC's) have very light weight, high strength, and stiffness and exhibit greater resistance to corrosion, oxidation and wear. which is essential for automotive application. These properties are not achievable with light weight monolithic titanium, magnesium, and aluminum alloys. Particulate metal matrix composites have nearly isotropic properties when compared to long fiber reinforced composite. But the mechanical behavior of the composite depends on the matrix material composition, size, and weight fraction of the reinforcement and method utilized to manufacture the composite. The distribution of the reinforcement particles in the matrix alloy is influenced by several factors such as rheological behavior of the matrix melt, the particle in corporation method, interaction of particles and the matrix before, during, and after mixing . Non homogeneous particle distribution is one of the greatest problems in casting of metal matrix composites .

Aluminum silicon carbide metal matrix composite has low density and light weight, high temperature strength, hardness and stiffness, high fatigue strength and wear resistance etc. in comparison to the monolithic materials . However, aluminum alloy with discontinuous ceramic reinforced MMC is rapidly replacing conventional materials in various automotive, aerospace, and automobile industries . Amongst various processing routes stir casting is one of the promising liquid metallurgy technique utilized to fabricate the composites. The process is simple, flexible, and applicable for large quantity production. The liquid metallurgy technique is the most economical of all the available technique in producing of MMC . Aluminum alloy based composites containing 10wt% alumina (size range: 150225 mm) were prepared by liquid metallurgy technique using the vortex method . . Various researchers have utilized conventional stir casting technique for producing MMC . but still applied research is needed for successful utilization of the process for manufacturing of MMC.

In this study stir casting is accepted as a particularly promising route, currently can be practiced commercially. Its advantages lie in its simplicity, flexibility and applicability to large quantity production. It is also attractive because, in principle, it allows a conventional metal processing route to be used, and hence minimizes the final cost of the product. This liquid metallurgy technique is the most economical of all the available routes for metal matrix composite production, and allows very large sized components to be fabricated. The cost of preparing composites material using a casting method is about one third to half that of competitive methods, and for high volume production, it is projected that the cost

will fall to one tenth . In general, the solidification synthesis of metal matrix composites involves producing a melt of the selected matrix material followed by the introduction of a reinforcement material into the melt. To obtain a suitable dispersion the stir casting method is used. The solidification of the melt containing suspended SiC particles is done under selected conditions to obtain the desired distribution.

In this study, different weight fractions of Silicon Carbide particulates are added with aluminum matrix to fabricate the Al/SiC metal matrix composites. Different samples have been fabricated by melt stirring casting and their microstructure, hardness, tensile strength, and impact strength are studied. In this study the influences of the reinforced particulate size (220 mesh, 300 mesh, 400 mesh) and weight fraction (2%, 4%,6%) on mechanical properties like Proportionality (MPa) limit, Tensile strength upper yield point (MPa), Tensile strength lower yield point (MPa), Ultimate tensile strength (MPa), Breaking strength (MPa), % Elongation, % Reduction in area, Hardness (HRB), Density (gm/cc), Impact Strength (N.m) are investigated.

MATERIAL USED

ALUMINUM – base material.

SILICON CARBIDE – reinforcement.

MAGNESIUM – ingot.

Fabrication of Al/SiC Metal Matrix Composites

Silicon Carbide (SiC) reinforced particles of average particle size 220 mesh, 300 mesh, 400 mesh respectively are used for casting of Al/SiC MMCs by melt stir casting technique.

Experiments were carried out to study the effect of settling the reinforced particulates on the solidification microstructure and mechanical properties of the cast MMC. In the present study, commercially available aluminium is used as matrix reinforced with Silicon Carbide (SiC) particulates. The melting was carried out in a magnesium (Mg) ingot placed inside the resistance furnace. An induction resistance furnace with temperature regulator cum indicator is utilized for melting of Al/SiCMMCs.

STIR CASTING

Stir casting can be regarded as a popular process for manufacturing AMCs for research applications. The process is usually carried out in a stir casting furnace with the matrix and reinforcements added to the furnace and then stirred continuously. different dimensions of round bars with 2vol%, 4vol%, 6vol% of reinforced particles of size 22mmdia and 200mm length of respectively

A stir casting machine consists of mainly the following parts.

· Control and Display Unit

· Stirring mechanism

· Main Casting furnace

· Pre-heating furnace

Composites with up to 6% volume fractions can be suitably manufactured using this method. The dispersal of the particles in the final solid depends on strength of mixing, wetting condition of the particles with the melt, rate of solidification and relative density. Geometry of the mechanical stirrer, position of stirrer in the melt, melt temperature, and the properties of the particles added governs the distribution of particles in molten matrix.

Mechanical properties testing

- Tensile strength
- Compression
- Hardness
- Impact

Tensile test

In any design work, it is important to consider practically realizable values of strength of the materials used in design. The tension test is one of the basic tests to determine these practical values. The range of values obtained from the tests forms the basis for the size of the material in the products for the factor of safety. The tension test is conducted on a universal testing machine at room temperature.

The stretch undergone by the specimen is measured by an elongation scale with a least count of 1 mm fixed to the loading unit for every increment in the load. The simple stress and strain developed in gauge length portion is calculated using the formulae.

Stress (**σ**) = Load/ Original cross sectional area

Strain (**e**) = Increment in length / original gauge length

Compression test

Compression test was performed on Al-SiC composite specimens with length to diameter ratio of 1.5. Tests were performed on UTM of 100 KN capacity. The sample was compressed between two flat platens and the maximum failure load was recorded

Hardness test

The Rockwell hardness test was done Twelve samples of Al/SicMMC's for different sizes and weight fraction of SiC particles were prepared.

Impact strength

Impact Test was carried out on Izod Impact Testing Machine and results were recorded in table. According to size and weight fraction of SiC particles Twelve Specimens Al/SicMMC's were prepared of Square cross section of size (10X10X75) with single V notches .The size of V notches is 45° and 2mm depth.

Conclusions

(a)Tensile Strength: From the result graphs Proportionality (MPa) limit, Tensile strength upper yield point (MPa), Tensile strength lower yield point (MPa), Ultimate tensile strength (MPa) and Breaking strength (MPa) increases with the increase in reinforced particulate size(220 mesh, 300 mesh, 400 mesh) and weight fraction (2%, 4%, 6%,) of SiC particles. % Elongation and % Reduction in area decreases with the increase in reinforced particulate size (220 mesh, 300 meshes, 400 mesh) and weight fraction (2%, 4%, 6%) of SiC particles.

(b) Hardness (HRB) and Density (gm/cc) increases with the increase in reinforced particulate size(220 mesh, 300 mesh, 400 mesh) and weight fraction (2%,4% ,6%,) of SiC particles.

(c) Impact Strength (N.m) decreases with the increase in reinforced particulate size(220 mesh, 300 mesh, 400 mesh) and increases with the increase in weight fraction (2%,4%,6%) of SiC particles.

References

[1] Hashim, J., Looney, L. and Hashmi, M.S.J., "Particle Distribution in Metal Matrix Composites," PartI, *Journal of Materials Processing Technology*, 123: 251257.2002.

[2] Nather, S., Brabazon, D. and Looney, L., "Simulation of the Stir Casting Process," *Journal of Materials Processing Technology*, 143144:567571.2003.

[3] Nai, S.M.L. and Gupta, M. ,"Synthesis and Characterization of Free Standing, Bulk Al/Sicp Functionally Gradient Materials: Effects of Different Stirrer Geometries," *Material Research Bulletin*, 38: 15731589.2003.

[4] Hashim, J., Looney, L. and Hashmi, M.S.J., "Metal Matrix Composites: Production by the Stir Casting Method," *Journal of Materials Processing Technology*, 9293:17.1999.

[5] Manna, A. and Bhattacharyya, B., "Study on Different Tooling Systems during Turning for Effective Machining ofAl/SiCMMC," The Institution of Engineers (India) *JournalProduction*,83: 4650.2003

[6] Allison, J.E. and Cole, G.S., "Metal Matrix Composite in Automotive Industry: Opportunities and Challenges," *Journal of Mechanical Science*, 1924.1993.

[7] Surappa, M.K., "Microstructure Evolution during Solidification of DRMMCs: State of the Art," *Journal of Materials Processing Technology*, 63: 325333.3078 A. MANNA ET AL.1997.

[8] Yang, J., Pickard, S.M., Ctedy, C., Evans, A.G. and Mehrabian, T.,"The Stress/Strain Behavior of Aluminium Matrix Composites with Discontinuous Reinforcements," *Acta Metallurgica Materialia*, 39: 18631870.1997.

[9] Lloyd, D.J., Lagace, H., Mcleod, A. and Morris, P.L. (1989). Micro Structural Aspect of Aluminium Silicon Carbide Particulate Composites Produced by a Casting Method, Materials Science and Engineering, A107: 7379.

[10] Guo, Z., Xiong, J., Yang, M. and Li, W., "Microstructure and Properties of Tetrapodlike ZnO Whiskers Reinforced Al Matrix Composite," *Journal of Alloy and Compounds*, 461: 342345.2008.