Fabrication of Zinc Metal Matrix Composites Reinforced with Silicon Carbide and Industrial Waste Metallic Chips

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Abstract –*In this world, the development of composite materials as well as the related design and manufacturing technologies is one of the most important advances in the history of materials. Composites are combination of materials having mechanical and physical properties which can be tailored to meet the requirements of a particular application. Many composites also exhibit great resistance to wear, corrosion, and greater heat dissipation capacity. These unique characteristics provide the mechanical engineer with design opportunities not possible with conventional monolithic materials. MMCs are important materials which are now used widely, not only in the aerospace industry, but also in a large and increasing number of mechanical engineering applications, such as internal combustion engines; machine components; automobile, train, and aircraft structures and mechanical components, such as brakes, drive shafts, flywheels, tanks. Zinc itself has a greater melting point so as to reduce the heat dissipation in various parts of the heat treatment processes. The reinforcements like the silicon carbide powder in preparation of Zn based MMCs gives material the greater strength, weight reduction property, greater hardness, reduction in cost, improved life of the component.*

***Key Words*: Zinc, Metal Matrix Composites, Silicon carbide, hardness, tensile strength, nature of microstructure**

1. INTRODUCTION

1.1 Zinc [Zn]:

Metal matrix composites (MMCs) have recently become candidates for critical structural applications because of a combination of superior mechanical properties such as better elastic modulus, tensile strength, high temperature stability and wear resistance in comparison with the parent matrix alloys. MMCs offer designers benefits as they are particularly suited for applications requiring good strength at high temperature, good structural rigidity, dimensional stability and light weight. The present day trend is towards safe usage of the MMC parts in the automobile engines, which work particularly at high temperature and pressure environments[1]. The increase in demand for lightweight, stiff and strong materials has led to the development of MMCs reinforced with ceramic dispersoids. These MMCs possess excellent mechanical and tribological properties and are considered as potential engineering materials for various wear related applications. Several researchers have worked on sliding wear mechanism of MMCs reinforced with ceramic particulates like SiC, Al_2O_3 and garnet particles etc. and have observed improvement in wear and abrasion resistance [2]. Zinc casting alloys are versatile engineering materials. No other alloy system provides the combination of strength, toughness, rigidity, bearing performance and economical cast ability. Zinc alloys are feasible matrix materials owing to their good bearing and wear properties, lower casting temperatures and lower cost [3]. Zinc–aluminum (ZA) alloys containing small amount of copper have been observed to be possible as cost and energy effective substitutes for a variety of ferrous and non-ferrous alloys owing to their higher strength, better wear resistance, lower casting temperature and abundant resources [4].

1.2 Silicon carbide[SiC]:

Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is not attacked by any acids or alkalis or molten salts up to 800°C. In air, SiC forms a protective silicon oxide coating at 1200°C and is able to be used up to 1600°C. The high thermal conductivity coupled with low thermal expansion and high strength give this material exceptional thermal shock resistant qualities.

Fig.1.2.1 Silicon carbide powder

1.3 Zinc metal matrix composite:

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2. FABRICATION OF ZINC METAL MATRIX COMPOSITES

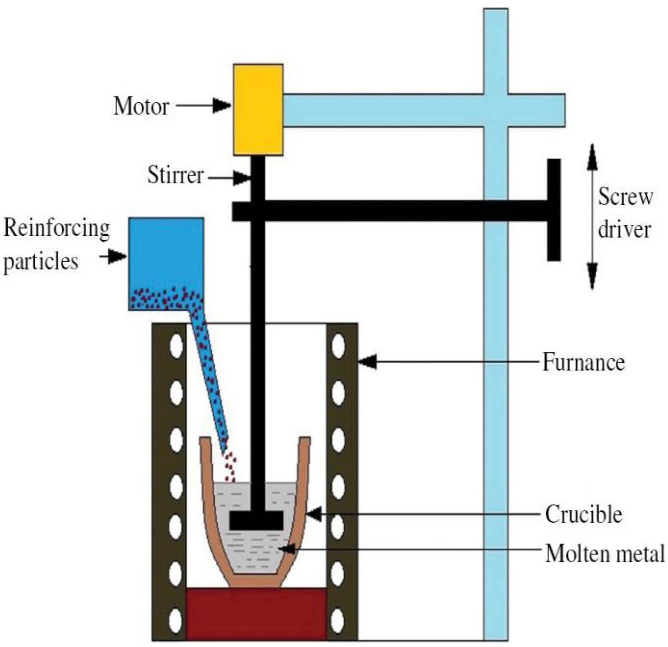

Fig.2.1 Stir casting process setup

The fabrication of MMCs involved three steps as follows:

Step 1:

2.1.1 Melting of zinc metal matrix material:

First the Zinc metal is get melted at 800°C in graphite crucible using resistance heating furnace.

2.1.2. Preheating of silicon carbide powder:

Preheat the silicon carbide powder at 1100°C for two hours to remove the moisture.

Step 2:

2.2.1 Stirring of molten Zinc metal:

Stirring of molten metal continuously at a speed of 550-600 rpm.

2.2.2 Feeding the reinforcing elements:

Feeding the silicon carbide at a rate of 15 to 20g/minutes into the molten zinc alloy at a speed of 300 rpm.

Step 3:

2.3.1. Pouring the mixture in mould:

Pouring the mixture in the graphite mould.

2.3.2. Solidification:

Solidification of the mixture takes place at this final step.

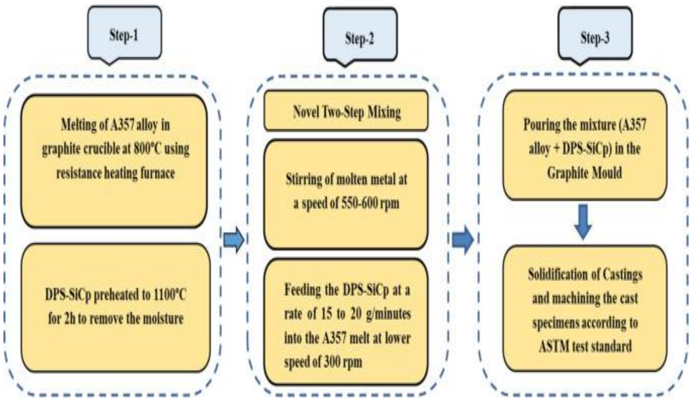

Fig.2.2 Flowchart of fabrication process

3. EFFECT OF SILICON CARBIDE ON MECHANICAL PROPERTIES OF COMPOSITES

Addition of silicon carbide to the Zinc Metal Matrix Composite enhances the physical properties as well as mechanical properties of the system. The hardness is effectively increased by the addition of silicon carbide. Since it has the greater melting point, it will also get used in the various heat treatment processes without failure which is the most important factor in those processes. Along with these all properties, silicon carbide is a ceramic, that means the tensile strength, compressive strength will get automatically increased by the addition of silicon carbide.

4. EXPERIMENTATION FOR CALCULATION OF MECHANICAL PROPERTIES

4.1 Tensile Strength and Compressive Strength

The tensile properties as well as compressive properties of the composite material is analysed by using computerized universal testing machine having 1000KN load capacity.

4.2 Hardness

Hardness tests are carried out on the Brinell Hardness Tester with 5mm diameter hardened steel ball indenter.

4.3 Density

The density measurements are carried out for both base alloy and with the reinforced elements.

4.4 Weight Reduction

The unreinforced material and the reinforced material are weighed for the calculation of percentage weight reduction of the MMC.

5. RESULTS

1. Zinc MMCs with 2% silicon carbide and 9% silicon carbide addition provide best results. The tensile strength can be increases from 15% to 25%.
2. The hardness of MMC can be effectively increased from 20% to 35% by the addition of 6% and 10% silicon carbide respectively.
3. The theoretical density is more than the practical density.

6. CONCLUSIONS

1. The Zinc alloy MMC reinforced with silicon carbide have been successfully fabricated by using electric stir casting technique.
2. The tensile strength, hardness are effectively increased by the addition of silicon carbide.
3. The greatest value of the tensile strength is observed at an addition of 9% of silicon carbide to the Zn MMC.

7. ACKNOWLEDGMENT

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