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Production And Wear Analysis Of Aluminium Metal Matrix Composite

Arjun Haridas
PG Student mechanical, Bannari Amman Institute of Technology, Sathyamangalam, India
Ravikumar M
Professor of Mechanical Department, Bannari Amman Institute of Technology, Sathyamangalam, India
Uvaraja V C
Associate Professor, Bannari Amman Institute of Technology, Sathyamangalam, India

Abstract:

The metal matrix composites which are used in industrial application face many problems or difficulties such as design, cost, recycling, etc. By developing a new phase composite material it is possible to overcome some of the difficulties by improving its tribological as well as mechanical properties. This paper presents a review of the production methodology of Aluminium metal matrix composite by stir casting process. Certain test methods such as XRD (X-ray diffraction), Optical microscopy are used to examine the mixture of matrix and reinforcement in the component made and also tribological and mechanical characteristics are measured using pin-on-disc and rockwell hardness test respectively. The experiment results show that the proposed phase offers a good performance as reinforcement and it can be considered as ideal solution for general problems.

Key words: *Metal matrix composite, Optical microscopy,Rockwell hardness,Stir casting,tribology, XRD.*

1.Introduction

In the present life metals are used for the variety of applications like automobile, aerospace, daily using utilities and for other infrastructure [1]. These metals have influenced the human life very much.So, there is a need of new metals or composition of metals which satisfy the requirement and characteristics [1].

Each metals exhibit its own characteristics, which vary with respect to property of metals. Therefore a specific metal can only be used for a particular application. This leads to a need of composition of different metals, which will helps to combine the characteristics of different metals that can be used for particular application with satisfied characteristics. Hence each application may need different composition of different metal depending on the applications [3].

The composite material havevarious applications in the fields like industrial, automobile, marine and aerospace etc. Composite can be generally defined as combination of two or more dissimilar materials having a distinct interface between them such that the properties of resulting material are superior to the individual constituting components.There are three main groups of composite material Metal Matrix Composites(MMC), Ceramic Matrix Composites(CMC), Polymer Matrix Composites(PMC) [7].

In this work composition of Al 7075 reinforced with SiC and Ni particulates are used and stir casting is used for the development of composite samples. There are different parameters for characterization of the composite like friction, wear, tensile load, shear stress, bending stress, torsional force, etc. There are various test methods to characterize the metal composition like, XRD analysis (X-ray diffraction), optical microscopy, Rockwell hardness test, pin-on- disc test and SEM (scanning electron microscopy).

This paper is organized as follows. Section II describes methods of production, methodology and testing used for the tribological characterization. Section III discusses the experimental results. In Section IV conclusion of paper is discussed.

2.Methodology And Materials

In the composite materials two or more dissimilar materials that are intimately bonded to form integrated structure. There are two main segments of the composite material one is matrix which is continuous and the other one is reinforcement which is discontinues.

Processing techniques using for the production of the composite materials are broadly classified into solid state and liquid state processing. The selection of the processing technique mainly depends on the application and state of the matrix and reinforcement materials.

In this work, liquid state processing is preferred for the manufacturing of the desired composite material. Several methods are available for the liquid state processing like stir casting, infiltration, spray deposition, etc.

The stir casting is considered for the process.

2.1 Stir Casting

Stir casting is one of the processes in which dissimilar materials are mixed by stirring process. This method is simple and more commercially used technique and it is also called as vortex technique. The main advantage of the stir casting process is to create good wetting between the particulate reinforcement and the liquid aluminium melt. This will lead to a good bonding between the reinforcement and matrix material. Pre-treating is required before the process. In this work, matrix material Al7075 is just heated to some temperature level before the melting to the liquid form. For the stirring process rotating impeller and hand stirring may be used. Rotating impeller may lead to air bubble formation in the material during stirring process which cause pores in the resulting material. In this work hand stirring is used.

2.2.Materials Used

The main materials used in the proposed composite materials are Al7075, SiC, and Ni. Each has specific application and properties.

Al7075 is used as the matrix material and SiC, Ni are used as reinforcement material.

2.2.1 Aluminium7075 (Al7075)

Aluminium 7075 is an aluminium alloy, in which zinc as the primary alloying element. 7075 aluminium alloy's composition roughly includes 5.6–6.1% zinc, 2.1–2.5% magnesium, 1.2–1.6% copper, and less than half a percent of silicon, iron, manganese, titanium, chromium, and other metals. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability, but

has less resistance to corrosion than many other Al alloys. Its relatively high cost limits its use to applications where cheaper alloys are not suitable. It is produced in many tempers, some of which are 7075-O, 7075-T6, 7075-T651.It has maximum tensile strength no more than 40,000 psi (276 MPa), and maximum yield strength no more than 21,000 psi (145 MPa). The material has an elongation (stretch before ultimate failure) of 9–10%. 7000 series alloys such as 7075 are often used in transport applications, including marine, automotive and aviation, due to their high strength-to-density ratio.Their strength and light weight is also desirable in other fields. Rock climbing equipment, bicycle components, and hang glider airframes are commonly made from 7075 aluminium alloy.

2.2.2 .Silicon Carbide (SiC)

Silicon carbide is a compound of silicon and carbon with chemical formula SiC. It occurs in nature as the extremely rare mineral moissanite. Silicon carbide powder has been mass-produced since 1893 for use as an abrasive. Grains of silicon carbide can be bonded together by sintering to form very hard ceramics which are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plates in bulletproof vests. Silicon-infiltrated carbon-carbon composite is used for high performance "ceramic" brake discs, as it is able to withstand extreme temperatures.

2.2.3 .Nickel (Ni)

Nickel is a chemical element. It is a silvery-white lustrous metal with a slight golden tinge. Large pieces of the metal are slow to reach with air at ambient conditions due to the formation of a protective oxide surface. Because of nickel's slow rate of oxidation at room temperature it is considered corrosion resistant. Nickel is one of four elements that are ferromagnetic around room temperature. Nickel has the unique propertieshigh melting point (1453ºC), adherent oxide film, resists alkalis, ductile, alloys readily - as solute and solvent, magnetic at room temperature, deposited by electroplating, Catalytic. Today nickel-containing materials are used in buildings, water supply systems, foodpreparation, energy industry, chemical industry, transport industry, electronic components, medical equipment.

2.3.Tests

XRD test, Electron microscopy test and rockwell test are conducted for the characterization of the composite material. These tests are gave the results for the pattern and particle study of the composite material.

2.3.1.XRD Test

A focused x-ray beam is shot at the sample at a specific angle of incidence. The x-rays deflect or diffract in various way depends on the crystal structure (inter atomic distance) of the sample. The locations or angles and intensities of the diffracted X-rays are measured. Every compound has a unique diffraction pattern.

In order to identify a substance, the diffraction pattern of simple is compared to a library database of known pattern.The application of the XRD test are phase composition determination, measurement of hard coating composition and structure.

2.3.2.Optical Microscopic Test

Optical microscope is a type of microscope that illuminates a specimen and produce a magnified image. It can reveal the structure of object. Optical microscopes are used to investigate the particle distribution ultrastructure of a wide range of biological and inorganic specimen including microorganism, cells, large molecules, biopsy sample, metals and crystals.

2.3.3.Rockwell Hardness

The Rockwell scale is a hardness scale based on the indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload. There are different scales, denoted by a single letter, that use different loads or indenters. The result is a dimensionless number noted as HRA, where A is the scale letter. When testing metals, indentation hardness correlates linearly with tensile strength.

3.Experimental Results

There are different tests to study the characteristics of the composite material. Results of these tests determine the performance and application of the proposed composite material.

There are four samples of the composite materials are used to test. In each mixture sample 1kg of aluminium matrix material is used and it mixed with the different proportion of the reinforced material (Sic and Ni). 2.5%, 5%, 7.5%, and 10% are the different percentage of the reinforcement material used in the four samples.

3.1.Optical Microscope

Result of the optical microscope which shows the particle arrangement or the structure of the smaller object. In this work four different samples are scanned with 100x magnification. Four samples are different in amount of addition of reinforcement. Depending on the proportion of added reinforcement the particle arrangement or crystalline structure have changed. The corresponding images are shown in fig 2,3,4,5.

Figure 1: Optical Microscope image of matrix material Al7075 with 100Xmagnification.

Figure 2: Optical Microscope image of 2.5% SiC and Ni particulate reinforced Al7075

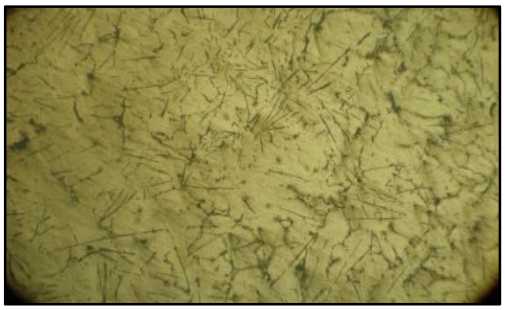

Figure 3: Optical Microscope image of 5% SiC and Ni particulate reinforced Al7075

Figure 4: Optical Microscope image of 7.5% SiC and Ni particulate reinforced Al7075

Figure 5: Optical Microscope image of 10% SiC and Ni particulate reinforced Al7075

3.2.XRD Test

XRD test which provide information about the crystal structure or the inter-atomic distance of the sample. Peak shapes and intensities give information about phase identification, along with phase quantification, percentage crystallinity, crystallite size and unit cell size.XRD test profile results are shown in fig 6,7,8,9.

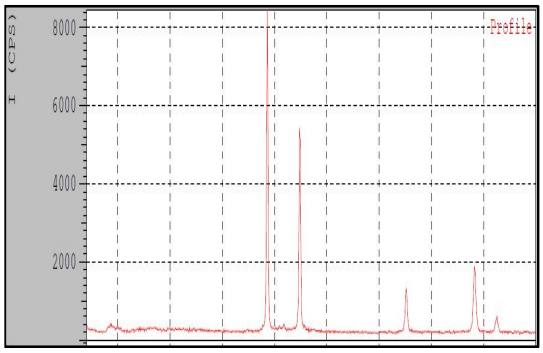

Figure 6: XRD analysis resultof 2.5% SiC and Ni particulate reinforced Al7075

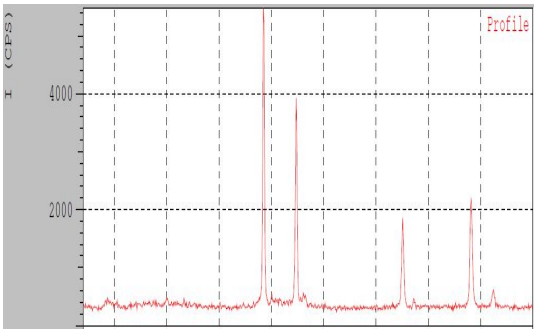

Figure 7: XRD analysis result of 5% SiC and Ni particulate reinforced Al7075

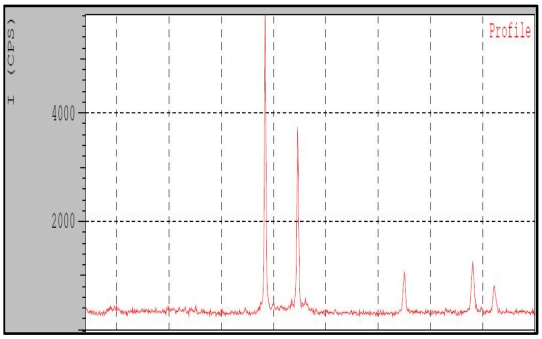

Figure 8: XRD analysis result of 7.5% SiC and Ni particulate reinforced Al7075

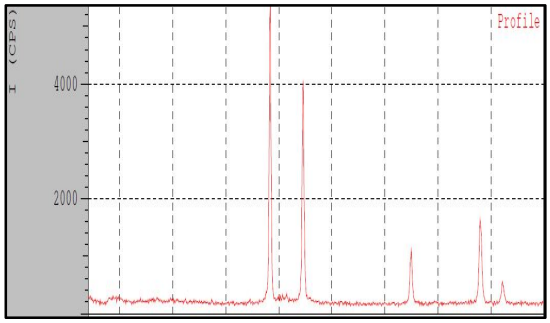

Figure 9: XRD analysis result of 10% SiC and Ni particulate reinforced Al7075

XRD analysis graph shows general profile of the composite material sample. Peak shows the quantification of the mixtures of the composite material. The highest peak shows the aluminium and the other peaks are indicating the remaining materials in the composite material. The first strongest peak of the graph shows the intensities or count 2140, 1607, 650 respectively.

3.3.Rockwell Hardness Test

The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load. Hardness of the matrix and proposed composite material are measured. The measured values are shown in table 1.

Material	**Rockwell Hardness (HRC)**
Matrix material (Al7075)	74.87
Proposed composite material	77.57

Table 1: Measurement Of Hardness

Comparison between the hardness of the proposed composite material and the matrix material is shown in fig 10.

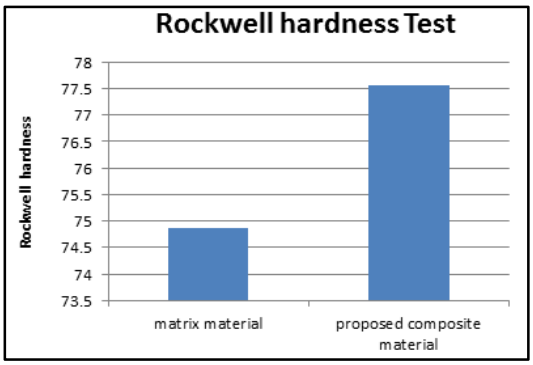

Figure 10: Comparison between the hardness

4.Conclusion

Composite materials have the crucial role in the many industrial applications. To characterize the composite material many tests are needed. In this work composite material materials tested by the optical microscope, XRD test and rockwell hardness test. Hardness of the matrix material Al7075 has improved by added reinforcement material Sic and Ni. The matrix and reinforcement material are well mixed by the stir casting and gives the better material profile. Profile have changes while adding different amount of reinforcement material. Therefore each sample exhibit smaller changes in profile.

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