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Enhancement of Mechanical Behaviour of Aluminium Metal Matrix Composite Reinforced with TiO2

Mohammad Faisal Ansari[1], Dr. Muhammad Ramzan[2], Malik Shahzad Mahvi[3], Zulfiqar Ansari[4]
[1,2,3,4]*(Asst. Prof., Mechanical Engineering Department, MMANTC, Mansoora, Malegaon, India)*

Abstract: *Recent applications in engineering require materials which are stronger, lighter and cheaper. A good example is the interest in the development of materials those have good strength to weight ratio suitable for automobile applications where fuel economies with improved engine performance are becoming more critical. For many applications it is necessary to improve their mechanical behavior and wear resistance. Aluminium based metal matrix composites are being used for a variety of applications such as military, aerospace, electrical industries and automotive purposes owing to their improved properties such as high strength to weight ratio, good ductility, high strength and high modulus, excellent wear and corrosion resistance. AMC attracts much attention due to their lightness, high thermal conductivity, and moderate casting temperature, corrosion resistance. Engine pistons, engine blocks and other automotive and aircraft parts operating under severe friction conditions are fabricated from reinforced aluminum matrix composites. The pure Aluminium was reinforced with TiO2 particles 5% by wt., 10% by wt.,15% by wt. The composites were characterized by XRD, TGA, Wear, Compressive, Tensile, Hardness and Impact tests were carried out in order to identify mechanical properties.*

Keywords: *Metal Matrix Composite, Aluminium & TiO2, XRD, TGA, Wear, Hardness, Impact, Compressive & Tensile tests.*

I. Introduction

Now a days modern development needs advanced engineering materials for various applications. To fulfill such demand metal matrix composite (MMC) is one of the reliable source. A metal matrix composite (MMC) is composite material with at least two constituent parts, first being a metal necessarily, the second material may be a different metal or another material, such as a ceramic or organic compound. MMCs mostly made by dispersing a reinforcing material into a metal matrix. Metal matrix composite are significant class of material with non metallic reinforcement incorporated in metal matrices , enhancement in material properties can be witnessed. When compared with monolithic and conventional alloys of a metal , MMCs will attained high strength and stiffness . In view of this pure aluminium as a matrix material and reinforcing it with TiO2 particle a result in MMCs with high specific strength for various light weight application. During the last twenty years, metal matrix composites (MMCs) have emerged as very important class of materials for structural, wear, thermal, transportation ,electrical & other applications. Metal matrix composites (MMCs) possess significantly improved properties including high strength; modulus, damping capacity and good wear resistance compared to unreinforced one. Al Metal Matrix Composites (MMCs) got over other conventional materials in the field of aerospace engg., automobile engg. and marine engg. applications due to their excellent improved properties. These materials are of much interest to the research fellow from few decades. These composites replaced Cast Iron and Bronze alloys in beginning but restricted due to their poor wear and seizure resistance, they were subjected to many experiments and the wear behavior of these composites were elaborated to a maximum extent and were reported by number of research scholars for the past three decades.

II. Experimental Work

Preparation of Sample

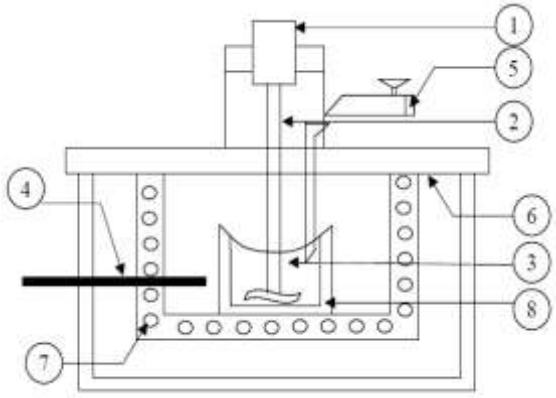
Aluminium was melted in a crucible by heating it in a furnace at 805ºC for three & half hours. The furnace temperature was first raised above the liquidus temperature of aluminium near about 755ºC to melt the aluminium completely and was then cooled down just below the liquidus to keep the slurry in Semi liquid state.

Automatic arrangement in stirring was carried out with the help of radial drilling machine for about 10 minutes at stirring rate of 295 RPM. At this stage, the TiO2 particles were added manually to the vortex. In the final mixing processes the furnace temperature was controlled within 700 ºC. After stirring process the mixture was pour in the other mould to get desired shape of specimen as shown in fig. The presence of reinforcement throughout the specimen was inspected by chipping out the casting at different locations and under XRD

examination. Same process was used for specimens with different compositions of TiO2. Compositions are shown in table.

Composition of sample

S.No.	Sample	Aluminium(gm)	TiO2 (gm)	Remarks
1	TP 0	170	0	TiO2 =0%
2	TP 5	170	8.5	TiO2 =5%
3	TP 10	170	17	TiO2 =10%
4	TP 15	170	25.5	TiO2 =15%



Schematic setup view of Stir Casting

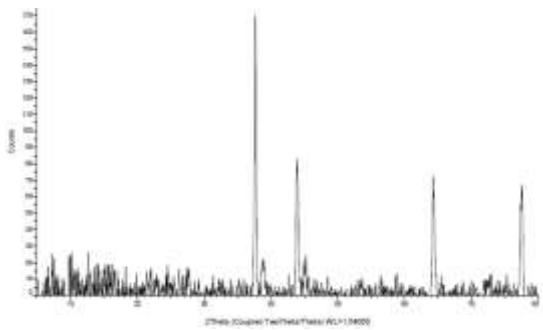
1) Motor
2) Shaft
3) Molten Aluminium
4) Thermocouple
5) Particle Injection Chamber
6) Insulation Hard Chamber
7) Furnace
8) Graphite Crucible

Casting of Sample

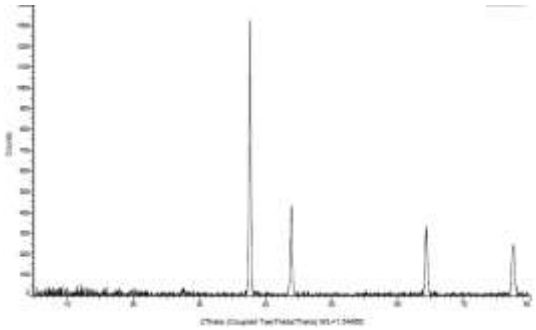
III. Results And Discussion

XRD Test

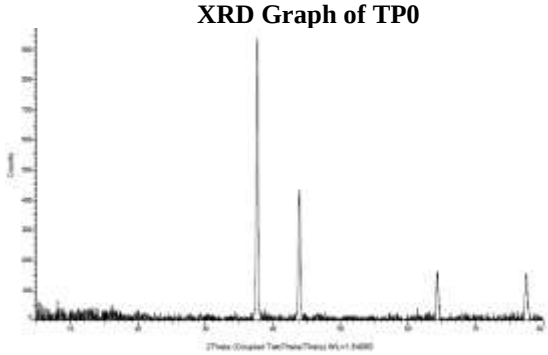
X-Ray Diffraction techniques are a family of non-destructive analytical techniques which indicates information about the crystalline structure, chemical constituents, and physical characteristics of materials and very thin films. These techniques are based on observing the scattered intensity of an X-Ray beam hitting a sample as a function of incident and angle of scatter, polarized, and wavelength or power.X-Ray crystallography is a method of determining the arrangement of atoms within a crystalline, in which X-Rays strikes a crystal and causes the beam of light to spread into many particular directions. From the angles and intensities of these diffracted beams, a crystallographer can produce a three dimensional picture of the density of electrons within the crystal.



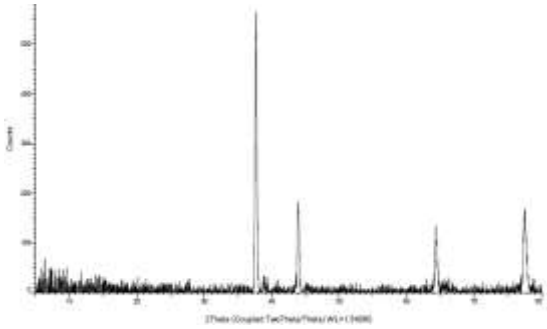
XRD Graph of TP0



XRD Graph of TP5



XRD Graph of TP10



XRD Graph of TP15

TGA Test

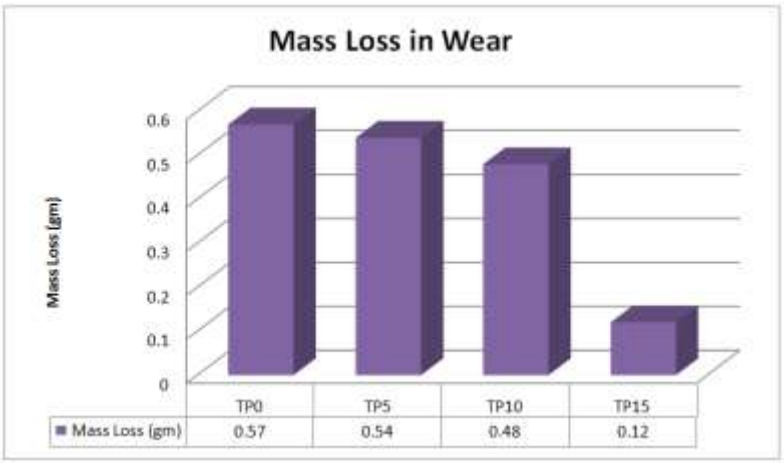
In thermo gravimetric analysis the weight loss at high temperature is measured. The TGA is done in nitrogen atmosphere the flow rate is kept 50 ml/min with platinum cell and the temperature 20 °C to 900 °C.

Wear Test

Wear is tested on pin and disc wear tester. In this two metals comes in contact out of which on metal is stationary and other is rotating due to this there is friction between the two material and hence there is material loss due to friction.

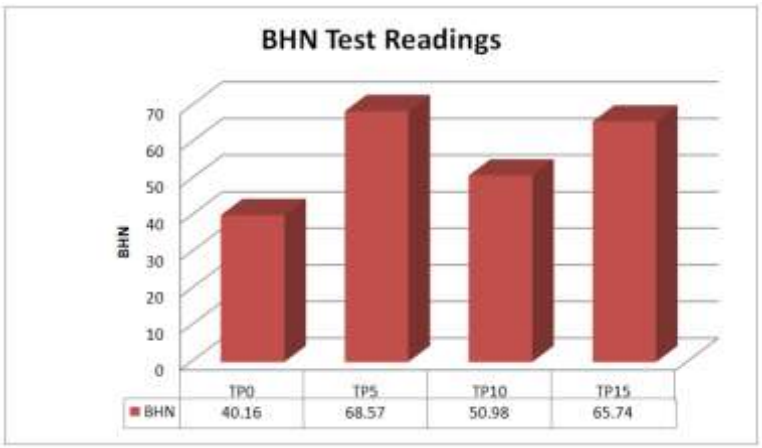
Wear Test Table

Sr. No.	Sample	Initial Mass (gm)	Final Mass (gm)	Difference in Mass (gm)
1	TP 0	33.17	32.60	0.57
2	TP 5	33.17	32.63	0.54
3	TP10	33.78	33.30	0.48
4	TP15	35.16	35.04	0.12



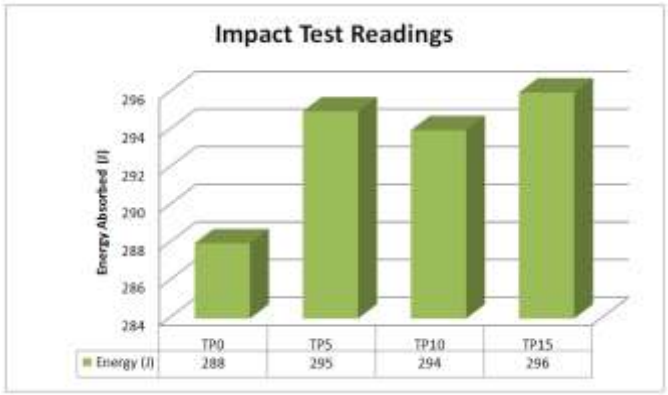
BHN Test

Breniel hardness testing machine is used to measure hardness measurement. The surface to be tested is requiring the metallographic finish and it was done by 100, 220, 400, 600 and 1000 grit size emery paper. Load used on Breniel hardness tester is 100 Kgf, Ball diameter is 1.56mm, results for breniel hardness testing is as under.



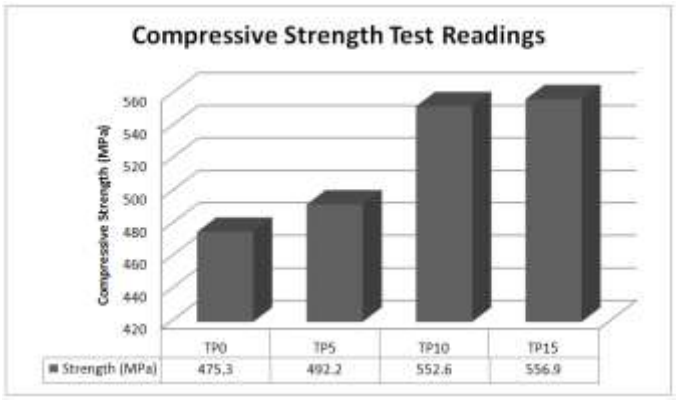
Impact Test

Charpy test is also known as the charpy V notch test is standardized high strain test which determines the energy absorbed by material during fracture. This absorbed energy is measure of toughness for given material. The energy absorbed by the material is shown as under.



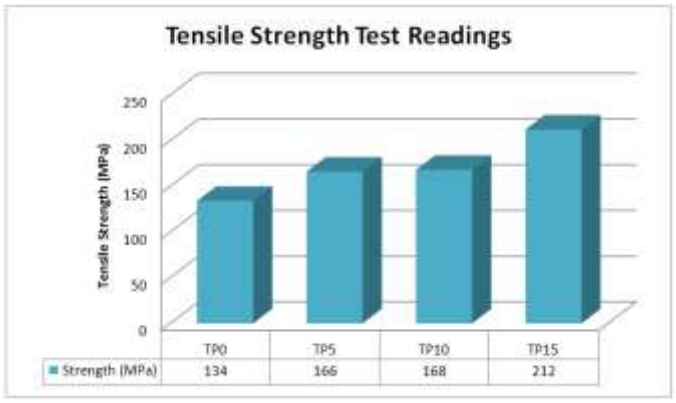
Compressive Strength Test

Compressive strength test is strength taken by the material during the compressive load. In compressive test the sample length is taken 40mm and load is applied on the sample the results are as shown.



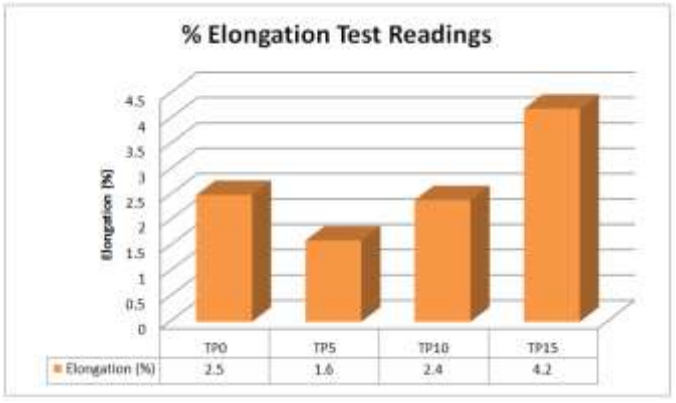
Tensile Strength Test

Tensile test were asses the mechanical behavior of reinforced composite and metal matrix. The reinforced composite and metal matrix machined to tensile specimen as per ASTM E8. Ultimate tensile strength(UTS), often shorten to tensile strength or ultimate strength is the maximum stress that can withstand while stretched or pulled before necking. The tensile strength is as shown.



Elongation Comparison

As shown in graph the % Elongation from TP0 to TP5 goes on decreasing which is due to not proper mixing of TiO2 in the Aluminium Matrix.



IV. Conclusion

The above test results confirmed that stir die cast Aluminium with TiO2 reinforced composites is clearly better than the base Aluminium in the comparison of Tensile strength, Impact strength & Hardness. Dispersion of TiO2 particles in aluminium matrix improves the hardness of the matrix material. It appears from this study that UTS and Yield strength trend starts increases with increase in weight percentage of TiO2 in the matrix. It appears from the study that weight loss goes on decreasing with increase in percentage of TiO2 in the matrix in pin and disc wear testing. XRD results showed the presence TiO2 particles in micro form in metal matrix. Weight loss goes on increasing in TGA with increase in percentage of TiO2.

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