Fabrication and Mechanical characterization of hybrid AA6063/Red mud/TiO_2 Composite

A PROJECT REPORT

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STUDENT'S DECLARATION

I, Jeeteshwar singh (Roll No. 2K19/PIE/04), hereby certify that the work which is being presented in this report titled "Fabrication and mechanical characterization of AA6063/Red mud composites" is submitted in the partial fulfilment of the requirement for degree of Master of Technology (Production and Industrial engineering) in Department of Mechanical Engineering at Delhi Technological University is an authentic record of my own work carried out under the supervision of Prof. N. Yuvraj. The matter presented in this report has not been submitted in any other University/Institute for the award of Master of Technology Degree. Also, it has not been directly copied from any source without giving its proper reference.

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CERTIFICATE

This is to certify that this report titled, “Fabrication and mechanical characterization of AA6063/Red mud/TiO_2 composites” being submitted by Jeeteshwar singh (Roll No. 2K19/PIE/04) at Delhi Technological University, Delhi for partial fulfilment of the Degree of Master of Technology as per academic curriculum. It is a record of bonafide research work carried out by the student under my supervision and guidance, towards partial fulfilment of the requirement for the award of Master of Technology degree in Computational Design. The work is original as it has not been submitted earlier in part or full for any purposebefore.

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ABSTRACT

Composite materials are produced by adding two or more materials together. The materials that are included in composite have unique physical or chemical properties individually but when they are mixed together, the produced material has different properties unlike to individual elements.Aluminum Metal Matrix Composites (AMMC's) are most popular composite material used in wide sectors such as automobiles, defense, aerospace etc. due to its properties like hardness, low density, non-magnetic, low maintenance and many more. AMMC's are fabricated using various processes such as stir casting, diffusion bonding and Power Metallurgy (PM) process. Amongst all, stir casting is most economical and simpleprocess.

Red mud is the waste by-product during the production of alumina from bauxite by the Bayer's process. It is insoluble waste produced due to digestion of bauxite at high temperature and pressure. Utilization and disposal of red mud is a major environmental concern. To overcome that red mud is used as reinforcement in MMC (Metal Matrix Composite). Using red mud as reinforcement with Aluminum matrix improves the hardness of the Matrix Composite and shows the Composite characteristics.

CONTENTS

Chapter 1

INTR0DUCTION

1.1. CompositeMaterials

Composite materials are produced from two or more individual materials called constituent materials. On combining the properties and characteristics of a produce a material is totally different from what they as an original property. These constituent materials are characterized into two main categories called **Matrix** and **Reinforcement**. The physical properties of Matrix and Reinforcement are different from each other and are different from produced Composite material as well.

There are different kinds of composites available nowadays. They are broadly categorized based on matrix and reinforcement

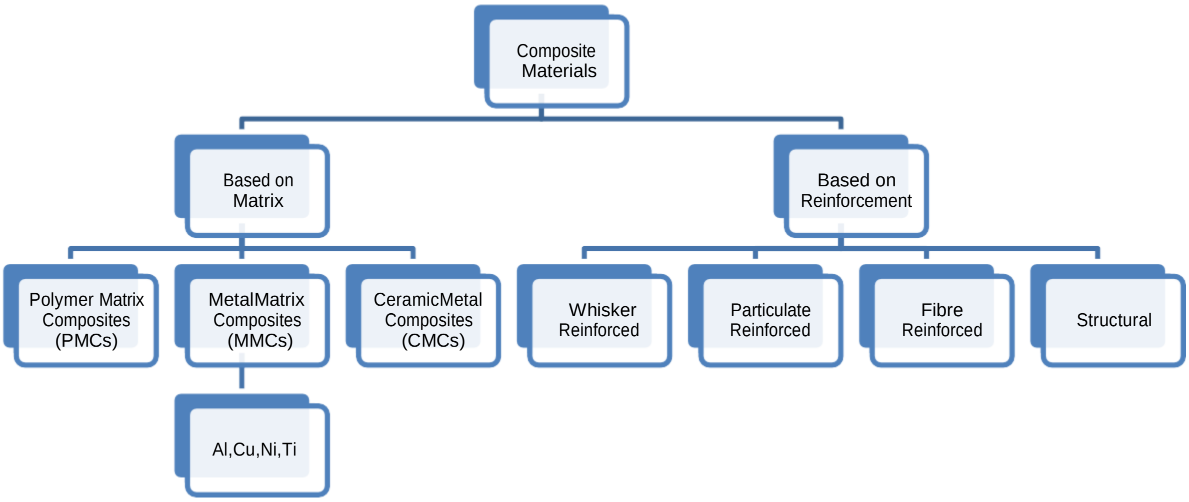

Fig 1.1: Classification of Composite material

1.1.1. Properties of Composite Material:

1. Composite material has better stiffness and torsional property.
2. Composite material has high fatigue endurancelimit.
3. They are 30-50% lighter than the conventionalmaterials.
4. Composite make less noise and lessvibration.
5. Additional Versatile.
6. Composite materials have3-4 times higher tensile strength than conventional a materials like steel and Aluminum.
7. They have low embeddedenergy.

1.1.2. Classification ofComposites

On the basis of matrix, they are classified as:

- Polymer Matrix composites(PMC)
- Ceramic Matrix composites(CMC)
- Metal–matrix composites(MMC)

On the basis of reinforcement, they are classified as:

- Particle reinforcedcomposites
- Continuous fiber composites(sheet)
- Short fiber composites(whisker)

1.1.3. Role of Matrix in Composite

Although the matrix has some inferior properties as compared to reinforcement, but its physical presence is important in composite to provide shape to the composite. It acts as a shield for reinforcement to protect it from moisture and also protect against mechanical degradation.

The matrix is relatively soft continuous phase of composites and holds the reinforcements in a particular orientation

1.1.4. Role of Reinforcement in Composite

Reinforcement means the action or process of reinforcing or the process of reinforcing or strengthening. So, Reinforcement in Composite provides strength to the composite along with other properties such as stiffness, heat resistance or conduction.

The matrix and reinforcements are chemically or mechanically bonded together to achieve different characteristics of a composite.

1.2. Metal Matrix Composite

Based on Matrix in Composite, Metal Matrix Composite is one of the types of composite materials. As discussed in previous section, composite material is combination of matrix and reinforcement. In metal matrix -composite, matrix is one of the metals. Pure metal is used rarely in MMCs, generally an alloy isused.

MMCs are collection of fibers or particles surrounded by matrix of metal. The metal matrix provides very high stiffness and high temperature resistance to composite. The temperature resistance is way more than that of pure metal. The main matrix materials used in MMCs are Titanium, Aluminum, Magnesium, and Copper.

MMCs are known to for its low thermal expansion coefficient, high strength to weight ratio, goodabrasion and wear resistance, low density, mechanical compatibility, high young's modulus, enhanced electrical performance, good process ability, thermal stability, economic efficiency, etc. that are hardly obtained by pure monolithic materials.

Due to excellent thermal and mechanical properties and the global need for high-performance, cost-effective and lightweight materials, MMCs received a lot of attention in research field over several years. Aluminum MMCs received much interest in commercial sector due to its mechanical properties.

Table 1.1: Some important MMCs systems

Sr. No.	Matrix	Reinforcements and their types	Properties	Applications
1	Aluminum	Continuous fibers: alumina, Boron, Silicon carbide graphite. Discontinuous fibers: boron carbide, alumina, alumina-silica Whiskers: silicon carbide Particulates: silicon carbide.	High stiffness, high strength and high modulus of elasticity even at elevated temperatures, low density, high thermal conductivity, good abrasion resistance.	Automobile parts likebrakecomponents, piston, pushrods,bicycles, golf clubs, electronic components, cores of high voltage carrying cables.
2	Magnesium	Continuous fibers:alumina, Silicon carbide Whiskers: graphite, Silicon carbide Particulates:Boron carbide, alumina	Highstiffness, low density, high modulus of elasticity, good wear resistance, strength and creep resistance at elevated temperatures is good.	Components of cars radiators, gearboxes and engines of aircrafts, biomedical implants, hydrogen storage.
3	Titanium	Continuous fibers: silicon carbide, coated boron Particulates: titanium carbide	High specific strength, high biocompatibility nature, high creep resistance, great thermal stability, light weightand good wearresistance.	landing gear of aircrafts, automotive components like engine valves and connecting rods, implants of human hard tissue, blades of turbine.

4	Copper	Continuous fibers: graphite, Sic Wires: niobium-tin, Niobium-titanium Particulates:boron carbide, silicon carbide, titanium carbide.	thermal expansion coefficient is low, modulus of elasticity is high, both electrical and thermal conductivity is good, high wear resistance.	Hybrid modules, electric springs. electrical relays, and other electrical or electronic components.
5	Superalloy	Wires: Tungsten	Excellent mechanical strength and resistance torising temperatures, good local stability, and corrosion as well as oxidation resistance.	Chemical processing industry, nuclear reactors, turbine blades

1.3. Manufacturing and FormingMethods

There many different techniques by which MMCs can be produced. The selection of appropriate process isdesired type, quantity and distribution of the reinforcing parts, matrix metal/alloy and application. Even having the same design andcomponent values, different features profiles can be achieved by changing the production method, processing and finishing performance. The most successful methods are defined by breaking them down into liquid, in situ and solid processes.

Fabrication of MMCs is divided into two categories:

- Liquid State Process
- Solid State Process

1.3.1. Liquid State Process

In liquid state process of fabrication of metal matrix composite, molten metal is taken as matrix and then solidify it. Stir casting is one of the most used and cheap liquid statemethod.

Proper wetting is required between the reinforcement and the molten metal matrix in order to get good mechanical properties. In order to get good interfacial bonding particles of dispersed phase can be coated. Coating of a reinforcement particles can decrease their surface energy level and chemical affinity towards the continuous phase (metal matrix). This layer of coating can help in locking of these dispersed phase particles in the base matrix.

1.3.2. Comparison among liquid-state fabrication ofMMCs

Route	Cost	Application	Comments
Stir casting	Less expensive	Commercial method of producing aluminum base composites.	Depends on properties and process parameters of the material. AMC is suitable for particulate reinforcement.
Compo-casting	Low	Used in aerospace & automotive Industries.	For discontinuous fibers, especially particulate reinforcement.
Squeeze casting	Medium	Used in automotive & for manufacturingobjects having complex shapes.	control volume fraction of fibers more accurately. Make preform more homogeneous.
Spray casting	Medium	Used to produce	Produced full

		friction materials, contacts, cutting, electrical brushes and grinding tools.	density materials
In-situ (reactive) processing	Expensive	Applications in automobile.	Distribution of reinforcing particles is homogeneous.
Liquid-metal infiltration	Low/Medium	Rods, tubes, beam etc. with uniaxialdirectional properties can be produced.	reinforcement in the form of filament is used.

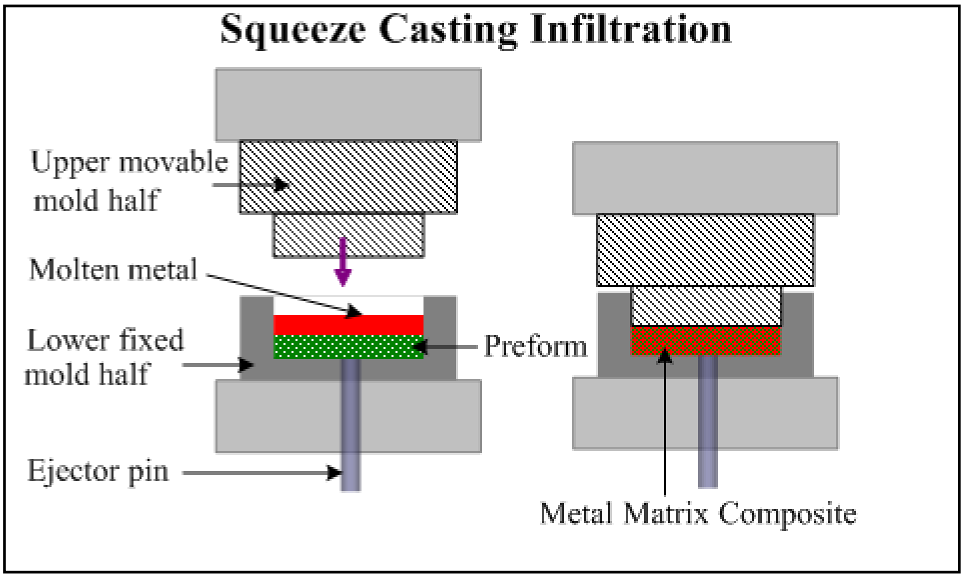

Fig 1.2: Squeeze Casting Infiltration

i. **Spray Forming**

To prepare thick layers of fine, molten metal droplets or semi- deposited particles onto a substrate and solidified.

ii. **In-Situ Synthesis**

This method involves formation of dispersed phase as a result of precipitation from the melt during its cooling and till it solidifies.

iii. **Liquid MetalInfiltration**

In this methodology, short fibers/ceramics are soaked into melted metal matrix that fills the space between the dispersed phase inclusions. Employed in making tungsten- copper composites.

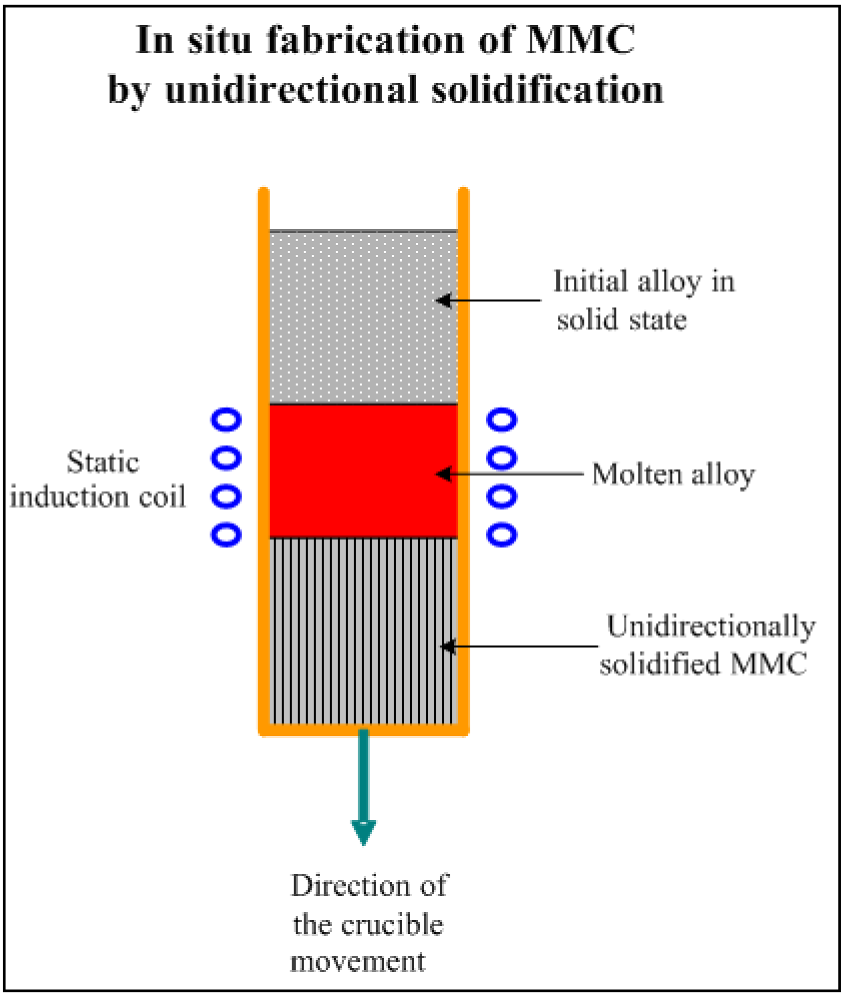

Fig 1.3: In-Situ Synthesis

1.3.3. Solid State Process

In Solid State Process, metal matrix is in solid form or in powder form. Some ofcommon solid states method are,

i. PowderMetallurgy
ii. High Energy BallMilling
iii. Ultrasonic Probe AssistedMethod
iv. DiffusionBonding

    In this method, long fibers and matrix in foil form are stacked in particular order.

v. Friction StirWelding

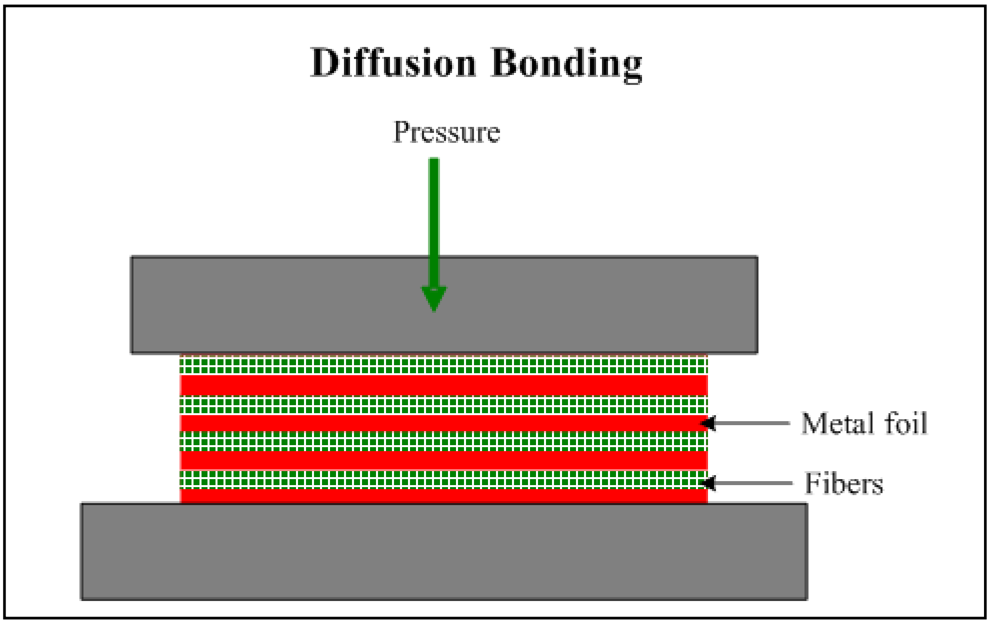

Fig 1.4: Diffusion Bonding

1.4. MMCs from IndustrialWaste

Due to industrialization, the growth of industrial waste also got increased which leads to environmental pollution. Because of issues facing in disposal of this waste, the researchers are focusing on this to utilize it as reinforcement material in composite. The industrial waste that can be used with AA6063 canbe Fly Ash and Redmud.

Chapter2
Literature Survey

Reports suggest that the energy consumed by recycling of Aluminum is only ~5% of what is required in aluminum production. There are certain limitations as well which are associated with recycled aluminum like, presence of impurities. This issue can be overcome using the right selection of reinforcement material and the fabrication method. Lot of fabrication methods are available to prepare Aluminum Metal Matrix Composite, but stir casting method is one of the efficient methods and are used commercially. It is useful for large quantity fabrication. Here, in this study we have used Red Mud as reinforcement for Aluminum metal matrix composite using stir casting method.
The disposal of red mud is becoming an environmental issue and no solution till date available for its use. There are several literature surveys which suggests that red mud can be used for some metal values recovery such as Titanium, Vanadium and Zinc; can used in ceramics, etc. There are ongoing research and development work in India on utilization of red mud. Some of them are given below

N.E. Udoye et al. [1] fabricated aluminum AA6061/Rice Husk Ash [RHA] composites though stir casting by varying the percentage of reinforcement. microstructural test SEM/EDS and mechanical properties are studies for different specimen of 0%,2%,4%,6% and 8% [RHA] reinforced. The mechanical properties with 8 wt % RHA reinforced AA6061 is better than other weight percentages of produced composites. SEM shows homogenous dispersal of reinforced particles.

P. Raghuvaran et al. [2]. Investigated the wear and mechanical behaviour of aluminum matrix composites fabricated through stir casting method. In this AL7075 matrix is reinforced through SIC particles of size 150 µm. four different composites are fabricated by varying the weight percentage of Sic in a step of 2 from 2% to 8%. AL7075 is heated in a furnace to a liquid state and with the help stirrer stirring was done at constant 250 rpm due to which a vortex is formed. Preheated Sic particles are introduced in the vortex with the help of feeding gun. Preheating is done to remove the impurities and moisture from the reinforcement. Tensile test, hardness test and wear test were performed on the casted composites. Test reveals that with the increase in the weight percentage of sic particles tensile strength, hardness number increases and wear rate decreases for the 6% weight of Sic and for 8% weight of Sic tensile strength, hardness number decreases and minor decrease in wear rate. Therefore, they concluded that Al7075-6 wt% Sic composites made by stir casting will be used for aerospace and automobile applications.

Srivallirani et al. [3]. Composed hybrid Al 7050/ TiO2/ BN Metal Matrix Composites and study mechanical properties of the fabricated material. First heated the AL 7050 to a temperature 680 c in a coiled induction furnace. Preheated Boron nitride (BN) and TiO2 particle of size 40µm is added to molten matrix. Different samples were drawn by varying TiO2 particles 1%,3% and 5% by weight while keeping BN as constant at 2% wt in all samples. They conclude that tensile strength increased by 27%, percentage of elongation decreases with the increase in percentage of TiO2, theoretical and practical density are closer and porosity of samples is below 4%.

B. Ravi et al. [4]. Fabricated and characterization of aluminum matrix composites (AA6061/B_4C) using stir casting method. AA6061 is melted in a muffle furnace at a temperature of 850℃ and reinforcement particle is preheated at a temperature of 250℃ in a separate furnace and after mixing and stirring of mixture pour in a preheated mould to a temperature of 650℃. Casting is in the shape of plate from that sample piece for a tensile and hardness test is taken out. Mechanical properties both tensile and hardness enhanced and homogenous fabrication is done.

V. Balaji et al. [5]. Used stir casting to manufacture aluminum matrix composites (AL7075/Sic). Heating the AL7075 at a temperature of 750℃ and add 20µm size Sic preheated particles in it and stirring is done for 10 minutes at a 400 RPM. They conclude that 6% by weight of Sic can be added to get successful fabrication of AL7075/Sic MMCs can formed. Improved in the density as compared to the base metal. Uniform distribution of particles of Sic in the metal matrix revealed by the micro structural analysis. Sic particles significantly increases the wear resistance properties of a composites and AL7075/Sic exhibits the super mechanical and tribological properties.

V. Jaya Prasad et al. [6]. Fabricate hybrid metal matrix composites of aluminium reinforced with (TiB_2/Sic) micro ceramic particles and also their mechanical and tribological characterization. SEM and X-Ray diffraction technique shows the uniform dispersion of TiB2 and Sic particles in the aluminum matrix there is some places where there are some agglomerations of particle that causes porosity presence. There is improvement in the hardness of a composites with the increase in the percentage of reinforced particles and have maximum value of hardness is 78.5 HV. Tribological properties are also improved because of addition of TiB2 and Sic particles improves the self-lubricating properties of a composites.

Manish Shukla et al. [7]. Done a review of behavioural characteristics of aluminum metal matrix composites. Stir casting methodology is used to mix the reinforcement particles with in the aluminum matrix with the help of mechanical stirrer. Metal matrix composites Al+5%Sic; Al+10%Sic; Al+15%Sic; Al+20%Sic shows an impact strength of 22N-M; 24 N-M; 30 N-M; 36 N-M respectively. Here they find that there is a clustering of reinforcement particles due to their density difference and because of that reinforcement particles distribution is not completely homogeneous.

Abhishek kumar et al. [8]. Fabricated A359/Al_2O_3 metal matrix composite by using electromagnetic stirrer and the characterization of MMCs. A359 is used as a metal matrix and reinforced with $Al_2O_3$of average size of 30μm in the weight percentage of 2 wt.%, 4 wt.%, 6 wt.%, 8 wt.%. hardness of MMCs is higher than that of base metal. With increase in the weight percentage of Al_2O_3there is increase in the tensile strength of a cast composites. Overall observation is that small size grain particles with good interfacial bonding can successfully produce by electromagnetic stirring method.

Baskar Chandra kandpal et al. [9]. Aluminum 6061 alloy is reinforced with aluminum oxide by stir casting. They developed indigenously stir casting setup to fabricate AA 6061/ Al_2O_3composites. Aluminum percentage increases due to addition of aluminum oxide result shown in spectrometry test. As the percentage of reinforcement particle of aluminum oxide increases from 5% to 20% there is continuous increase in tensile strength, hardness test and UTS of a composite but there is decrease in percentage of elongation. Fracture mode is move toward brittle from ductile with the increase in aluminum oxide percentage.

$AA6061/Al_2O_3$ fabrication shows increase in the reasonable hardness and decrease in ductility with aluminum oxide. $AA6061/Al_2O_3$successfully fabricated with the newly developed stir casting setup.

Narender Panwar et al. [10]. Aluminum 6061 is reinforced with red mud by stir casting and done micro structure analysis. AA6061 melted at 800℃ in crucible and stirring is done in molten metal to form vortex and in this preheated red mud at a temperature of 400℃ injected in it and cast it traditionally. Then heat treatment is done to get more uniformity of the structure and properties. SEM image shows uniform distribution of particles in the metal matrix. Heat treatment reduces the surface cracks and red mud based aluminum composite is successfully fabricated by stir casting. EDS is done on a fabricated to reveals the presence of various elements inside the matrix like Ca, O, Na, Fe, etc.

Abhijit Bhowmik et al. [11]. Study the tribological properties of a $AL7075/BiT_2$.Metal matrix composites fabricated by the stir casting process. Varying percentage of $BiT_2$from 0%, 3%, 6%, and 9% of grain sized 13µm is dispersed in a matrix with the help of stirrer. X-Ray diffraction method show that BiT_2 particles dispersed uniformly throughout the matrix. Wear test shows that least removal of material is in composition having 9% percentage of $BiT_2$and recommended AL7075-9% material where light weight matting or sliding is required. Wear test also show that with the increase in load there is improvement in wear rate but coefficient of friction decreases.

Uppadaramakanth et al. [12]. Study the mechanical behaviour of a fabricated hybrid composites having base metal Al-Zn alloy and fly ash/and Sic particles by using stir casting. In this inert gas is used to reduce the void and containment and also oxidation containment. Low density of fly ash causes the decrease in the density of the composites when compared with the base metal. Hardness of composites increases with increase in the content of reinforcement particles. Ultimate tensile strength and yield strength both are increasing of a composite material.

Sivananthan et al. [13]. Prepare and evaluate the properties of a $AL6061\text{-}Al_2O_3$ metal matrix composites by using stir casting. AL6061 is reinforced with particles of Al_2O_3 with average size 26-30 µm. First AL6061 is heated to molten stage than preheated particles of

Al_2O_3 at a temperature 400℃ is slowly added and stirring is done at 600 rpm. Mixture at a temperature of 790℃ is poured in a preheated die at temperature of 200℃ of cast iron. Increase in both the ultimate tensile strength and the hardness of a AL6061 with the increase in percentage of Al_2O_3reinforcement particles with maximum hardness 81HV and 164MPa at 4wt% of Al_2O_3. Compressive strength increases up to 9% by reinforcing it to 4wt% of Al_2O_3particles.

S. sathiyaraj et al. [14]. Investigate the mechanical properties of AL-B_4C metal matrix composites fabricated by stir casting method. Composition of B_4C with 3.5%, 7%, 10.5% by weight percentage is reinforced in to the base matrix. With the increase in B_4C reinforcement particles tensile strength increases up to 7wt% and then decreases with further addition of particles of B_4C. Hardness test follows the same trends as tensile strength shows and give maximum hardness of 70(HV 0.5) for 7wt% of B_4C. yield strength decreases with the increase in weight percentage of B_4C where as percentage of elongation increases with the increase in weight percentage of B_4C.

A Baradeswaran et al. [15]. Study the properties of AA7075 reinforced by graphite with the help of stir casting. Percentage of graphite particles with 5%, 10%, 15%, 20% by weight is used to reinforcement of AA7075 matrix by stir casting. Tensile strength test shows that the addition of graphite reinforcement strength of a composite decreases due to brittle nature of graphite. Hardness test shows the same trends as shown by the tensile test because of the soft nature of graphite.

Chapter 3

Experimental Procedure

3.1 MaterialSelection

Prior importance is given to a Metal matrix and reinforcement while selecting a material for a metal matrix composites (MMCs). Selection of reinforcement material is based on their properties as well as on their individual use. Before combining materials properties and characteristics are evaluated individually to check whether a selected materials mix together or not. For MMCs aluminum is the best suitable candidate because of its light weight, good strength and corrosion resistance properties.

Al6063 is used as a matrix material for this study. Table 3.1 represents the chemical composition of Al6063. The material selection is based on properties such as high elastic modulus, high temperature, high thermal and electrical conductivity, increased strength, low coefficient of thermal expansion, etc.

Aluminum composites have unique properties of conductivity and thermal properties. Also having good wettability, strong bonding and design flexibility.

During extraction of aluminum from a bauxite ore produces a red mud as a by-product. Red mud is produced in aluminum industry is disposed in cement and other construction works. In Bayer’s process, 2 tons of Alumina is used to produce 1 ton of aluminum. ~58% alumina and ~42% red mud comes out from 1 ton of bauxite. The ration of red mud to Aluminum is 2:1 and this huge amount of red mud waste is increasing all over the world. Table 3.2 shows the Chemical Composition of Red Mud.

Table 3.1: Chemical Composition of AL6063 Metal Matrix

%	Constituent
0.10	Cu
0.40	Si
0.15	Fe
0.10	Mn
0.80	Mg
0.10	Zn
0.10	Ti
98.15	Al

Table 3.2 Chemical Composition of Red Mud

%	Constituent
48.50	Fe_2O_3
14.41	Al_2O_3
11.53	SiO_2
7.50	Na_2O
5.42	TiO_2
3.96	CaO
0.17	MnO

In this study we are going to fabricate and mechanical characterization of a hybrid composite of Al 6063/ Red Mud/TiO_2

3.1.1 Fabrication Method Used – StirCasting

Stir Casting is very simple and easy to use MMC method. This process involves chemical mixing of reinforcing material into molten metal. During mixing stirrer is used. The mixture is transfer into the mold before it solidifies.

In the process stir casting base metal first converted into molten state byheating it above a melting temperature for some time and then reinforcement materials either heated or cooled are added into a molten matrix with the help of a mechanical stirrer. There are various parameters like stirring time, reinforcement preheating, impeller blade angle, etc. which affect the distribution of dispersed particles within the molted matrix. It is a straight forward, forward-looking approach in the production of MMCs

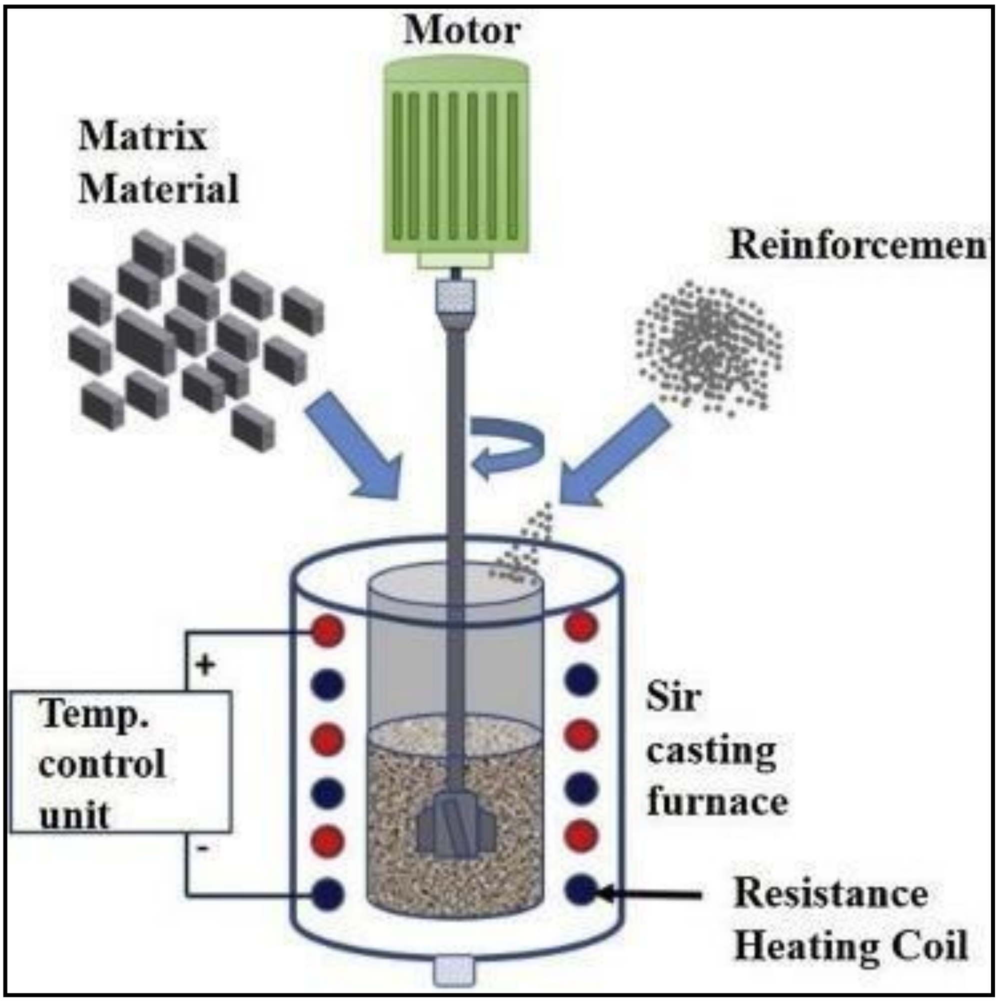

Fig 3.1: Schematic diagram for Stir Casting Process

Since there is a cooling rate gradient from the center to the top, homogeneity of the element is the major factor in this approach. This process promotes negative matrix moisture and solidification. Ultrasonic assisting process appears to be promising solution. Extruded-cast MMCs are known for having good mixing and matching reinforcement. The initial heating of the solidifying particles before dispersing is also proven to improve the solidification particles by a melted matrix. Heating also reduces porosity in the structure. In addition, the addition of particles by two phases (where the gas layer around the particles layer prevents the wetting between the particles and the molten metal is effectively broken down by mixing the particles in a solid state and effectively broken down by mixing the particles in the solid state and effectively Injecting particles with inert gas at melting is also a useful tool to improve the distribution of reinforcing particles.

3.1.2 Working method

Rod of aluminum 6063 is first cut into small pieces with the help of hacksaw. After weighing desired amount of quantity of AA6063 is placed in a stirring crucible and preset the furnace temperature. After presetting we turn on the furnace, metal first heated to a temperature of 650℃ and then start melting to a temperature of 900℃. Both the red mud and the TiO_2 in a desired quantity is heated in a separate muffle furnace at a temperature of 400℃to remove moisture which is required for the proper wetting action between reinforcement and the molten matrix. When AA6063 completely converted into a molten state then stirring of a molten metal is started and we add reinforcement gradually in it manually. After complete mixing we pour the mixture in a preheated permanent mold and allow time for cooling gradually.

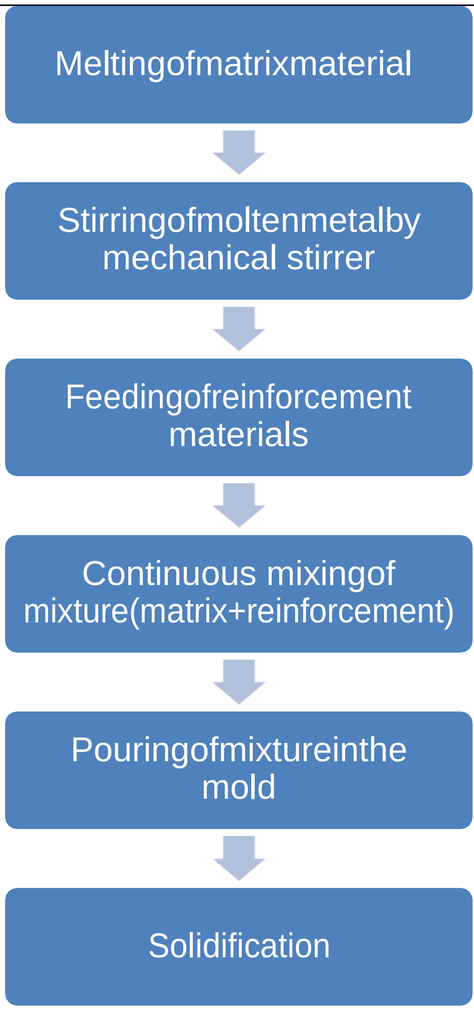

Fig 3.2: Various steps involved in stir casting process

3.1.3 Effect and optimization of stirring process parameters

Parameters like stirrer speed, stirring time, stirrer position, blade angle and the rate of reinforcement feed are the main which play vital role in distribution of particles of dispersed phase in the molten matrix phase. Vortex is formed with the help of stirrer and maintain the suspension of reinforcement particles in the molten metal.

1. Stirrer speed

Stirrer speed plays a vital role in homogeneous dispersion of the reinforcement particles in a molten metal. High speed mechanical stirrer effectively dispersed the particle in the molten matrix which finally increase the effective strength of the composites. For high strength it is desirable that stirring is done at high speed.

2. Stirring time

Optimum time of stirring is required for give composite fabrication. Too much stirring time leads to wear of stirrer blade and small duration of stirring causes accumulation of a dispersed particles. If we done stirring in a certain optimum time to get good strength of a fabricated composite because proper mixing of the ingredients of composite. So it is necessary to give adequate stirring time.

3. Pouring temperature

Pouring rate, running temperature, the dimensions of reinforcement, distance in between mold and crucible are vital factors for the standard of casting, to avoid entrapping of gases, the Pouring rate ought to be uniform and pouring temperature should be sufficiently high.

4. Wetting elements

The addition of alloying elements such as calcium, magnesium can enhance the wettability with reinforcement particles. Alloying element reduces the surface tension there by enhance the wettability.

5. Reinforcement preheating

Preheating of red mud and TiO_2particle is done in a separate furnace at a temperature of 400℃ for 5 minutes toremoves moisture and any substance which result in the formation ofgases during stirring and casting. This is less complex methodology where we heat theparticles of red mud and TiO_2at elevated temperature. This method increases the wettability of reinforcement with the matrix.

6. Preheating ofmold

Preheating of the mold helps to get rid of the porositywhich can be formed in the cast. Preheating is done to remove moisture from the mold in advance for this it is heated in a muffle furnace otherwise it will get evaporated and get entrapped within the casting and reduce its strength. It will enhance the mechanical properties of the cast.

7. Impeller bladeangle

In order to get good axial flow and shearing action we need a suitable angle of a blade. Reinforcement particles accumulation is break and also uniform distribution of a particles in the molten metal is done by the shearing action of a blade of a stirrer.

In a investigation using water and CFD model to find effect of blade angle in a stir casting. Through investigation it is found that blade angle[α=32°] of impeller is suitable for uniform distribution of reinforcement particles without concentration. For blade angle less than [α=20°] particles accumulate below the stirrer and for higher blade angle greater than [α=35°] particles get accumulate or stick below the tip a blade.

8. Impeller Position

The height of a impeller from the base of a crucible should be less than 30% of the total height of a molten metal in order to avoid agglomeration of reinforcement particles at the base of a impeller blade.

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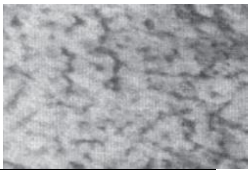
Fig 3.3:Stir Casting setup

The preheated 6063 aluminum alloy was taken and the temperature of the fire was raised to 750 ° C and allowed to reach the liquid state. Red mud and TiO_2 were preheated to 400 ° C and then added to the melted liquid. After that a filter is applied and the impeller rotation level is set to 550 RPM for 10 minutes. The melted mixture is poured into the skin and allowed to cool.

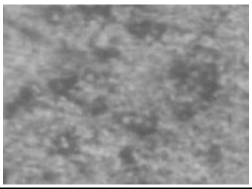
3.2 MECHANICAL CHARACTERIZATION

3.2.1 Microstructure Analysis

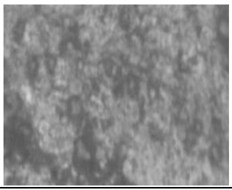
Metallurgical microscope is used to analysis the microstructure of each sample at 200X. first each sample were prepared by grinding with different grit size emery papers to obtain a mirror like polished surface. After polishing sample were etched with the etchant containing nitric acid, HCL, HF and water in the quantity 2.5mL, 1.5mL, 1.0mL and 95mL respectively. The etched samples were dried with help of drier and then the microstructure was observed in the metallurgical microscope. Fig 2 (a-e) shows a microstructure of cast AA6063/tio_2/red mud MMCs with different weight fraction of red mud and tio_2 at 200 X magnification. Microstructure reveals that both the reinforcement tio_2 and red mud distributed homogeneously in the casting. We have also seen some of the agglomeration in the sample having 2wt% of tio_2 and 8wt% of red mud. Dark black color shows the presence of red mud and silvery white spots shows the presence of tio_2.



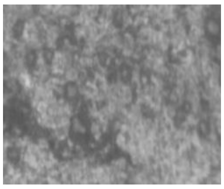
(a) AA6063



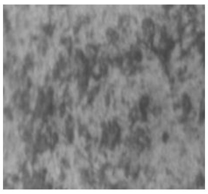
(b) AA6063 + 2wt% red mud+ 0.5wt% tio_2



(c) AA6063 + 4wt% red mud + 1.5wt% tio2



(d) AA6063 + 6wt% red mud+ 1.5wt% tio_2



(e) AA6063 + 8wt% red mud + 2.0wt% tio2

Fig 3.4: **microstructure of each sample under 200X magnification**

3.2.2 Hardness test

Brinell hardness testing machine is used to test the hardness of a specimen. A steel ball indenter of 5mm diameter is used to indent the specimen at a load of 500kgf for all specimen. We use a cylindrical specimen of diameter 30mm and height 25mm. specimen is place on the anvil so that its surface will be normal to the direction of the applied load. Load applied on the specimen for a period of 15 seconds. After indentation area of a indent is measured with help of microscope.

Fig 3.5: Tested samples of brinell hardness test

To find Brinell hardness number we use

$$BHN = \frac{2P}{\pi D(D-\sqrt{D^2-d^2})}$$

Where P = load in “Kgf”

D = steel ball diameter in “mm”

d = diameter of indentation in “mm”

table 3.1: calculation table for BHN number

	D	d_1	d_2	$d = \frac{d1 + d2}{2}$	BHN
1	5mm	3.432mm	3.435mm	3.4335mm	46.664
2	5mm	3.421mm	3.428mm	3.4240mm	46.936
3	5mm	3.422mm	3.421mm	3.4215mm	47.017
4	5mm	3.422mm	3.425mm	3.4230mm	46.960
5	5mm	3.409mm	3.407mm	3.4080mm	47.460

Hardness measurement shows that with the increase in wt % of both tio_2 and red mud hardness of a composite increases however we have seen there is a decrease in hardness of composite having 1.5wt% of tio_2 and 6wt% of red mud. But overall result shows that with increase in the weight percentage of a reinforcement overall hardness of a composite increases.

3.2.3 WEAR TEST

Pin on disc tribometer is used to evaluate the tribological properties of the samples. In these EN31 of steel as a rotating disc and specimens with 10mm diameter and 30mm in length is used to conduct the wear test. First both the disc and the specimens cleaned with the acetone then pin is held normal against the disc at distance of 30mm from the center. After fixing the pin in Fixture pin is loaded with 20N force through dead weight loading system. Wear test of each pin was conducted for two different sliding velocity 2.04 and 4.08 m/s and under a constant load of 20N. weight measurement of specimen pins were conducted prior and after the experiment by using a digital weighing machine.

Fig 3.5: Sample specimen of wear test

The graph is plotted between the weight loss of specimen with respect to their respective composition at a sliding velocity od 2.04 m/s and separate graph of weight loss for specimen at 4.08 m/s sliding speed. It has been seen that weight losses is higher with higher sliding velocities for a same composite and weight losses is decreasing with the increase in the weight percentage of tio_2 and red mud composition.

Table 3.2: wear test table

S.NO.	SPECIMEN NAME	Sliding speed 2.04m/s			Sliding speed 4.08m/s		
		Initial weight (gm)	**Final weight (gm)**	**Weight loss (gm)**	**Initial weight (gm)**	**Final weight (gm)**	**Weight loss (gm)**
1.	Pure AA6063	6.2712	6.23608	0.03512	6.23608	6.19706	0.03902
2.	AA6063 + 2wt% red mud+ 0.5wt% tio_2	6.09076	6.06205	0.02871	6.06205	6.03214	0.02991
3.	AA6063 + 4wt% red mud + 1.0wt% tio_2	6.2635	6.24531	0.01819	6.24531	6.22012	0.02519
4.	AA6063 + 6wt% red mud + 1.5wt% tio_2	6.05565	6.0408	0.01485	6.0408	6.01995	0.02085
5.	AA6063 + 8wt% red mud + 2.0wt% tio_2	6.39871	6.3815	0.01121	6.3815	6.36239	0.01911

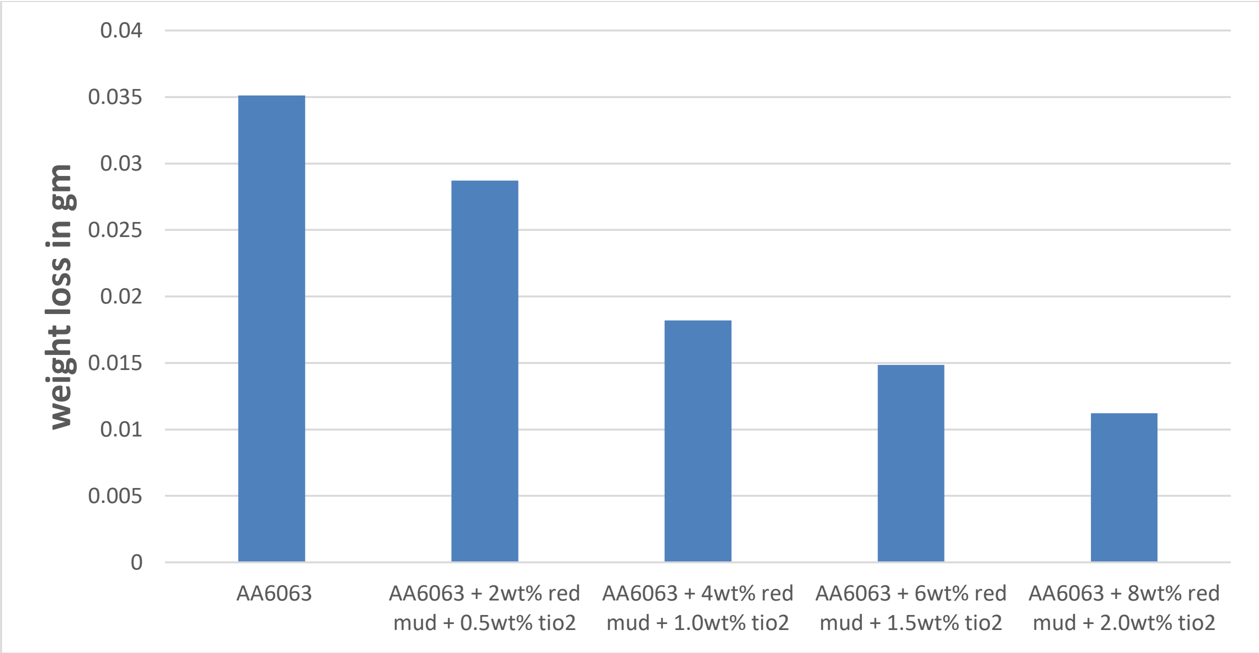


Fig 3.6 Weight loss of specimen at 2.04m/s sliding speed

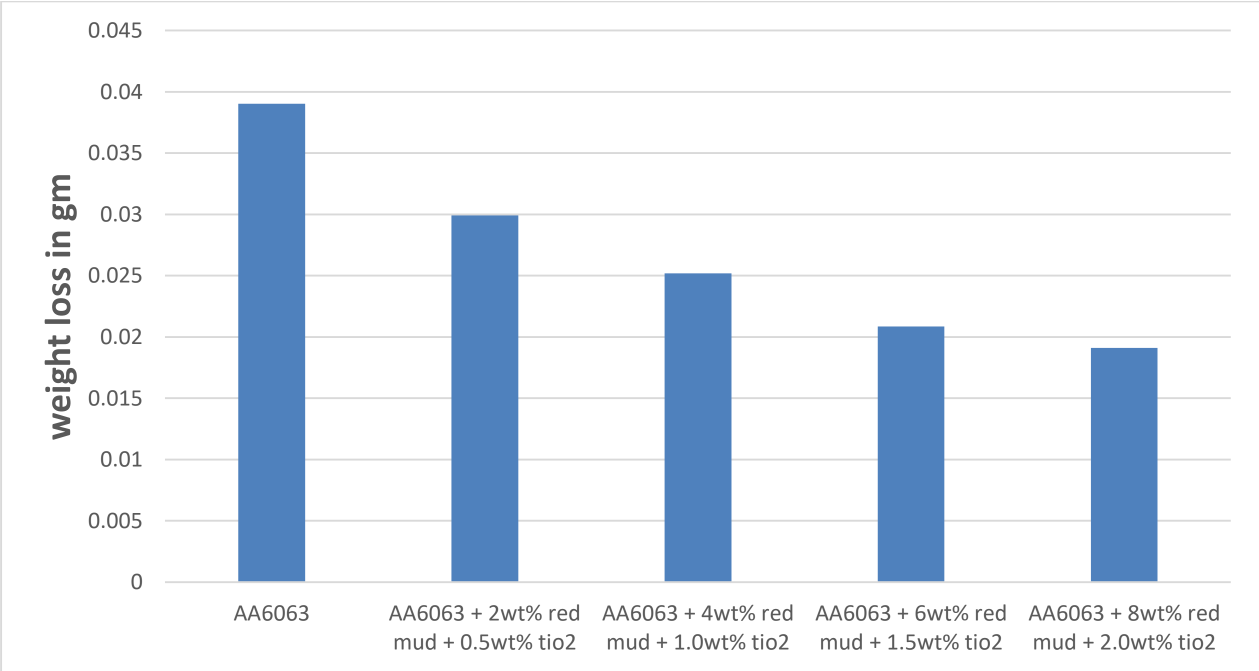


Fig 3.7 Weight loss of specimen at 4.08m/s sliding speed

Chapter 4

Conclusion

MMCs are widely used materials.Costs within the production using MMCs the stir casting distribution process is surprisingly low they are compared to various other competitive technology, so if the price is significantly drop then expect to produce a higher volume. This discussion explores the importance of selecting moving boundaries in addition to the properties of the desired sticker combination of current industrial demand. This investigates the impact and efficiency of dynamic parameters

- Red Mud, the by-product waste coming out from industries can be used as reinforcement in MMCproduction.
- Utilization of red mud can help us to overcome the issue of disposal and storage of redmud.
- Utilization of red mud could enhance energy efficiency of our country and can provide alternate engineering materials toindustry.
- Mechanical properties like, hardness, tensile strength, wear abrasion, compressive strength and yieldstrength.

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