Determination of Mechanical Properties of Al2024+SiC+Gr Hybrid Metal Matrix Composites by using Stir Casting Method

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Abstract: Aluminium alloys are extensively used in aircraft, supercars, and marine applications owing to its corrosion resistance and density.However, the Hybrid Metal Matrix Composites (HMMCs) are advanced materials, which can develop some desirable properties than the matrix material and Metal matrix composites have attracted a lot of attention in the recent years due to their excellent properties in different applications.The Present Work has been done on Al2024-Silicon Carbide-Graphite Composite.These are fabricated using Al 2024 powders as the matrix material and SiC and Gr powders are as the reinforcement materials Using Stir Casting Method.The Composites are fabricated and the obtained composites are sized into small specimens and tests like hardness test, wear test and corrosion test are conducted on the samples and the Experimental results areobtained.

KEYWORDS: Hybrid Metal Matrix Composite,Stir Casting, Composites, Al2024, SiC, Gr

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INTRODUCTION:

Scientists are continuously trying to improve various properties of engineering materials. This led to new category of materials called composite materials; they are composed of a combination of distinctly different two or more micro or macro constituents that differ in the form of composition and it is insoluble in each other. Composite materials have a continuous, phase called the matrix; and a dispersed,
non-continuous, phase called the reinforcement. The reinforcing phase material may be in the form of fibres', particles, or flakes. The matrix phase materials are generally continuous. In a composite, each material retains its original properties but when composited it yields superior properties which cannot be obtained separately

In Metal Matrix Composites (MMCs), ceramics or metals in form of fibres, whiskers or particles used to reinforce in a metal matrix. Most commonly used matrixes are aluminum, magnesium, copper, titanium and zinc. The most commonly used reinforcements are silicon carbide, alumina, boron, graphite and fly ash. The strengthening effect of the reinforcements in composites depends on the orientation of the reinforcements to the direction of the loads. Aluminium metal matrix composites (AMMCs) have gained significant attention in recent years. This is primarily due to their lightweight, low coefficient of thermal expansion (CTE), machinability, and improved mechanical properties. Due to these advantages, they are used in aerospace industries (airframe and aerospacecomponents), automobileindustries (enginepistons), and electronic components. Stir casting (vortex technique) is generally accepted commercially as a low cost method for fabricating AMMCs. Its advantages lie in its simplicity, flexibility, and applicability to large volume production. This process is the most economical of all the available routes for AMMCs production, and it allows very large-sized components to be fabricated.

The main aim of this study is to fabricate the Composites by stir casting method and improve the quality of the fabricated composites. The mechanical properties of the composites were also investigated and the results were discussed.

STRUCTURE OF PAPER

The paper is organized as follows: In Section 1, the introduction of the paper is provided along with the structure, important terms, objectives and overall description. In Section 2 related work is discussed. In Section 3 complete information about Methodology is provided Section 4 tells about the Results of the Testings and 5 tells us about theconclusion and future scope, ends with References.

OBJECTIVES

The objectives of this project are to fabricate metal matrix composites with the base metal as Aluminum 2024 reinforced with different composition of Silicon carbide particulates and graphite particulates by Stir casting method and to determine the Mechanical Properties such as Hardness , Corrosion, Wear of the fabricated Hybrid metal matrix composite specimens.

RELATED WORK

One approach taken by R. Bowles who used ceramic fibres to improve tensile strength of a hypoeutectic 332.0 alloy.Moreover, A. Shakesheff has used ceramic particulate for reinforcing another type of hypoeutectic A359 alloy.In a similar approach, cast aluminum MMC for pistons using eutectic alloy such as the 413.0 type, hasbeen described by P. Rohatgi.Vikram Singh and R.C. Prasad had fabricated and analyzed the tensile and fracture behavior of 6061 Al-SiCp metal matrix Composite by reinforcing with 5%, 10% and 15 volume % SiCparticles.VidyaSagarAvadutala had analyzed the cracks in composite materials (aluminum and low carbon steel)

METHODOLOGY

3.1 Materials and Percentage in Composition

Aluminium 2024 as the matrix material in the form of solid rods and the Silicon Carbide as the Reinforcement-1 in the form of Powder Size 100Microns and Graphite as the Reinforcement-1 in the Form of Powder Size 100 microns.

The Percentage in Composition of The Hybrid Metal Matrix Composite is

1. 96% Al2024+2% Sic+2% gr
2. 94% Al 2024+4% Sic+2% gr
3. 92% Al 2024+6% Sic+2% gr
4. 90% Al 2024+8% Sic+2% gr

3.2 Fabrication Method

Stir Casting Method is used to fabricate the Hybrid Metal Matrix Composite.It is the simplest and the most cost effective method of liquid state fabrication. Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibres) is mixed with a molten matrix metal by means of mechanical stirring.

In stir casting the stirrer is used to agitate the molten metal matrix. The stirrer is generally made up of a material which can withstand at a higher melting temperature than the matrix temperature. Generally graphite stirrer is used in stir casting. The stirrer is consisting of mainly two components cylindrical rod and impeller. The one end of rod is connected to impeller and other end is connected to shaft of the motor. The stirrer is generally held in vertical position and is rotated by a motor at various speeds. The resultant molten metal is then poured in die for casting. In this method first the Al2024 metal of 96%Wt Composition is heated above its liquid temperature so that it is completely in molten state. After it is cooled down to temperature between liquid and solidus state means it is in a semi-solid state. Then reinforcement particles which are SiC of 2% Composition and Gr of 2% Composition added to molten matrix and again heated to fully liquid state so that they mixed thoroughly each other and the same Process is performed to other three Compositions.The Molten Metal is be taken into the die which is of our required shape and size and let the die don't to be disturbed for some time so that the required Specimens are Fabricated sucessfully of length 12mm and diameter 8mm.In this Projectthe Mechanical Properties like Hardness,Wear and Corrosion are determined for each composition specimen that had Fabricated.

Fig 1 Fabricated Specimens

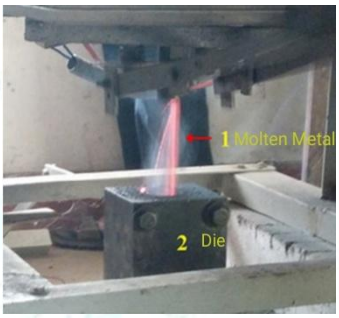


Fig 2 Molten Metal

Fig 2 Stir Casting Equipment

3.3 Hardness Testing

The Micro Vickers Method is Opted for Hardness Testing because as it is best and accurate method for hybrid composites and for small and thin specimens. It is based on Optical measurement system. The micro hardness test procedure, specifies a range of light loads using a diamond indenter to make an indentation which is measured and converted to a hardness value. It is very useful for testing on a wide type of materials as long as test samples are carefully prepared. A square base pyramid shaped diamond is used for testing in the Vickers scale. Typically loads are very light, ranging from a few grams to one or several kilograms.

The Micro Vickers hardness test utilizes a quadrilateral diamond pyramid with an angle of 136°

between the opposite faces subjected to load of 0.5kg.The full load is normally applied for 10 to 15 seconds. The two diagonals of the indentation left in the surface of the material after removal of the load are measured using a microscope and their average calculated More over the adoption of the square base pyramid shape provides freedom from distortion under load. The diagonal is measure by focusing a cross wire device in the optical equipment. The Hardness test is to be performed for 4 different Specimens that had fabricated and for two times tested on different places on the specimens.

3.4 Wear Testing

Pin on disc machine was used to carry out the wear behavior of Hybrid Metal Matrix Composites.Pin sample dimensions selected were diameter of 8 mm and a height of 40 mm . Acetone was used to clean the pin at the start of each trial and digital electronic balance was used for measuring weight. The wear rates were determined using the weight loss method.

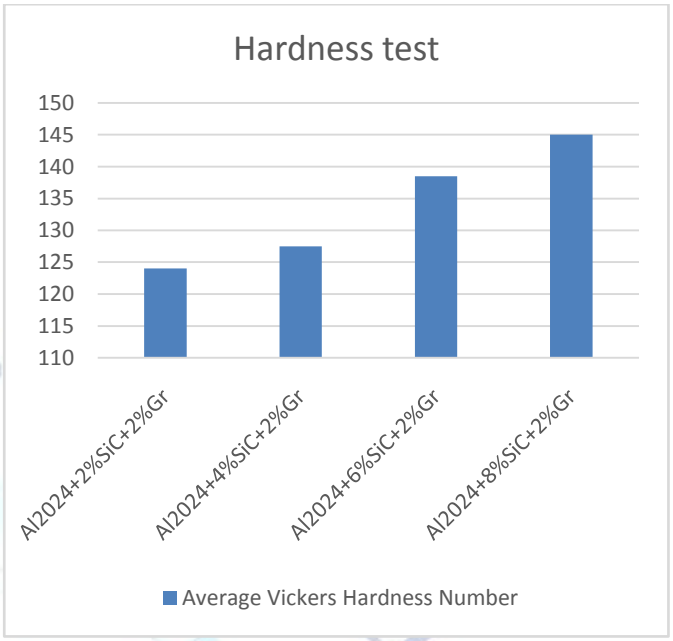
Here the load applied is 1Kg and varies track distance with 200,400,600 metres and took values accordingly.The Weight of the Specimen is initially measured and after the experiment the weight of the specimen again measured and the Weight loss is Calculated and taken as Wear.

3.5 Corrosion Testing

10% of concentrated HCL was taken in four beakers containing with 90% of water. The specimens were initially weighed and dropped into the solution and beakers were covered with paper. The specimens were taken out from solution after two hour and weight was measured. Then again specimens were dropped into the solution and taken out after completion of second hour and weight was measured. This above process is repeated for fourth ,sixth ,eigthand tenth hours also by increasing Percentage of HCL to 20% ,30% .The values are compared for different percentages of Al2024, SiC for second hour, fourth hour,sixth,eigth and tenth hours.

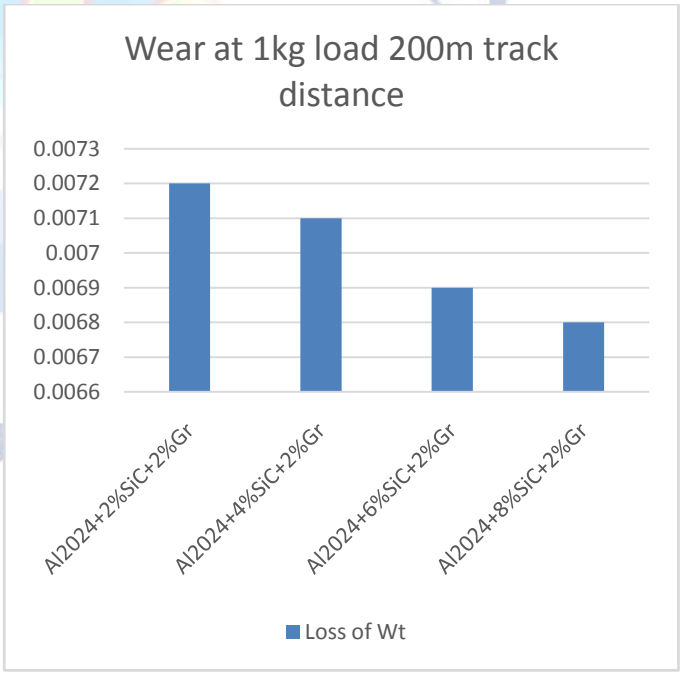
RESULTS

4.1 Hardness Test Results

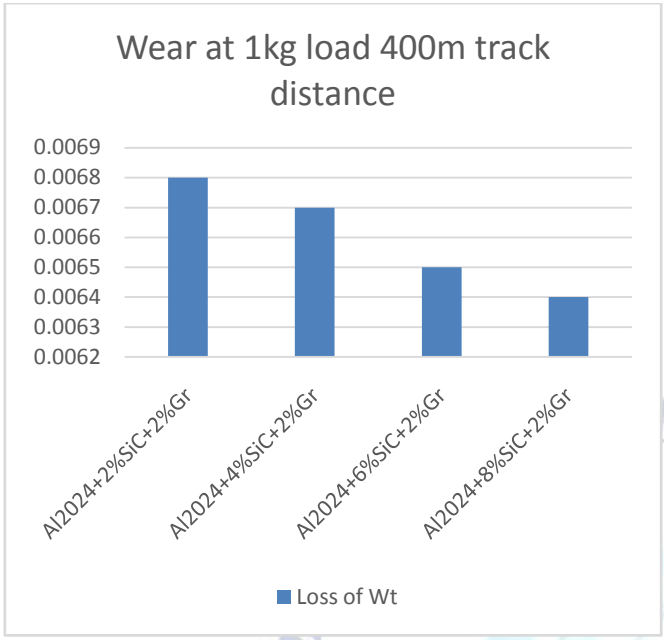


4.2 Wear Test Results

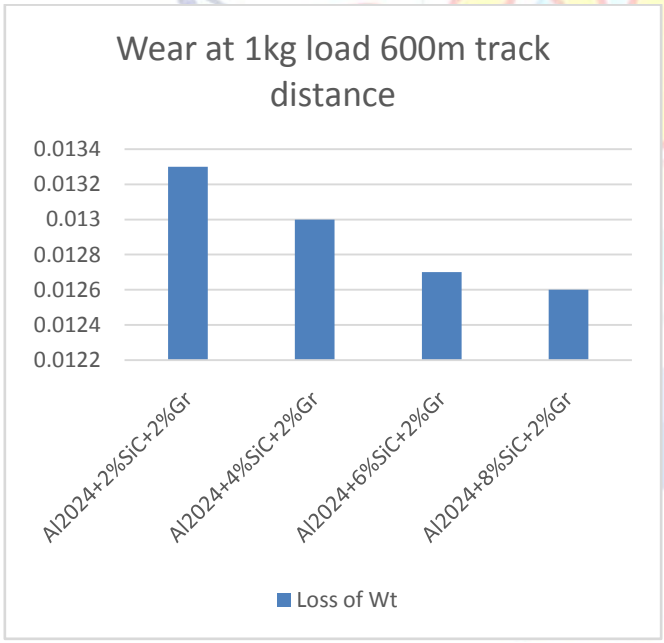
Wear at 1Kg Load and 200Mts Track Distance



Wear at 1Kg load and 400mts track distance

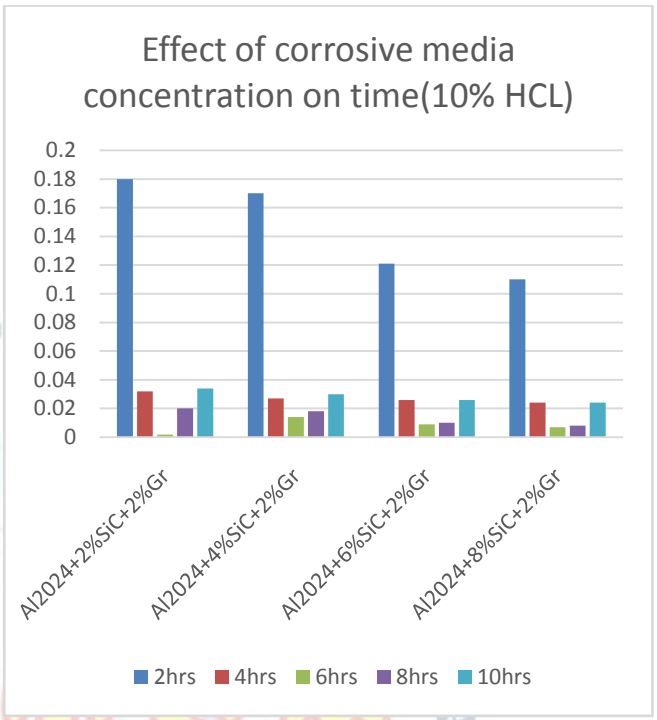


Wear at load 1Kg and 600 mts TrackDistance

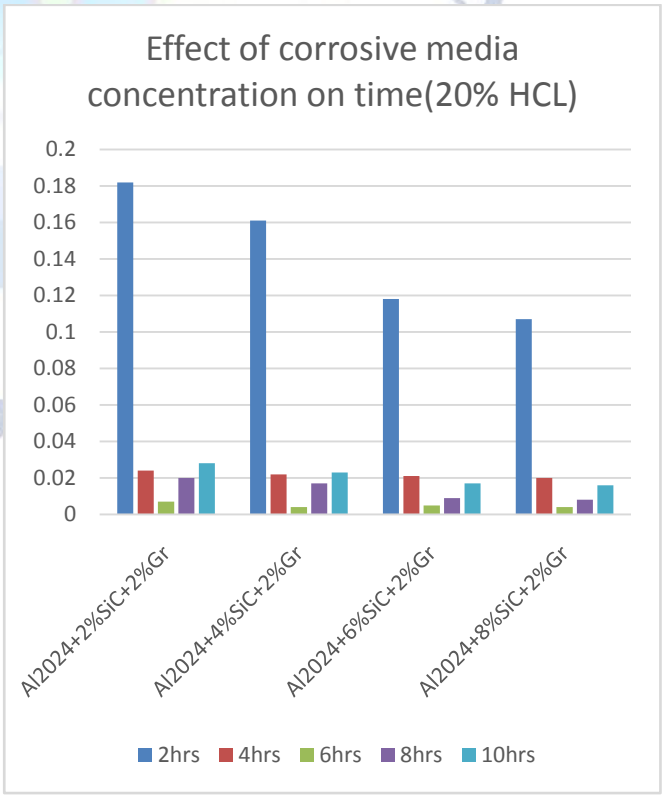


4.3 Corrosion Test Results

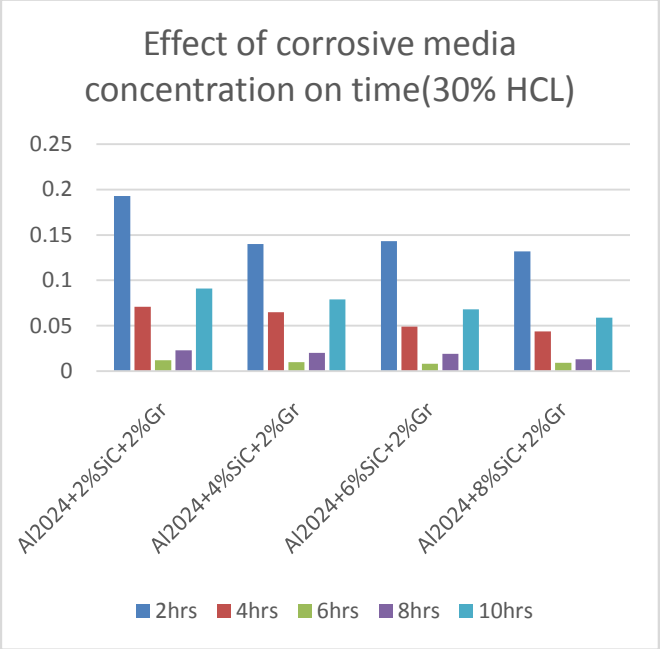
Effect of corrosive media concentration on time (10% HCl)



Effect of corrosive media concentration on time (20% HCl)



Effect of corrosive media concentration on time (30% HCl)



CONLUSION AND FUTURE SCOPE

The conclusions of the research work undertaken are:

The AL2024-SiC-Gr Hybrid metal matrix composite materials have been successfully fabricated by Stir casting method.ThenanoSiC-Gr particulates are evenly dispersed in the matrix alloy.Themicrohardness of AL2024-SiC-Gr nano metal matrix composite material is superior than the matrix material.The micro hardness increases by 12.2% by the addition of 2 wt.% of SIC-GRnano particulates in aluminum (AL2024) matrix alloy.The wear resistance increases as the wt.percentage of reinforcement substance amplifies in the matrix material.The wear resistance of aluminium (AL2024) +6 % nanoSiC-Gr Metal Matrix Composite shows 40.76% increase in the wear resistance as compared to wear resistance of aluminum (AL2024)alloy.As the percentage of reinforcement increases there is also increases in hardness that is due to harder reinforcement and as comparatively single reinforcement non hybrid composites hardness is low because of graphite is having machinableproperty.As the percentage of sic increases there will be decrease in weight due to add of graphiteBy the nature itself graphite is self lubricating devices which can act as self lubricated.Rate of corrosion are also less comparatively base materials because of addition of graphite and this can be obtained by the proper distribution of reinforcement.

There is a very wide scope for future scholars to explore this area of research, Thisworkcan be further extended to study other aspects of such composites like use of other potential fillers for development of hybrid composites and evaluation of their mechanical behaviour and the resulting experimental findings can be similarly analyzed.

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