AN EXPERIMENTAL INVESTIGATION OF TRIBOLOGICAL BEHAVIOUR ON FLY ASH AND TITANIUM DI-BORIDE REINFORCED ALUMINIUM HYBRID METAL MATRIX COMPOSITES

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CERTIFICATE

This is to certify that the project report entitled **"AN EXPERIMENTAL RESEARCH ON TRIBOLOGICAL PROPRETIES OF FLY ASH AND TITANIUM DI-BORIDE REINFORCED ALUMINIUM METAL MATRIX COMPOSITES"** has been carried out by THADI VARAPRASAD (319126520L24), GUDLA AVINASH REDDY (318126520140), MEESALA SIVA SAI AKHIL (318126520149), VELAGADA CHANTI NAIDU (318126520170) my guidance, in partial fulfilment of the requirements of degree of bachelor of mechanical engineering of Andhra university, Visakhapatnam.

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ABSTRACT

Aluminium hybrid metal matrix composites (AHMMC) are finding wide applications in all engineering sectors. The Al7075 known for its application in aerospace and aviation sector due to its inherent properties like high strength to weight ratio and good thermal properties. Fly ash (FA) is combustion by product available in power plants. Titanium diboride (TiB_2)is a proved to a best material to enhance the properties of composites.

In our present study, we made an attempt to combine the FA and titanium diboride in 5:3, 4:4 and 3:5 (wt %) respective proportions to aluminium matrix AL7075. The AHMMC containing 3% TiB_2 and 5% FA is found to have higher wear resistance among all hybrid cases. Wear resistance of AHMMC was considerably enhanced by the addition of fly ash particles. However, all hybrid cases have shown better wear resistance than pure alloy.

Keywords: Al alloy, fly ash, titanium diboride, tribological properties, microstructure

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CHAPTER-1

CHAPTER 1

INTRODUCTION:

1.1 COMPOSITES

A composite material is a combination of two materials with different physical and chemical properties. When they are combined they create a material which is specialised to do a certain job, for instance to become stronger, lighter or resistant to electricity. They can also improve strength and stiffness. The reason for their use over traditional materials is because they improve the properties of their base materials and are applicable in many situations.

Weight saving is one of the main reasons for using composite materials rather than conventional materials for components. While composites are lighter they can also be stronger than other materials.

Another advantage of using a composite over a conventional type of material is the thermal and chemical resistance as well as the electrical insulation properties. Unlike conventional materials, composites can have multiple properties not often found in a single material.

Fibre reinforced composites, such as fibre reinforced plastic (FRP composites), are finding increasing use in the design and manufacture of final products for commercialisation.

1.2 ADVANTAGES:

- Low costs compared to metals
- Design flexibility
- Resistance to a wide range of chemical agents
- Low weight
- Durability
- Electric insulation
- High Impact strength

1.3 USES:

Weight saving is one of the main reasons for using composite materials rather than conventional materials for components. While composites are lighter they can also be stronger than other materials, for example, reinforced carbon-fibre can be up to five times stronger than 1020 grade steel and only one fifth of the weight, making it perfect for structural purposes.

Another advantage of using a composite over a conventional type of material is the thermal and chemical resistance as well as the electrical insulation properties. Unlike conventional materials, composites can have multiple properties not often found in a single material.

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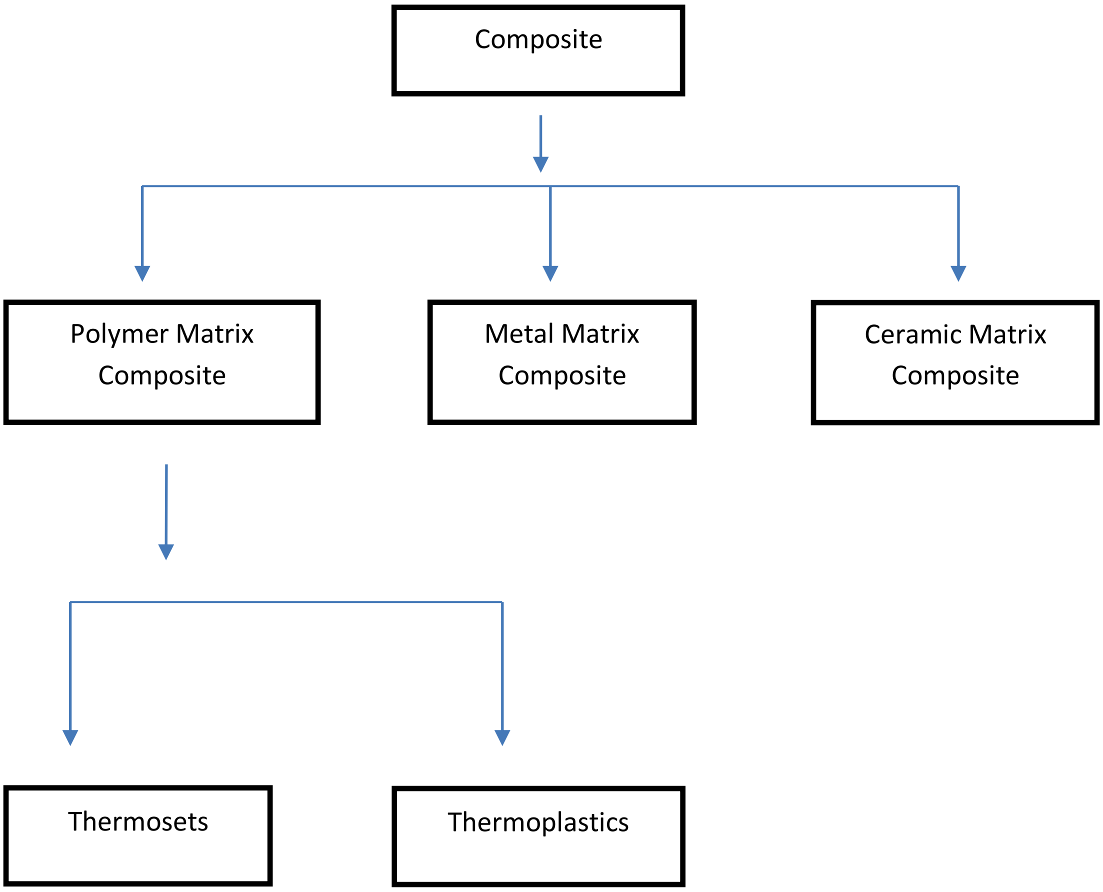
1.4 APPLICATIONS:

- Aerospace industry
- Automotive
- construction
- marine
- corrosion resistant equipment
- consumer products, appliance/business equipment.

1.5 MATRIX:

Composites usually comprising one continuous phase known as a matrix together with one or more discontinuous phase are called reinforcements. Composite materials have two phases, the reinforcing and matrix, for the matrix phase, ceramic's metals or polymers utilized, and for reinforcing phase Fibers, Particles utilized. The matrix binds the fiber reinforcement, transfers loads between fibers, gives the composite component its net shape and determines its surface quality. A composite matrix may be a polymer, ceramic, metal or carbon. Polymer matrices are the most widely used for composites in commercial and high-performance aerospace applications. Ceramic and metal matrices are typically used in very high-temperature environments, such as engines. Carbon as a matrix is used in extreme high-temperature applications, such as carbon/carbon brakes and rocket nozzles.



1.6 TYPES OF MATRIX:

1) Ceramic matrix composition :

Composite material comprised into two parts one is matrix and another one is reinforcement. Matrix provides strength and stiffness. Ceramic matrix compositions are subgroup of composite material.

The ceramic matrix consists of ceramic fiber reinforced (CFRc)

CMC Reinforcing Materials:

Typical reinforcing fiber materials include the following:

- Carbon, C
- Silicon Carbide, SiC
- Alumina, Al_2O_3
- Mullite or Alumina Silica, Al_2O_3-SiO_2

2) Metal matrix composition :

Metal matrix composites (MMCs) are composite materials that contain at least two constituent parts – a metal and another material or a different metal. The metal matrix is reinforced with the other material to improve strength and wear. Where three or more constituent parts are present, it is called a hybrid composite. In structural applications, the matrix is usually composed of a lighter metal such as magnesium, titanium, or aluminium. In high temperature applications, cobalt and cobalt-nickel alloy matrices are common. Typical MMC's manufacturing is basically divided into three types: solid, liquid, and vapour. Continuous carbon, silicon carbide, or ceramic fibers are some of the materials that can be embedded in a metallic matrix material. MMCs are fire resistant, operate in a wide range of temperatures, do not absorb moisture, and possess better electrical and thermal conductivity. They have also found applications to be resistant to radiation damage, and to not suffer from out gassing. Most metals and alloys make good matrices for composite applications.

3) Polymer matrix composition:

Polymer matrix composites (PMCs) can be divided into three sub-types, namely, thermoset, thermoplastic, and rubber. Polymer is a large molecule composed of repeating structural units connected by covalent chemical bonds. PMC's consist of a polymer matrix combined with a fibrous reinforcing dispersed phase. They are cheaper with easier fabrication methods. PMC's are less dense than metals or ceramics, can resist atmospheric and other forms of corrosion, and exhibit superior resistance to the conduction of electrical current.

Thermosets: Thermosets have qualities such as well-bounded three dimensional molecular structures after curing. They decompose instead of hardening.

Thermoplastics: Thermoplastics have one or two dimensional molecular structure they tend to at an elevated temperature and show exaggerated melting point another advantage is that the process of softening at elevated temperatures can reversed to regain its properties during cooling.

1.7 FUNCTIONS OF MATRIX:

- Holds the fibres together
- Protects the fibre from environment
- Distributes the loads evenly between fibres so that all fibres are subjected to the same amount of strain
- Enhances transverse properties of a laminate
- Improves impact and fracture resistance of a component
- Carry inner laminar shear

1.8 REINFORCEMENT:

Reinforcement is defined as the action or process of strengthening the composite material. Reinforcement material was added to the matrix material for physical properties of the final composite material. There are Two kind of reinforcement material was used mostly one is synthetic fiber and another one is natural fiber. Secondary reinforcement was added to the composite material to further enhance the properties of the composite. When two or more reinforcement material were added to the matrix material, then composite was called as hybrid composite. Reinforcement increases the mechanical properties and it provides strength and stiffness to the composite. The reinforcement changes the material properties like wear resistance, thermal conductivity.

1.8.1 FIBRE REINFORCEMENT COMPOSITES (FRC):

Fibres are the most important class of reinforcement as they satisfy the desired conditions and transfer strength to the matrix constituent influencing and enhancing their properties as desired. Fibres fall sort of ideal performance due to several factors. The performance of the fibre judged by its length, shape, orientation and composition of the fibres and the mechanical properties of the matrix. The orientation of the fibre in matrix is an indication of strength.

1.8.2 TYPES OF REINFORCEMENT:

1) Whiskers reinforcement composites: In whiskers reinforcement composite has single crystals grown with nearly zero defects are termed as whiskers. They are usually discontinuous and short fibres of different cross sections made from several materials like graphite, silicon carbide, copper etc. typically they are in 3 to 5mm range.
2) Flake reinforcement composites: In flake reinforcement composites have single flakes are often used in place of fibres as can be densely packed. Metal flakes that are in close contact with each other in polymer matrices can conduct electricity or heat, while mica flakes and glass can resist both
3) Particulate reinforced composites: In particulate reinforced composites the microstructures of metal and ceramics composites, which show particles of one phase strewn in the other. Square, triangular and round shapes of reinforcement are known but the dimensions of all their sides are observed to be more are less equal.

1.8.3 FUNCTIONS OF REINFORCEMENT:

- It provides strength and stiffness
- Provides heat resistance
- Provides corrosion resistance
- Properties of composite are controlled by properties of fillers

CHAPTER-2

CHAPTER 2

LITEATURE REVIEW

Wear rate of Al–TiB_2 composites is a function of TiB_2 content. It has been shown that wear rate of composites decreases with the increasing amount of TiB_2 particles. Wear rate per unit amount of TiB_2 particles is an important parameter and indirectly gives the load bearing capability of composite. This parameter should be taken into consideration to explain the load carrying capacity of Al–TiB_2 composites.[1]

Weight percentage of fly ash showed a direct relation with hardness, tensile strength, impact strength and wear. Increase in addition of fly ash restricts the deformation of the aluminium alloy, resulting in increased hardness, tensile strength and wear resistance. Wear rate was also influenced directly by the applied load, the wear rate increasing with increase in load and vice versa.[2]

The addition of fly ash particles decreased the wear volume of Al/3.25Cu/8.5Si alloy. The increase in fly ash content also decreased the wear volume due to the presence of hard particles. For a given particle size and percentage reinforcement, an increase in applied load and sliding speed increased the wear volume of the composites due to an increase in the degree of abrasion.[3]

Wetting of fly ash particles with the Al matrix was further improved by the addition of 1.5 wt%Mg. The density of the composites decreased with increasing fly ash reinforcement content. . Increasing fly ash content resulted in increase in the tensile strength of the Al. . Wear resistance of the commercial Al was considerably enhanced by the addition of fly ash particles and the wear resistance of the composites was much superior to the unreinforced aluminium over the entire load range tested under dry sliding conditions.[4]

The mechanical characteristics of stir cast Al6061–TiB_2 matrix composite reveals that there is an increase in the hardness with the addition of reinforcement of TiB_2 with Al6061 matrix. This is mainly due to the hard nature of the reinforcement of TiB_2 . Increase in the amount of TiB2 increases the tensile strength, ultimate tensile strength and modulus of the Al6061. [5]

From their study of Al 1120-TiB2 metal matrix composite prepared by adding weight percentage of TiB_2 2,4,6 and 8%. The wear rate all the compositions decreased initially as the sliding distance increases and after that, it becomes almost constant with the increase in sliding distance. Owing to the high hardness of Al alloy reinforced with 8% TiB_2, it showed the lowest wear rate.[6]

Stir casting method can be successfully used to manufacture metal matrix composite with desired properties. Reinforcing Aluminium and its alloys with ceramics particles has shown an appreciable increase in its mechanical properties. Organic reinforcements like coconut ash, rice husk ash also improved the mechanical properties of the aluminium along with the tribological behaviour of the composite. Hybrid ceramic reinforcement has increased the mechanical properties much but literature on tribological properties in case of hybrid reinforcement is limited.[7]

The best combination protocol for the production of aluminium matrix composite reinforced with TiB_2 particles is Al / 7% wt. $TiB_{2.}$ the agglomeration of the particles within the composite and weakened It has been found out that increasing the percentage of TiB_2 particles up to 7 wt. % resulted in its engineering properties. increased stirring duration improved composites' engineering properties due to uniform scattering of the reinforcing particles inside the composite matrix.[8]

AA7075 based hybrid composites were fabricated via stir casting process successfully. The tribological behaviour of hybrid composites was analysed using pin on disc machine. The fabricated hybrid composites exhibits enhanced properties like hardness, tensile and impact strength comparing to base metal, which have improved by the addition of TiB_2 reinforcement. The maximum tensile strength is obtained for the sample C of 3 wt. % which is 173 MPa. The addition of weight percentage of TiB_2 and MoS_2 reduces the wear rate of the hybrid composites.[9]

Four hybrid composite materials consisting of 2 wt % of Al_2O_3 particles and 2, 4, 6, and 8 wt.% of TiB_2 particles were produced using powder metallurgy route and sintering process. The mechanical properties such as tensile strength and hardness of the produced hybrid composites were compared with that of the base material AA6061 which was also produced using the powder metallurgy route. The sintered hybrid composite sample C consisting of 2 wt.% of Al_2O_3 particles and 6 wt.% of TiB_2 particles exhibited fewer defects than the base materials.[10]

From their work,Al5083-graphene-fly ash composites, increased hardness was noticed for the composite due to the grain refinement and reinforced graphene and fly ash. Higher variations in the cutting forces were also noticed in the composite which is due to the added graphene and fly ash. The results suggest that by incorporating graphene and fly ash into Al5083, structures with higher hardness and improved machinability ca be produced.[11]

The microstructure through SEM observation of the hybrid composites reveals the fairly uniform distributions of beryl and graphene in to the base matrix material. .Tensile strength of Al7075-beryl-graphene composites show a peak strength of 216.62 MPa at 6 wt.% of beryl and 1 wt.% of graphene particulate showing improvement of 76.84% when compared to Al7075 matrix material without addition of reinforcement. [12]

Micro hardness was enhanced from 85Hv to 90 Hv in fabricated surface hybrid Al 7075/SiC & Gr composites because of reinforcement. Wear rated was reduced compare to Al 7075 because of lubricating property of Gr in Al 7075 Load is the significant parameter on wear compared to sliding velocity and composition of reinforcements.[13]

After all the standard tests it was observed that the nitrided composites have shown better wear resistance than the non-nitrided composites. [14]

Al7075-2 wt% TiO_2-2 wt% SiC hybrid composite has been successfully synthesised by liquid metallurgy technique. Optical microstructure studies clearly reveal uniform dispersion of particles in matrix material. Hybrid composite demonstrate considerable enhancement in hardness and ultimate tensile strength when evaluated with matrix alloy. Higher hardness of reinforcing phases. Addition of hard reinforcements (SiC and Titanium dioxide) in the soft ductile matrix contributes to improvement in the hardness of the composites. Due to large variation in coefficient of thermal expansion between AA7075 alloy and reinforced particles, dislocation increases and acts as barrier for plastic deformation. [15]

From the above literature reviews we found that Stir casting method can be successfully used to manufacture metal matrix composite with desired properties. Increase in addition of fly ash restricts the deformation of the aluminium alloy, resulting in wear resistance. Increase in TiB_2 increases tensile strength and ultimate tensile strength in aluminium.

CHAPTER-3

CHAPTER 3

MATERIALS SELECTION AND METHODOLOGY

3.1 AL 7075

7075 aluminium alloy (**AL7075**) is an aluminium alloy with zinc as the primary alloying element. It has excellent mechanical properties and exhibits good ductility, high strength, toughness, and good resistance to fatigue. It is more susceptible to embrittlement than many other aluminium alloys because of micro segregation, but has significantly better corrosion resistance than the alloys from the 2000 series. It is one of the most commonly used aluminium alloys for highly stressed structural applications and has been extensively used in aircraft structural parts.

Aluminium 7075 has a density of 2.810 g/cm^3.

3.1.1 COMPOSITION OF AL7075 :

Element	Symbol	Composition % (wt) in Al 7075
Zinc	Zn	5.1 - 6.1
Magnesium	Mg	2.1 - 2.9
Copper	Cu	1.2 – 2.0
Ferrite	Fe	0.50 (max)
Chromium	Cr	0.18 - 0.28
Manganese	Mn	0.3 (max)
Silicon	Si	0.4 (max)
Titanium	Ti	0.2 (max)
Aluminium	Al	Remaining

3.1.2 APPLICATIONS OF AL7075:

- Aircraft fittings
- Gears and shafts
- Missile parts
- Regulating valve parts
- Worm gears

- Aerospace/defence applications
- Automotive

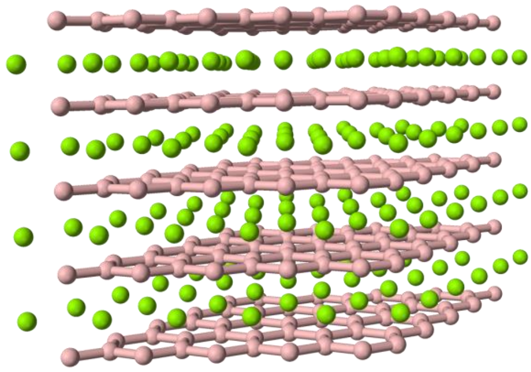
3.1.3 MECHANICAL PROPERTIES

Brinell Hardness = 150
Elastic (Young's, Tensile) Modulus = 70 GPa
Tensile Strength: Ultimate (UTS) = 560 MPa
Tensile Strength: Yield (Proof) = 480 MPa.
Elongation at break = 7.9%.
Fatigue Strength = 160 MPa.
Poisson's Ratio = 0.32
Shear Modulus = 26 GPa.
Shear Strength = 330 MPa

Disadvantages of 7075-T6 Aluminium

- The 7075 aluminium alloys represent a solid standard for great materials with a very convenient combination of properties for most jobs. However, they do have a few drawbacks that may be important to consider:
- When compared to other aluminium alloys, the 7075 have a lower resistance to corrosion. If an enhanced stress-corrosion cracking resistance is desired, the 7075-T7351 aluminium might be a more suitable selection than the 7075-T6.
- Despite having good machinability, its ductility is still the lowest when compared to other 7000-series alloys.
- Its cost is relatively high, which limits its use.

3.2 TITANIUM DIBORIDE :



Property	**value**
Density (g.cm^3)	4.52
Melting Point (°C)	2970
Modulus of Rupture (MPa)	410-448
Hardness (Knoop)	1800
Elastic modulus (GPa)	510-575
Poisson's Ratio	0.1-0.15
Thermal conductivity (W/m.K)	25

TiB_2 is the most stable of several titanium-boron compounds. Titanium Diboride (TiB_2) is a hard material with high strength and high wear resistance at elevated temperatures. The high density, combined with the high elastic modulus and high compressive strength, have lead of its use in armour components.

Titanium diboride (TiB_2) is well known as a ceramic material with relatively high strength and durability as characterized by the relatively high values of its melting point, hardness, strength to density ratio, and wear resistance.

An important evolving application is the use of TiB_2 cathodes in the electrochemical reduction of alumina to aluminium metal. Other applications may develop rapidly if the electrical discharge machining of TiB_2 can be perfected.

TiB_2 is also a reasonable electrical conductor, so it can be used as a cathode material in aluminium smelting and can be shaped by electrical discharge machining.

Among various synthesis routes, electrochemical synthesis and solid state reactions have been developed to prepare finer titanium diboride in large quantity. An example of solid state reaction is the borothermic reduction, which can be illustrated by the following reactions:

(1) $2\ TiO_2 + B_4C + 3C \rightarrow 2\ TiB_2 + 4\ CO$

(2) $TiO_2 + 3NaBH_4 \rightarrow TiB_2 + 2Na + NaBO_2 + 6H_2$

(3) $TiCl_4 + 2\ B + 4\ Na \rightarrow TiB_2 + 4\ NaCl$

3.3 FLY ASH

Fly ash consists of fine, powdery particles predominantly spherical in shape, either solid or hollow, and mostly amorphous in nature. In general, the specific gravity of coal ashes lies around 2.0 but varies to a large extent. This variation is due to a combination of several factors such as particle shape, gradation, and chemical composition.

Based on the grain size distribution fly ashes can be classified as sandy silt to silty sand. Particularly, Indian coal ashes are predominantly of silt-size, with some clay-size fraction.

Fly ash has high specific surface area and low bulk density.

The amount of unburned carbon and iron impact the color of fly ash, which can vary from orange to deep red, brown, or white to yellow.

3.3.1 CLASSIFICATION

Two classes of fly ash are defined by American Society for Testing and Materials (ASTM) C618: Class F fly ash and Class C fly ash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned (i.e., anthracite, bituminous, and lignite).

Class "F"

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 7% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime—mixed with water to react and produce cementitious compounds. Alternatively, adding a chemical activator such as sodium silicate (water glass) to a Class F ash can form a geopolymer.

Class "C"

Fly ash produced from the burning of younger lignite or sub-bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash hardens and gets stronger over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not require and activator. Alkali and sulfate (SO_4) contents are generally higher in Class C fly ashes.

3.3.2 COMPOSITION OF FLY ASH:

Fly ash is predominately composed of silica, aluminium, iron, calcium, and oxygen, but the particles may also contain heavy metals such as arsenic and lead at trace levels.

Component	Percentage
SiO_2	49.45
Al_2O_3	29.61
Fe_2O_3	10.72
CaO	3.47
MgO	1.3
K_2O	0.54
Na_2O	0.31
TiO_2	1.76
P_2O_5	0.53
Mn_2O_3	0.17
SO_3	0.27
LOI	1.45

USES OF FLY ASH :

- Portland Pozzolana Cement.
- Fly Ash Concrete.
- Fly Ash Bricks.
- Roller Compacted Concrete (RCC)
- Soil Stabilization.
- Embankments

3.4 MAGNESIUM :

Magnesium is a chemical element with the symbol Mg and atomic number 12. It is a shiny gray solid which shares many physical and chemical properties with the other five alkaline earth metals (group 2 of the periodic table).

This element is produced in large, aging stars from the sequential addition of three helium nuclei to a carbon nucleus. When such stars explode as supernovas, much of the magnesium is expelled into the interstellar medium where it may recycle into new star systems.

Magnesium is the eighth most abundant element in the Earth's crust and the fourth most common element in the Earth (after iron, oxygen and silicon), making up 13% of the planet's mass and a large fraction of the planet's mantle. It is the third most abundant element dissolved in seawater, after sodium and chlorine.

In our project, we used 1% magnesium to avoid porousity in aluminium composite.

3.5 THE METAL MATRIX COMPOSITION OF TITANIUM DIBORIDE, FLY ASH & ALUMINIUM:

The methodology we use in this project is stir casting, with three different materials like titanium diboride, fly ash with hybrid aluminium 7075. So here we are taking three metal matrix composition with different ratios and percentages of metals.

Now we are taking fixed aluminium 7075 as fixed composition of 95% and taking the Tib2 and fly ash in three ratios 5:3, 4:4, 3:5 as respectively

The density of ALUMINIUM 7075 = 2.81 g/cm^3

The density of TiB_2 = 4.52 g/cm^3

The density of Fly Ash = 1.7 g/cm^3

METALS	PERCENTAGE %	VOLUME (cm^3)	MASS (g)
Aluminium 7075	92	69	193.89
TiB_2	5	3.75	16.95
Fly Ash	3	2.25	3.825

Composition with 4:4

METALS	PERCENTAGE %	VOLUME (cm^3)	MASS (g)
Aluminium 7075	92	69	193.89
TiB_2	4	3	13.56
Fly Ash	4	3	5.1

Composition with 3:5

METALS	PERCENTAGE %	VOLUME (cm^3)	MASS (g)
Aluminium 7075	92	69	193.89
TiB_2	3	2.25	10.17
Fly Ash	5	3.75	6.37

Total material mass used for this project (Matrix and reinforcement)

The total Al7075 composition was 581.67 grams

The total TiB2 composition was 40.68 grams

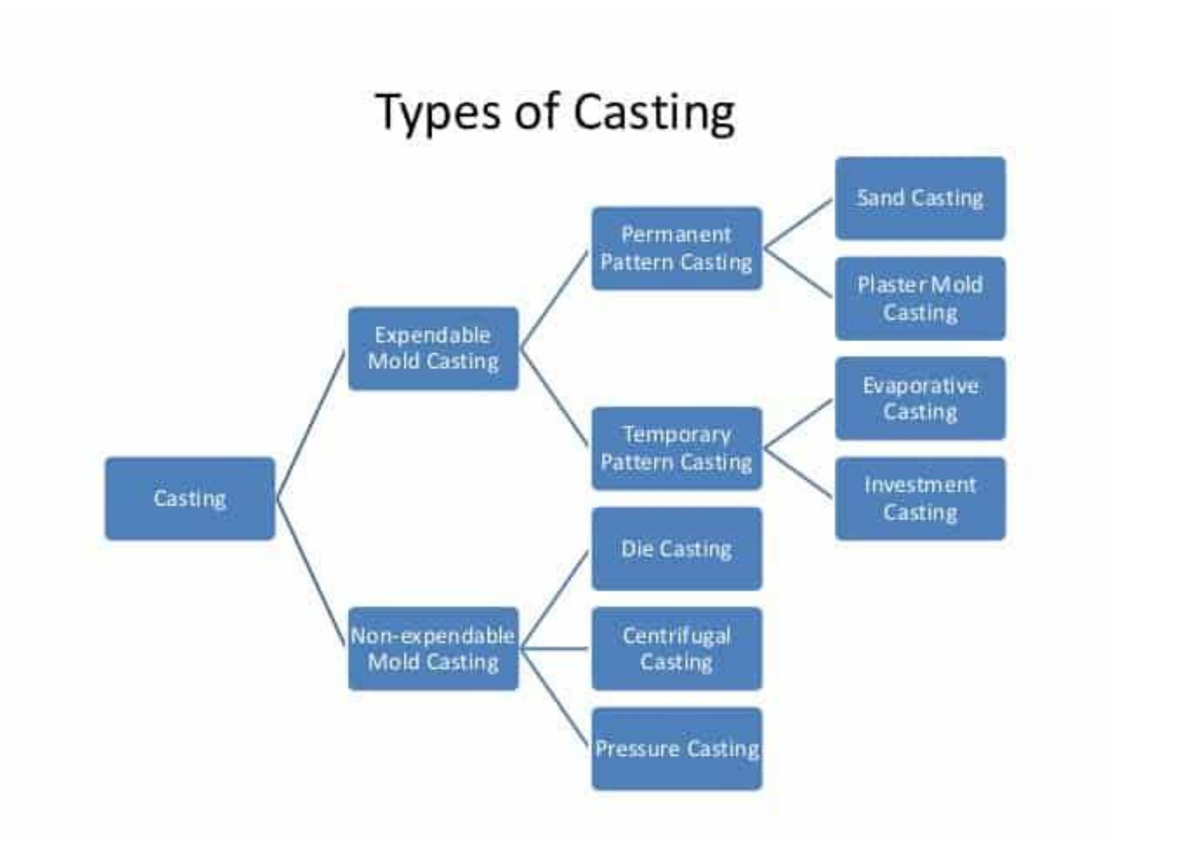
The total fly ash composition was 15.295 grams.

3.6 CASTING:

Casting is a process in which a liquid metal is delivered into a mold (usually by a crucible) that contains a negative impression (i.e., a three-dimensional negative image) of the intended shape. The metal is poured into the mold through a hollow channel called a sprue.

The metal and mold are then cooled, and the metal part (the casting) is extracted. Casting is most often used for making complex shapes that would be difficult or uneconomical to make by other methods.

TYPES OF CASTING :



3.6.1 STIR CASTING :

Stir casting is a type of casting process in which a mechanical stirrer is introduced to form vortex to mix reinforcement in the matrix material. It is a suitable process for production of metal matrix composites due to its cost effectiveness, applicability to mass production, simplicity, almost net shaping and easier control of composite structure.

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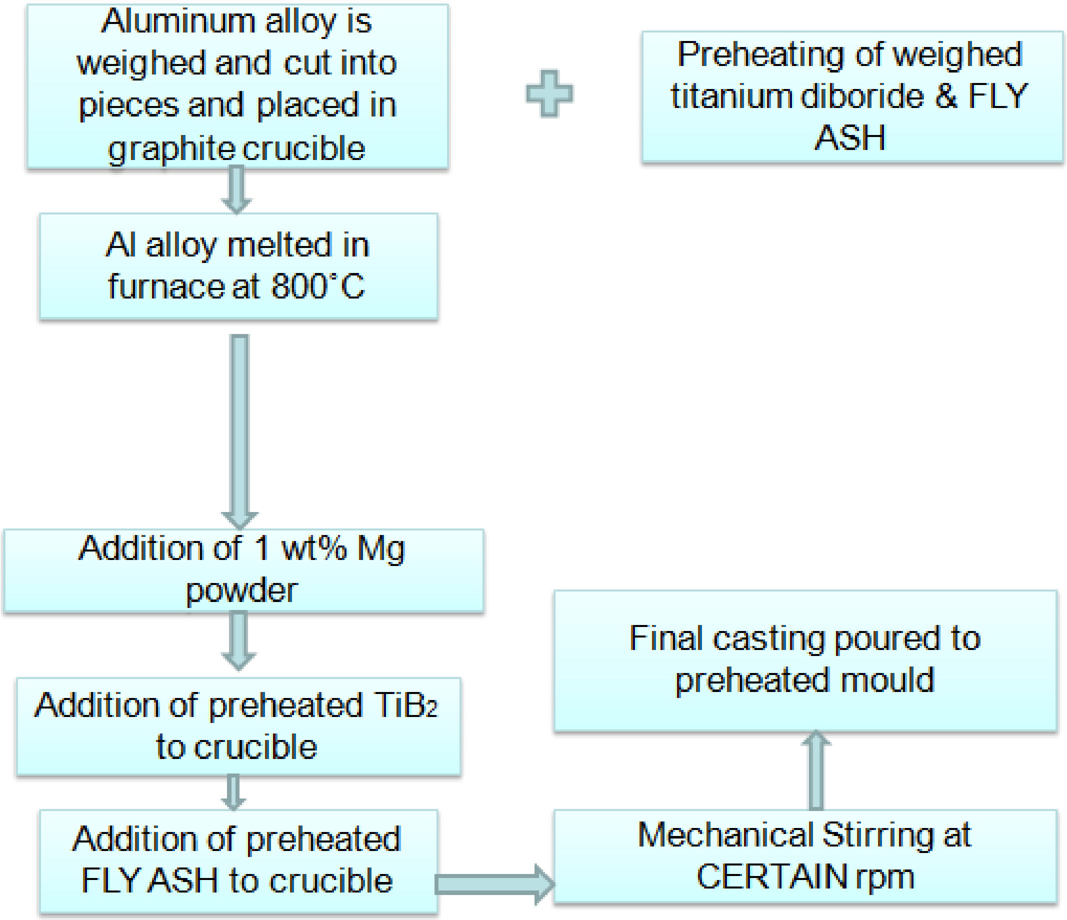
It is a suitable process for production of metal matrix composites due to its cost effectiveness, applicability to mass production, simplicity, almost net shaping and easier control of composite structure.

Stir casting consist of a furnace, reinforcement feeder and mechanical stirrer. The furnace is used to heating and melting of the materials. The bottom poring furnace is more suitable for the stir casting as after stirring of the mixed slurry instant poring is required to avoid the settling of the solid particles in the bottom the crucible.

The mechanical stirrer is used to form the vortex which leads the mixing of the reinforcement material which are introduced in the melt. Stirrer consists of the stirring rod and the impeller blade. The impeller blade may be of, various geometry and various number of blades. Flat blade with three number are the preferred as it leads to axial flow pattern in the crucible with less power consumption.

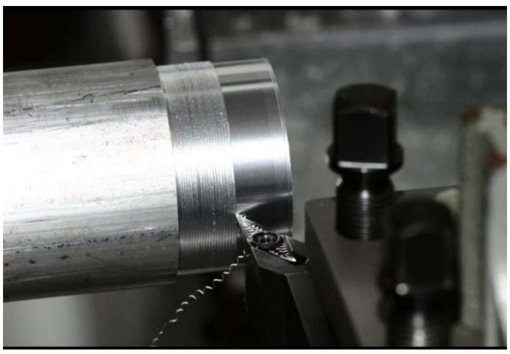
This stirrer is connected to the variable speed motors, the rotation speed of the stirrer is controlled by the regulator attached with the motor. Further, the feeder is attached with the furnace and used to feed the reinforcement powder in the melt. A permanent mold, sand mould a lost-wax mold used for pouring the mixed slurry.



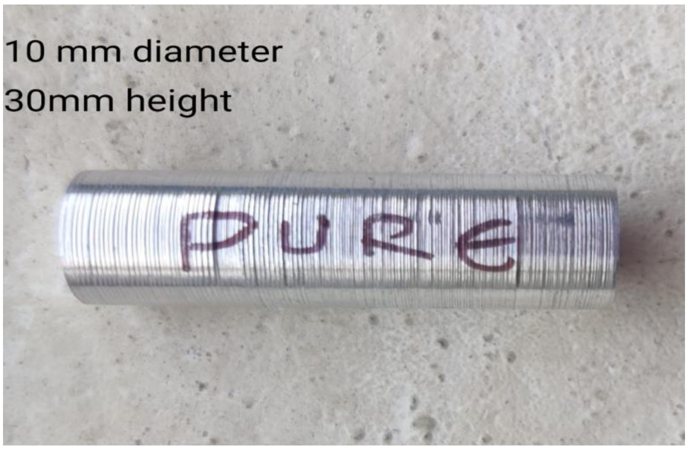
3.7 CUTTING AND TURNING:-

Turning is a machining operation performed on a lathe in which the work piece rotates at high speeds while a fixed cutting tool removes material.

The general process of turning involves rotating a part while a single-point cutting tool is moved parallel to the axis of rotation. Turning can be done on the external surface of the part as well as the internal surface (the process known as boring). The starting material is generally a work piece generated by other processes such as casting, forging, extrusion



FINAL SPECIMEN:



3.8 SURFACE FINISH:

Surface finish is also known as surface texture or surface topography, is the nature of a surface. It comprises the small local deviations of a surface from the perfectly flat ideal (a true plane).

The surface of every component has some form of texture which varies according to its structure and the way it has been manufactured.

3.8.1 SURFACE FINISH BY ABRASSIVE PAPERS:

Sandpaper and glass paper are names used for a type of coated abrasive that consists of sheets of paper or cloth with abrasive material glued to one face. There are many varieties of sandpaper, with variations in the paper or backing, the material used for the grit, grit size, and the bond.

Sandpaper is produced in a range of grit sizes and is used to remove material from surfaces, either to make them smoother (for example, in painting and wood finishing), to remove a layer of material (such as old paint), or sometimes to make the surface rougher (for example, as a preparation for gluing). The grit size of sandpaper is usually stated as a number that is inversely related to the particle size. A small number such as 20 or 40 indicates a coarse grit, while a large number such as 1500 indicates a fine grit.

3.9 POLISHING:

Polishing is the process of creating a smooth and shiny surface by rubbing it or by applying a chemical treatment, leaving a clean surface with a significant specular reflection (still limited by the index of refraction of the material according to the Fresnel equations). In some materials (such as metals, glasses, black or transparent stones), polishing is also able to reduce diffuse reflection to minimal values.

When an unpolished surface is magnified thousands of times, it usually looks like a succession of mountains and valleys. By repeated abrasion, those "mountains" are worn down until they are flat or just small "hills." The process of polishing with abrasives starts with a coarse grain size and gradually proceeds to the finer ones to efficiently flatten the surface imperfections and to obtain optimal results.

3.9.1 DOUBLE DISC POLISHING MACHINE:

The Disc Polishing Machines are extensively used for polishing the Metallography Samples for Microscopic observation to study various metal structures. Disc Polishing Machines are finely polished to ensure smooth, scratch free and mirror like appearance that enable accurate metallographic interpretation. Polishing is the final stage in producing a surface that is flat, smooth, scratch-free and mirror like in appearance. Such a surface is necessary for subsequent accurate metallographic interpretation, both qualitative & quantitative. In this Machine the drive is given the motor spindle, which is mounted on the motor shaft through friction mechanism. Polishing discs are fitted on the shaft and locked by nut. Shaft has two bearings, which are fitted into bearing holder for smooth working.

3.10 ETCHING :

Etching process with Keller’s reagent:

Keller's reagent can refer to either of two different mixtures of acids.

In metallurgy, Keller's reagent is a mixture of nitric acid, hydrochloric acid, and hydrofluoric acid, used to etch aluminium alloys to reveal their grain boundaries and orientations. It is also sometimes called Dix–Keller reagent, after E. H. Dix, Jr., and Fred Keller of the Aluminium Corporation of America, who pioneered the use of this technique in the late 1920s and early 1930s.

In organic chemistry, Keller's reagent is a mixture of anhydrous (glacial) acetic acid, concentrated sulphuric acid, and small amounts of ferric chloride, used to detect alkaloids. Keller's reagent can also be used to detect other kinds of alkaloids via reactions in which it produces products with a wide range of colours. Cohn describes its use to detect the principal components of digitalis. The reaction with this reagent is also known as the Keller–Kiliani reaction, after C. C. Keller and H. Kiliani, who both used it to study digitalis in the late 19th century.

COMPOSITION:

Ingredients	Volume (ml)
Distilled water	190
Nitric Acid (HNO_3)	5
Hydrochloric Acid (HCl)	3
Hydro fluoric Acid (HF)	2

3.12 WEAR TEST:

The pin-on-disc sliding wear test is a commonly used tribological characterization technique to estimate the coefficient of friction and the wear mechanism of diamond films. The study of sliding wear and friction properties is of great practical significance for hard coatings, which are aimed at increasing the life of any component.

The friction property of the NCD coatings was characterized using a pin-on-disc sliding wear test. In the configuration used, the disc rotated about a vertical axis and the pin was held stationary over the disc about the vertical axis. During the wear test, loads can be applied either mechanically or pneumatically. The speed of the rotating disc during testing can be controlled by electrically controlling the speed of the motors, which permits continuous monitoring of speed.

For the wear test, Pin on disc Tribo-meter was used to calculate the wear on Al7075 with Fly-ash and Titanium diboride specimen. Tool wear mechanisms can be studied under lab conditions using Pin-on-Disk reducing the material cost and improving the environmental sustainability of the process.

CHAPTER-4

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RESULTS AND DISCUSSIONS

WEAR TEST:

WEAR TEST EQUIPMENT

PIN ON DISC WEAR AND FRICTION TESTER

The wear tests are carried out in Pin-on-Disc wear testing machine based on ASTM G99-05 according to this, as cast specimens are machined with 10mm diameter and 30mm height. For wear tests, 10 mm diameter and 30 mm length pins were rotate against the counter plate disc made by HSS steel.

The pin-on-disc (PoD) tribometer used in the investigation was mounted in vacuum chamber disk substrates. All experiments were conducted with a load of 1N, 1.5N and 2N at 500 rpm using a 30 mm track diameter. The friction force was continuously monitored during the sliding friction experiments. The sliding wear and specific wear for the coatings was determined.

WEAR TEST OBSERVATION TABLE:

Al 7075,TiB_2 and fly ash have been fabricated successfully by stir casting process the results of wear test were tabulated below.

Experimental formulae:

Wear rate = weight loss / sliding distance

Specific wear rate = wear rate / load

SPECIMEN A: Pure AL7075

SPECIMEN B: 5:3(5% wt of TiB_2 : 3% wt of FA)

SPECIMEN C: 5:3(4% wt of TiB_2 : 4% wt of FA)

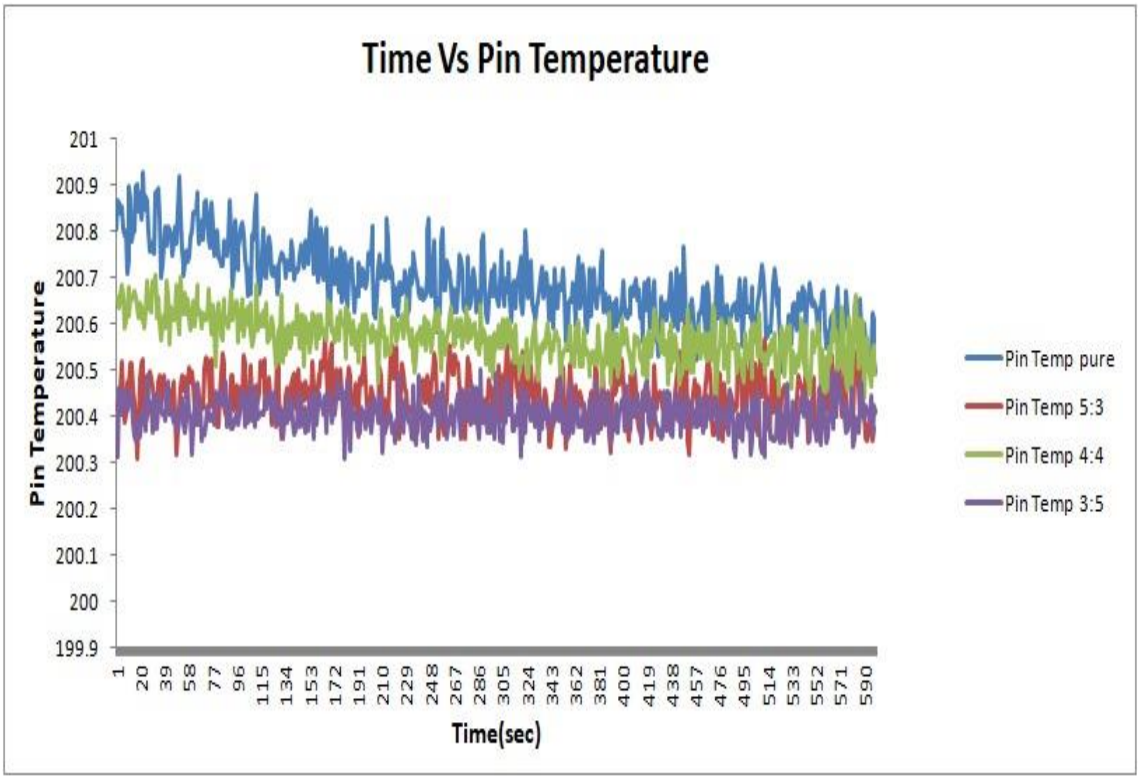
SPECIMEN D. 5:3(3% wt of TiB_2 : 5% wt of FA)

S.NO	SPECIMEN	SPEED (RPM)	TIME (T) MIN	LOAD (P)	SLIDING DISTANCE (M)	WEIGHT BEFORE WEAR TEST (G)	WEIGHT AFTER WEAR TEST (G)	WEIGHT LOSS	WEAR RATE g/m	SPECIFIC WEAR RATE
1	A	500	10	10	942.5	5.98	5.97	0.01	$1.061 x 10^{-5}$	$0.108 x 10^{-5}$
2.	A	500	10	15	942.5	6.63	6.62	0.01	$1.061 x 10^{-5}$	$0.072 x 10^{-5}$.
3.	A	500	10	20	942.5	6.56	6.55	0.01	$1.061 x 10^{-5}$	$0.054 x 10^{-5}$
4.	B	500	10	10	942.5	5.22	5.21	0.01	$1.061 x 10^{-5}$	$0.108 x 10^{-5}$
5.	B	500	10	15	942.5	5.36	5.35	0.01	$1.061 x 10^{-5}$	$0.072 x 10^{-5}$
6.	B	500	10	20	942.5	5.49	5.47	0.02	$2.122 x 10^{-5}$	$0.108 x 10^{-5}$
7.	C	500	10	10	942.5	6.60	6.59	0.01	$1.061 x 10^{-5}$	$0.108 x 10^{-5}$
8.	C	500	10	15	942.5	6.22	6.21	0.01	$1.061 x 10^{-5}$	$0.072 x 10^{-5}$
9.	C	500	10	20	942.5	6.63	6.62	0.01	$1.061 x 10^{-5}$	$0.054 x 10^{-5}$
10.	D	500	10	10	942.5	5.29	5.28	0.01	$1.061 x 10^{-5}$	$0.108 x 10^{-5}$
11.	D	500	10	15	942.5	5.29	5.27	0.02	$2.122 x 10^{-5}$	$0.144 x 10^{-5}$
12.	D	500	10	20	942.5	5.79	5.77	0.02	$2.122 x 10^{-5}$	$0.108 x 10^{-5}$

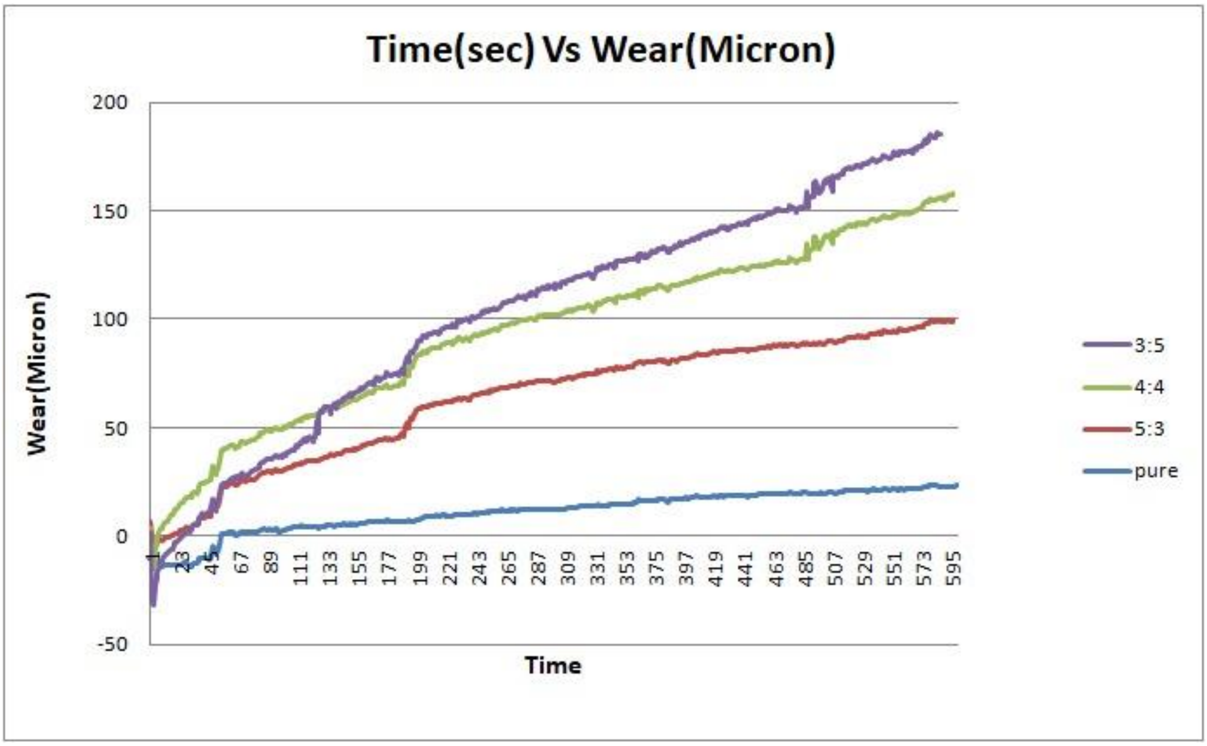
Wear test graphs:

Graph results after wear analysis as follows:

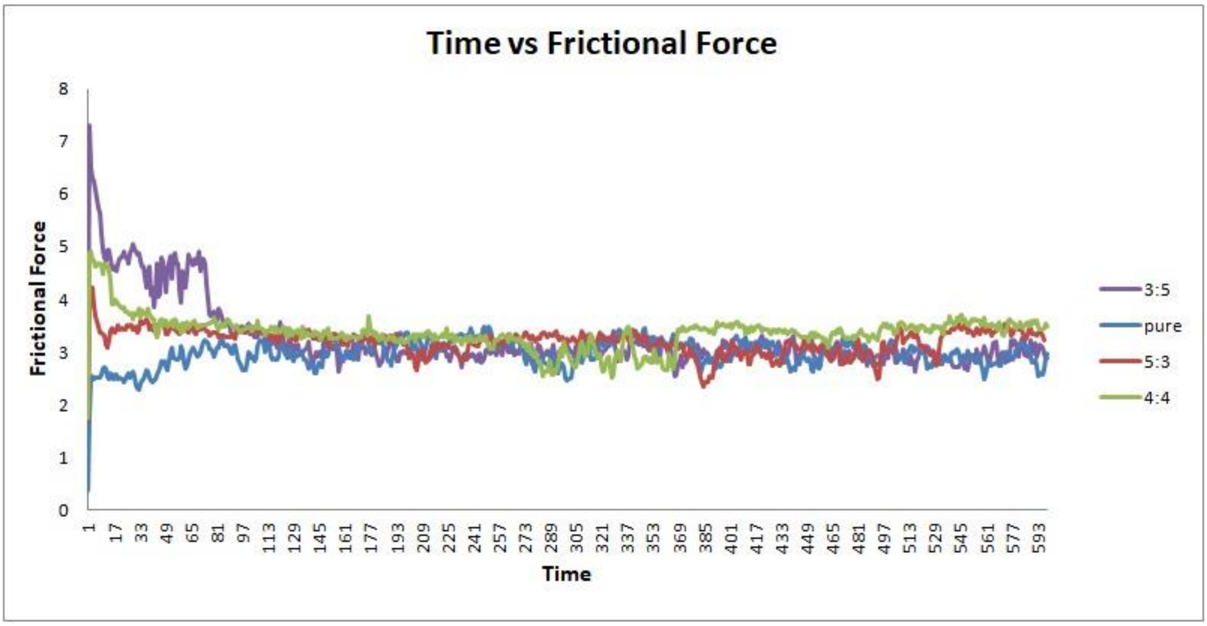
Graph1 Time Vs Pin Temperature



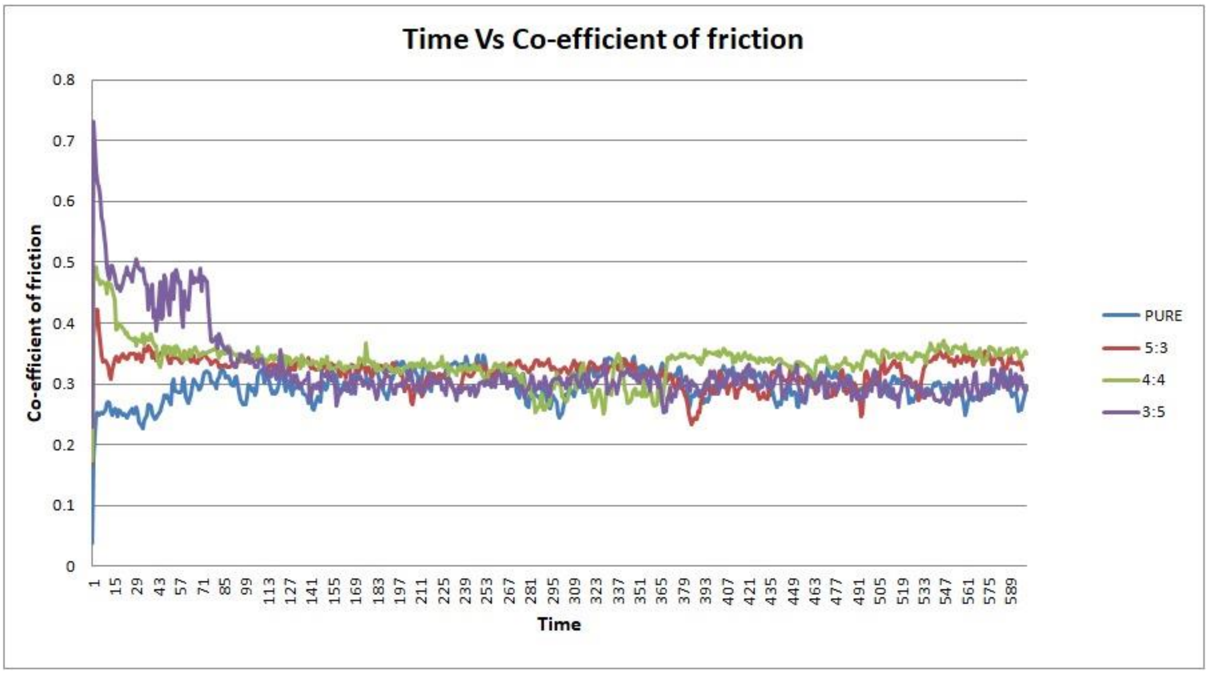
Graph 2: Time Vs Wear



Graph 3: Time Vs Frictional Force



Graph 4 :Time Vs Co-Efficient Of Friction



From the graphs it is found that weight loss decreases with increase in the composition percentage (wear resistance).the presence of fly ash and TiB_2 in the matrix of Al7075 tend to increase the wear resistance in the aluminium composite.

DISCUSSIONS:

Based on the tabulated results, various graphs are plotted and presented in Graph.1 to Graph. 4 for different percentage of reinforcement (TiB_2 &Fly ash) under different test conditions at constant speed 500 rpm and varying loads. It is seen from the plot that as sliding distance increases the wear of the hybrid composite and Al7075 alloy exhibited decreasing trend. This was due to that initially both the surfaces were associated with a large number of sharp asperities, and contact between the two surfaces was taken place primarily at these points. During the preliminary wear process, influence of low applied loads and low speeds were identified in the form of smoothness in work material and miniature lubricant layer in between work material and counter surface. The plastically deformed surface will fill the valley of the material in both pin and the counter face during the course of action and there was a possibility of fracturing a few asperities on both the surfaces leading to very fine debris. The asperities of the sliding pin surface were come in contact with the steel disc surface and work hardening of the matrix.

The effect of TiB_2 & Fly Ash on friction coefficient is shown in Graph. The presence of graphite in the hybrid composite decreases the coefficient of friction. The reduction in the coefficient of friction exhibited by the hybrid composite relative to Al 7075 is due to the release of TiB_2 &FLY ASH during their wear process which acted as the solid lubricant [24].

However it is observed that in all cases wear decreases with respect to increase in percentage addition of reinforcement up to 5%. The subsequent marginal increasing trend of these hybrid composites at 5 wt.% of reinforcement (i.e.TiB_2) overshooting the wear rate can be the adverse effect of the hard particle addition together with the increasing tendency of crack initiation and propagation at the reinforcement/metal interface.

CHAPTER-5

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CONCLUSION:

The objective of the study is to investigate the tribological properties of aluminium hybrid metal matrix composite reinforced by fly ash and titanium and di-boride and microstructured,wear tests were performed to complete this project.

The following conclusions have been drawn by performing the test:

- Fly ash as well as TiB_2 particles have been combined with various mass ratios and evenly strength through out the aluminum 7075.
- The AHMMC containing 3% TiB_2 and 5% FA is found to have higher wear resistance among all hybrid cases.
- It has been shown that wear rate of composites decreases with the increasing amount of TiB_2 particles.
- Wear resistance of the Al was considerably enhanced by the addition of fly ash particles.
- However, all hybrid cases have shown better wear resistance than pure alloy.

CHAPTER-6

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