Experimental Study on Fabrication of Aluminium 2024/ TiO$_2$ Metal Matrix Composite

Siddhesha.S$^1$ T.D Jagannath$^2$

$^1,^2$Assistant Professor

$^1,^2$Department of Mechanical Engineering
$^2$HMSIT, Tumkur

Abstract— Aluminium alloy materials found to the best alternative with its unique capacity of designing the materials to give required properties. Aluminium alloy Metal Matrix Composites are gaining wide spread acceptance for automobile, industrial, and aerospace applications because of their low density, high strength and good structural rigidity. In this study metal matrix composite is fabricated through stir casting method. Titanium Oxide (TiO$_2$) is used as reinforcement for the present study. The Metal Matrix Composite is prepared with varying the TiO$_2$ volume fraction ranging from 2% to 8%. Metal Matrix Composite is fabricated successfully through stir casting method and found that the mechanical properties of fabricated metal matrix composite materials like tensile strength, hardness and impact strength of the metal matrix material found by using different experimental methods. The experimental results show that the tensile strength of the metal matrix composites is increasing with volume fraction of Titanium Oxide. Similarly, hardness and impact strength of Metal Matrix Composite are increasing with volume fraction of Titanium Oxide.

Key words: Aluminium 2024, TiO$_2$, Stir Casting Method, Tensile Strength, Hardness, Impact Strength

I. INTRODUCTION

Recent increases in the performance requirements of materials for aerospace and automobile applications have led to the development of numerous structural composite materials. Composites are materials consisting of at least two constituents bonded together along the interface in the composite, each originating from a separate ingredient material which pre-exists the composite. Metal matrix composites (MMCs) are materials in which one constituent is a metal or alloy forming at least one percolating network. The other constituent is embedded in this metal matrix and usually serves as reinforcement. Reinforcements are characterized by their chemical composition, shape, dimensions, and properties as ingredient material and their volume fraction and spatial distribution in the matrix. Typical MMCs combine a tough metallic matrix which is contiguous with a hard ceramic reinforcement. Deonath and Rohatgi (1981) revealed that cast aluminium mica particulate composites and copper coated ground mica particles have enough strength and so they are used as bearings in several applications. Common matrix materials are aluminium, magnesium and titanium while the typical reinforcing ceramics are SiC, B$_4$C, Al$_2$O$_3$, TiC, WC and ZrO$_2$ either in a continuous, discontinuous or particulate form.$^2$ Hybrid aluminium matrix composites are used for high performance “ceramic” brake disks as it is able to withstand extreme temperatures. The silicon reacts with the graphite in the carbon composite to become carbon fiber reinforced silicon carbide. The SiCp particles scuff the counterpart leading to greater wear loss. The addition of solid lubricant particles such as graphite along with SiCp as hybrid reinforcements effectively improves the tribological properties of the composites. Metal matrix composites have a high application potential in automotive engineering in braking systems, piston rods, piston pins, pistons, frames, valve spring caps, brake discs, disc brake caliper, brake pads, card an shaft etc. They have also found application in military and civil aviation in the area of axle tubes, reinforcements, blade and gear box casing, turbine, fan, and compressor blades. In the aerospace industry MMCs have been applied in frames, reinforcements, aerals, joining elements etc. Al-based metal matrix composites (MMCs) are well-known for their high-specific strength, hardness, and attractive tribological properties. The silicon carbide- reinforced aluminium composites are increasingly used as substitute materials for cylinder heads, liners, pistons, and brake disks in automobile industry. The main purpose of the particulate-reinforced metal matrix composite production is to obtain materials having high-wearing resistance, light weight, and high-specific strength in order to reduce the costs of technological applications and fuel consumption.

II. EXPERIMENTAL PROCEDURE

A. Materials and Method

The matrix material in present study is Al2024. The reinforcing material selected is Titanium oxide TiO$_2$ of different composition. The Titanium oxide is varied by 2%, 4%, 6% and 8% weight of Aluminium 2024. The Aluminium 2024 alloy was used as the base matrix. This is melted at 700°C which is slightly more than 30°C above the liquids temperature. The reinforcing material used is TiO$_2$ powder of 2%, weight of Aluminium 2024. The stirring technique is adopted to fabricate the specimens in which a stir casting is created in the melt of the matrix alloy through a mechanical stirrer coated with aluminize and rotating at 550 rpm. The composites are fabricated with 2-8 weight % of the TiO$_2$ particle in steps of 2 weight %. The TiO$_2$ particles are added to the melted Aluminium 2024. Aluminium 2024 alloy is first preheated at 200$^o$ for 2h before melting and TiO$_2$ is added to melted material which improve the wetting properties by removing the absorbed hydroxide and other gases. The composite melt is thoroughly stirred. The composite slurry is then reheated to a fully liquid state and mechanical mixing is carried out for 20 min at 200 rpm average stirring speed. Finally the composite slurry is poured in permanent metallic mould. The composites are then cast in permanent moulds. Al alloy composites containing various TiO$_2$ contents, namely 2%, 4%, 6% and 8% by weight of Aluminium and similarly the composites are fabricated with 2-8 weight % of TiO$_2$.
The TiO₂ particles are added to the melted Aluminium 2024, were fabricated and tested and their properties. All tests are conducted in accordance with ASTM Standards. Tensile tests are performed at room temperature using a Universal Testing Machine in accordance with ASTM E8-82.

III. RESULTS AND DISCUSSIONS

Various tests are conducted on fabricated metal matrix composites samples to analyse the strength characteristics of aluminium 2024/ TiO₂ metal matrix composite. Mechanical properties such as tensile strength, impact strength and hardness have been determined on fabricated metal matrix composite. The tensile strength is carried out at room temperature on universal testing machine. Impact strength is carried out at room temperature on impact testing machine. Brinell hardness test is carried out on a hydraulic Brinell hardness test machine.

A. Tensile Strength

The results shows that the effect of TiO₂ content on tensile strength, hardness and impact strength of aluminium 2024/TiO₂ metal matrix composite. Figure 1.1 clearly shows that the effect of TiO₂ content on tensile stress of aluminium alloy composites.

It can be seen that as the TiO₂ content increases the tensile strength of the composite material increases monotonically by signification amount if other factors are kept constant.

The uniform distribution of TiO₂ particles and strong bonding with aluminium matrix are the causes for increase in tensile strength.

B. Hardness

Brinell hardness test is conducted on the aluminium 2024/ TiO₂ metal matrix composite. The test results shows that hardness of the composite material increases with increasing the TiO₂ content in the composite materials. The figure 1.2 shows that the hardness of aluminium 2024/TiO₂ metal matrix composite is 104.6 BHN at 2% of TiO₂ content. The hardness of 4% of TiO₂ is 108 BHN but when add 6% and 8% of TiO₂ with aluminium 2024 hardness is increases to 116 BHN and 124 BHN respectively. Hence, the hardness of the aluminium 2024/ TiO₂ metal matrix composite increases with increase the TiO₂ content in the composite material.

C. Impact Strength

The effect of TiO₂ content on the Impact strength of the aluminium 2024/ TiO₂ metal matrix composite material. The composite materials are prepared on different compositions of materials, Aluminium alloy composites containing various TiO₂ contents, namely 2%, 4%, 6% and 8% by weight of Aluminium. Figure 1.3 is a graph showing the effect of TiO₂ content on the Impact strength of the Aluminium alloy composite. The hardness of 2% TiO₂ is 2 N-m but when added 4% of TiO₂ with Aluminium -matrix it increases to 4 N-m and further with addition of 6% of TiO₂ 7 N-m and further with addition of 8% of TiO₂ 9 N-m. Hence, the Impact strength of the Al-TiO₂ MMC increases with increase in reinforced volume fraction. It is due to the hard nature of the reinforced particulates.

IV. CONCLUSION

The aluminium 2024/ TiO₂ metal matrix composite is prepared by stir casting method by varying the amount of TiO₂ particles. The different experiments are carried out on the fabricated aluminium 2024/ TiO₂ metal matrix composite as per ASTM standard. The experiments results was found that increasing the TiO₂ content in the aluminium metal matrix composite results in increasing in tensile strength, hardness and Impact strength of the material. The uniform distribution of TiO₂ particles and strong bonding with aluminium matrix are the causes for increase in tensile strength, hardness and Impact strength of the material.

REFERENCES

Experimental Study on Fabrication of Aluminium 2024/ TiO2 Metal Matrix Composite
(IJSRD/Vol. 4/Issue 05/2016/381)


