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# THE EFFECT OF ALLOYING ELEMENTS ON THE MECHANICAL AND MICROSTRUCTURAL PROPERTIES OF ALUMINIUM ALLOY

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**ABSTRACT**

Among automobile manufacturers, in recent times, a paramount importance has been given to less fuel consumption of the vehicles by utilizing lightweight and high strength materials. Metal matrix composites (MMCs) have been used commercially in the automotive market for nearly twenty years. Metal Matrix Composites (MMCs) have very light weight, high strength, stiffness and exhibit greater resistance to corrosion, oxidation, and wear. Tensile and compressive strength is an especially important property of Aluminium matrix composites which is essential for automotive application. From this experimental investigation studied hybrid Aluminium matrix composite was fabricated through sand casting process. Alumina oxide, Tungsten carbide (WC) and Marble dust particles were used as reinforcement phases for the present study. The hybrid MMC were prepared with varying the $AL_2O_3$, WC, & MD particles weight ratio ranging from 0% to 10% and fixed quantity of 1% of magnesium. Tensile strength is larger when the % volume of reinforcements is lower. Ratio-2 Al 6082+2.5% WC +5% AL2O3+2% MD was shown to have the least amount of wear rate on the specimen during the Pin on Disc analysis when compared to other ratio samples.

## INTRODUCTION

The ever-increasing demand for light weight, fuel efficiency and comfort in automobile industries has lead to the development of advanced materials along with optimized design. The increased demand for light-weight materials with specific strength in the aerospace and automotive industry has spread the development and use of one group of composites: metal-matrix composites (MMCs). MMCs are widely used in industries, as they have excellent mechanical properties and wear resistance. MMCs have slowly replaced some of the conventional light-weight metallic alloys such as the various grades of aluminum alloys in applications where low weight and energy saving are important considerations and yet without sacrificing the strength of the components.

A metal matrix composite (MMC) can be defined as a metallic matrix (usually an alloy of Al, Cu, Fe, Mg, Ti or Pb) containing three-dimensional inclusions (usually an oxide, carbide or nitride). In these

MMCs, the good ductility of the metallic alloy as the matrix material is retained while the modulus and strength of the composites are increased as a result of the reinforcement phases. By the correct combination of matrix material and reinforcements, MMCs can be tailored to give superior electrical, mechanical and even chemical properties. This is especially important in cases when monolithic metals and alloys can no longer fulfill the increasingly stringent requirements demanded by designers and engineers in newer engineering applications.

Metal-matrix composites (MMCs) exhibit the ability to withstand high tensile and compressive stresses by the transfer and distribution of the applied load from the ductile matrix to the reinforcement phase. These MMCs are fabricated by the addition of a reinforcement phase to the matrix by the use of several techniques such as powder metallurgy, liquid metallurgy and squeeze-casting. The inclusions in $MMC_S$ can be continuous fibers, discontinuous particulate or whiskers. Particulates make excellent inclusions, because they lead to predictable isotropic behavior in the composite. In addition some particulate metal matrix composites (PMMCs) are attracting attention because of their good mechanical, thermal and tribological properties. Particulate-reinforced composites cost less than fiber-reinforced composites owing to the lower cost of fibers and manufacturing cost.

Besides their increased strength, hardness and thermal conductivity, PMMCs have been found to have better wear resistance than the unreinforced matrix metal. Among the group of hard ceramic particles considered for inclusion in aluminum based MMCs Sic particles have been found to have an excellent compatibility with the aluminum matrix and can be obtained at low cost. Their excellent wear resistance also makes these SiC- particle-reinforced aluminum (Al/SiCp) composites important candidate materials for use in automobiles as pistons, brake rotors, calipers, connecting rods and cylinder liners. The attention has been given to aluminum PMMCs which contain particles of silicon carbide (SIC) or alumina. Such materials exhibit abrasive and sliding wear rates which are substantially lower than those of the unreinforced aluminum matrix. These hard particles have been found to be of great importance at high contact loads, because the particles serve to delay the transition from mild to severe wear.

## COMPOSITE

Composite material is a material composed of two or more distinct phases (matrix phase and reinforcing phase) and having bulk properties significantly different from those of any of the constituents. Many of common materials (metals, alloys, doped ceramics and polymers mixed with additives) also have a small amount of dispersed phases in their structures, however they are not considered as composite materials since their properties are similar to those of their constituents (physical property of steel are similar to those of pure iron) . Favorable properties of composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc.

## METAL MATRIX COMPOSITES (MMCS)

Automobile manufacturers are responding to demands for greater fuel efficiency through use of alternate materials such as metal matrix composites (MMCs). Parts made of MMCs offer significant weight savings while maintaining if not improving performance as compared with conventional materials. Over the last decade, MMCs have made slow but steady progress toward mainstream utilization in the automobile industry. To meet the demands of less fuel consumption, less pollution and more efficiency standards and to maintain competitiveness, automobile producers are seriously considering alternate materials in the design of their products. Advanced materials, such as metal matrix composites (MMC) appears a promising way to achieve significant improvements in performance.

## MMC ATTRIBUTES AND APPLICATIONS

MMCs are composed of a metal or metal alloy base (called the matrix) and a reinforcing (usually ceramic) material that is dispersed in the matrix. MMCs typically are stronger, stiffer, operate at higher temperatures, have better abrasion resistance, and have other advantages.MMC technology was first developed in the early 1960s. Since that time over $1 billion has been invested in research and development, mostly focused on military and aerospace applications, for which cost considerations are secondary to improved performance. Lower cost MMCs were developed based on this research and further R&D was undertaken by large primary aluminum producers and chemical companies to develop commercial applications. The automobile industry was targeted as an industry where suitable applications could be found and where the potential for large volumes of consumption is high.

Aluminum companies specifically targeted aluminum MMCs as a method of expanding aluminum demand.MMC properties and production costs are dependent on the type of reinforcement and the manufacturing process. The reinforcing material may be discontinuous or continuous. MMCs with continuous reinforcement have the most desirable properties. However, continuous reinforcement material is more expensive than discontinuous materials, and continuous-reinforced MMCs require costly processes to manufacture. Present production costs for the continuous-reinforced MMC exceed $200 per pound whereas costs for discontinuous- reinforced MMCs can be less than $2 per pound. The least expensive type of MMC part is the discontinuous type reinforced with particulates, which is relatively inexpensive. This type can be produced using conventional metal casting techniques. However, particulate MMCs can also produced using powder metallurgy processes that are more expensive but that produce MMCs with better physical properties.

The most promising MMCs for automobile applications are the aluminum-based types. Reinforced with particulates of silicon carbide or alumina, aluminum MMCs have been shown to be able to take the place of certain steel and cast iron parts in automobiles with weight savings in excess of 50 percent. Aluminum MMCs with particulate reinforcement appear to be practically viable for use in the automobile production process. Small amounts of aluminum MMCs are currently being used as cylinder liners and in pistons of certain Japanese automobiles.

## PARTICLE REINFORCED ALUMINUM MATRIX COMPOSITES (PAMCS)

These composites generally contain equiaxed ceramic reinforcements with an aspect ratio less than about 5. Ceramic reinforcements are generally oxides or carbides or borides ($Al_2O_3$ or SiC or $TiB_2$) and present in volume fraction less than 30% when used for structural and wear resistance applications. PAMCs are less expensive compared to CFAMCs. PAMCs are used as rotating blade sleeves in helicopters. The most notable large size and high volume use of PAMCs is in braking systems of trains and cars. Potential automotive applications of PAMCs include valves, crankshafts, gear parts and suspension arms. Particle reinforced AMCs are in use as recreational products including golf club shaft

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and head, skating shoe, base ball shafts, horseshoes and bicycle frames.

**SHORT FIBER AND WHISKER-REINFORCED ALUMINUM MATRIX COMPOSITES (SFAMCS)**

These contain reinforcements with an aspect ratio of greater than 5, but are not continuous. Short alumina fiber reinforced aluminum matrix composites is one of the first and most popular AMCs to be developed and used in pistons. However, in the recent years usage of whiskers as reinforcements in AMCs is fading due to perceived health hazards. SiC whisker-reinforced aluminum matrix composites have been produced and used as track shoes in advanced military tanks. Short fiber-reinforced AMCs are being used in piston and cylinder liner applications.

**CONTINUOUSFIBER-REINFORCED ALUMINUM MATRIX COMPOSITES (CFAMCS)**

Here, the reinforcements are in the form of continuous fibers (of alumina, SiC or carbon) with a diameter less than 20µm. The fibres can either be parallel or pre woven, braided prior to the production of the composite. Carbon fiber (continuous) reinforced Al matrix composites have been used as antenna wave guides for the Hubble Space Telescope. 7075 Al-boron fiber composites have been used as struts in main cargo bay of space shuttle.

**OBJECTIVES OF PRESENT WORK**

The requirement of composite material has gained popularity in these days due to their various properties like low density, good wear resistance, good tensile strength and good surface finish. Aluminium oxide is one of the least expensive and low density reinforcement available in huge quantities as solid waste by-product in ceramic plant. The Hardness strength will also be taken into consideration. For the achievement of the above, an experimental set up is prepared where all the necessary inputs will be made. In this work a composite is developed by adding Tungsten carbide, Aluminium oxide & Murble dust in Aluminum metal by mass ratio with various percentages. The composite has to be prepared by crucible casting technique and has to be analyzed various mechanical properties.

**ALUMINIUM-6082**

*6082 aluminum is heat-treatable aluminum alloy with copper as the primary alloying element. It is malleable when in the fully soft, annealed temper and can be heat-treated to high strength levels after forming. Due to its high strength to weight ratio, it is widely used in aerospace applications.*

| Element | % Present | |
|---|---|---|
| | min | max |
| Si | 0.40 | 0.80 |
| Fe | 0.0 | 0.70 |
| Cu | 0.15 | 0.40 |
| Mn | 0.0 | 0.15 |
| Mg | 0.80 | 1.20 |
| Zn | 0.0 | 0.25 |
| Ti | 0.0 | 0.15 |
| Cr | 0.04 | 0.35 |
| Al | - | Bal |

**Typical chemical composition for aluminum alloy 6082**

**APPLICATIONS OF 6082 ALUMINUM**

Alloy 6082 is typically used for heavy duty structures are Rail coaches, ruck frames, Ship building, Boiler making, Aerospace applications including helicopter rotor skins etc.,

**TUNGSTEN CARBIDE**

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It is one type of ceramic higher melting temperature. Tungsten carbide is a commonly used material for precision engineering due to its high degree of hardness, high Young's modulus, high wear resistance, high thermal conductivity, and excellent thermal and dimensional stability. Tungsten carbide wears up to 100 times longer than steel in conditions including abrasion, erosion and galling. Wear resistance of tungsten carbide is better than that of wear-resistance tool steels.1% Magnesium added to casting to induces wettability character.

**ALUMINA OXIDE**

Alumina is one of the most cost effective and widely used materials in the family of engineering ceramics. The raw materials from which this high-performance technical grade ceramic is made are readily available and reasonably priced, resulting in good value for the cost in fabricated alumina shapes. With an excellent combination of properties and an attractive price, it is no surprise that fine grain technical grade alumina has a very wide range of applications. Aluminum oxide, commonly referred to as alumina, possesses strong ionic inter atomic bonding giving rise to its desirable material characteristics. It can exist in several crystalline phases which all revert to the most stable hexagonal alpha phase at elevated temperatures. This is the phase of particular interest for structural applications and the material available from Accurate. Alpha phase alumina is the strongest and stiffest of the oxide ceramics. Its high hardness, excellent dielectric properties, refractoriness and good thermal properties make it the material of choice for a wide range of applications. High purity alumina is usable in both oxidizing and reducing atmospheres to 1925°C. Weight loss in vacuum ranges from $10^{-7}$ to $10^{-6}$ $g/cm^2$.sec over a temperature range of 1700° to 2000°C. It resists attack by all gases except wet fluorine and is resistant to all common reagents except hydrofluoric acid and phosphoric acid. Elevated temperature attack occurs in the presence of alkali metal vapors particularly at lower purity levels.

**MARBLE DUST**

The Marble dust powder was collected from local granite selling shop. The Specific gravity of marble dust powder is 2.64 and water absorption is 0.97%. It was sieved by IS-90 micron sieve before mixing in Aluminium alloy.

**MAGNESIUM**

Magnesium is a chemical element with the symbol Mg and atomic number 12. Its common oxidation number is 2. It is an alkaline earth metal and the eighth-most-abundant element in the Earth's crust and ninth in the known universe as a whole. Magnesium is the fourth-most-common element in the Earth as a whole (behind iron, oxygen and silicon), making up 13% of the planet's mass and a large fraction of the planet's mantle.

The relative abundance of magnesium is related to the fact that it easily builds up in supernova stars from a sequential addition of three helium nuclei to carbon .Due to magnesium ion's high solubility in water, it is the third-most-abundant element dissolved in seawater. Magnesium is produced in stars larger than 3 solar masses by fusing helium and neon in the alpha process at temperatures above 600 mega kelvins.

**CASTING PROCESS**

The aluminum metal matrix composite materials is the combination of two or more constituents in which one is matrix and other is filler materials (reinforcements). Aluminum metal matrix may be laminated, fibers or particulates composites. These materials are usually processed through powder metallurgy route, liquid cast metal technology or by using special manufacturing process. The processing of discontinuous particulate metal matrix material involves two major processes (1) powder metallurgy route (2) liquid cast metal technology. The powder metallurgy process has its own limitation such as processing cost and size of the components. Therefore only the casting method is to be considered as the most optimum

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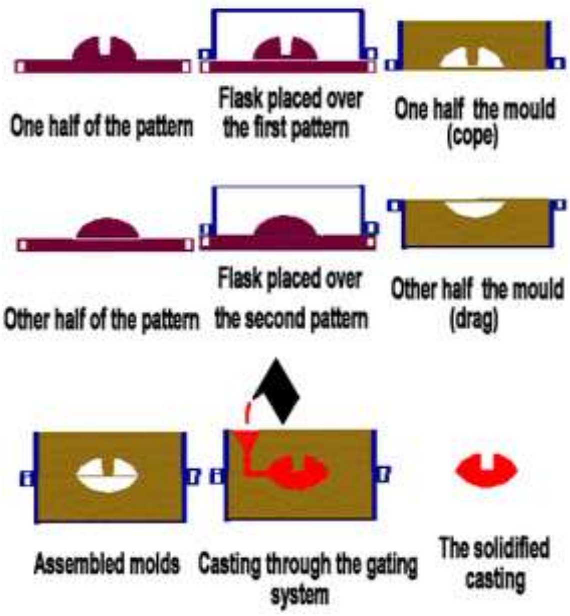
and economical route for processing of aluminum composite materials. For alloy development aluminum 6082 rod and Alumina oxide average particles size 200µm were purchased from local market. The aluminum rod was melted in a graphite crucible and alloyed with required quantity of reinforcements.

**CASTING**

In this project we have used sand mold casting for produce the requirement size. Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. It is relatively cheap and sufficiently refractory even for steel foundry use. A suitable bonding agent (usually clay) is mixed or occurs with the sand. The mixture is moistened with water to develop strength and plasticity of the clay and to make the aggregate suitable for molding.

The term "sand casting" can also refer to a casting produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 70% of all metal castings are produced via a sand casting process.




**5.4 MIXING RATIO**

Sample1: : AA 6082-100%

Sample2: : AA 6082+2.5 % WC +5% $AL_2O_3$ +2% MD

Sample3: : AA 6082+5 % WC + 10% $AL_2O_3$ +4% MD

**Mixing Ratio- Total Al 6082-480 gram per ratio**

| Ratio | AL 6082 grams | WC | $AL_2O_3$ %&Weight | MD |
|---|---|---|---|---|
| I | 500 | 0 | 0 | 0 |
| II | 500 | 2.5%-12.5g | 5%-25g | 2%-10g |
| III | 500 | 5%-25g | 10%-50g | 4%-20g |

**5.5 AFTER CASTING IMAGES**

The below mentioned figure:5.2 illustrates raw material of matrix and various reinforcements images.

**After Casting Images**

**ASTM STANDARD OF AMMC SPECIMEN**

The after casting the entire specimen were machined as per ASTM standard to find the various mechanical behaviours and optical charcteristics. The figure:5.3 shows tensile, compression, hardness & micro structure samples.

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**ASTM Standard of AMMC Specimen**

## MECHANICAL TEST

### HARDNESS

There are three types of tests used with accuracy by the metals industry; they are the Brinell hardness test, the Rockwell hardness test, and the Vickers hardness test. Since the definitions of metallurgic ultimate strength and hardness are rather similar, it can generally be assumed that a strong metal is also a hard metal. The way the three of these hardness tests measure a metal's hardness is to determine the metal's resistance to the penetration of a non-deformable ball or cone. The tests determine the depth which such a ball or cone will sink into the metal, under a given load, within a specific period of time. The followings are the most common hardness test methods used in today`s technology.

### TENSILE TEST&ELONGATION

Friction processed joints are evaluated for their mechanical characteristics through tensile testing. A tensile test helps determining tensile properties such as tensile strength, yield strength, percentage of elongation, and percentage of reduction in area and modulus of elasticity.

The welding parameters were randomly chosen within the range available in the machine. The joints were made with random parameters and evaluate tensile strength and burn off. Then the joints were made and evaluate the mechanical and metallurgical characteristics.

The friction welded specimens were prepared as per the ASTM standards. The test was carried out in a universal testing machine (UTM) 40 tones FIE make.

### Elongation

Deformation in continuum mechanics is the transformation of a body from a reference conFigureuration to a current conFigureuration. A conFigureuration is a set containing the positions of all particles of the body.

Contrary to the common definition of deformation, which implies distortion or change in shape, the continuum mechanics definition includes rigid body motions where shape changes do not take place A deformation may be caused by external loads, body forces (such as gravity or electromagnetic forces), or temperature changes within the body. Strain is a description of deformation in terms of relative displacement of particles in the body.

Different equivalent choices may be made for the expression of a strain field depending on whether it is defined with respect to the initial or the final conFigureuration of the body and on whether the metric tensor or its dual is considered. In a continuous body, a deformation field results from a stress field induced by applied forces or is due to changes in the temperature field inside the body. The relation between stresses and induced strains is expressed by constitutive equations, e.g., Hooke's law for linear elastic materials. Deformations which are recovered after the stress field has been removed are called elastic deformations. In this case, the continuum completely recovers its original configureuration.

On the other hand, irreversible deformations remain even after stresses have been removed. One type of irreversible deformation is plastic deformation, which occurs in material bodies after stresses have attained a certain threshold value known as the elastic limit or yield stress, and are the result of slip, or dislocation mechanisms at the atomic level. Another type of irreversible deformation is viscous deformation, which is the irreversible part of viscos elastic deformation.

## COMPRESSION TEST

**Compression Test Machine**

A compression test is any test in which a material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed, **"squashed"**, crushed, or flattened. Purpose of Compression Tests: The goal of a compression test is to determine the behavior or response of a material while it experiences a compressive load by measuring fundamental variables, such as, strain, stress, and deformation.

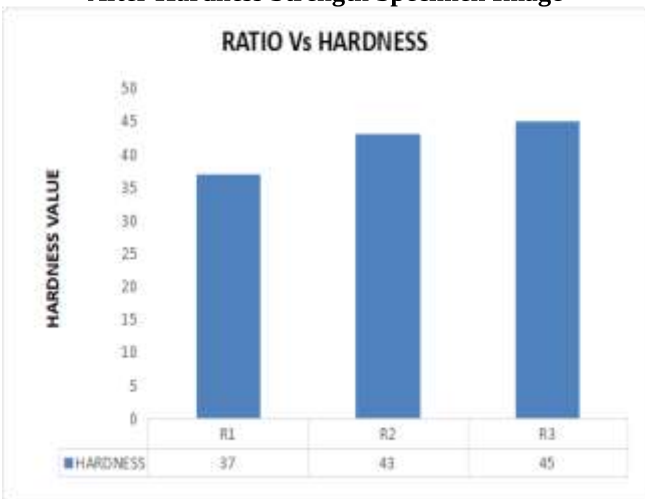
## HARDNESS VALUE

The HRB scale was used to determine the hardness of the different AMMC ratios. R3 obtained maximum hardness 45 HRB.

| S. No | Material | HRB |
|---|---|---|
| $R_1$ | AA 6082-100% | 37 |
| $R_2$ | AA 6082+2.5 % WC +5% $AL_2O_3$ +2% MD | 43 |
| $R_3$ | AA 6082+5 % WC + 10% $AL_2O_3$ +4% MD | 45 |

**Hardness Test strength**


**After Hardness Strength Specimen Image**




**Hardness Graph**

## TENSILE STRENGTH VALUES

Compared to other ratios, the maximum tensile strength was achieved with an $R_2$ ratio of 125 $N/mm^2$, particularly in the absence of reinforcements.

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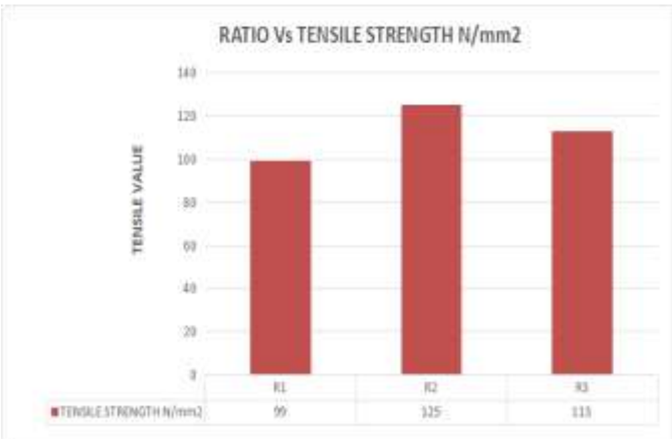
| Sample | Dia (mm) | CSA (mm2) | TL (KN) | TS (N/mm)$^2$ |
|---|---|---|---|---|
| $R_1$ | 15.85 | 197.389 | 24.6 | 99 |
| $R_2$ | 15.83 | 196.891 | 22.5 | 125 |
| $R_3$ | 15.84 | 197.140 | 19.0 | 113 |

**Tensile Strength**

**After Tensile Strength Specimen Image**




**Tensile strength Graph**

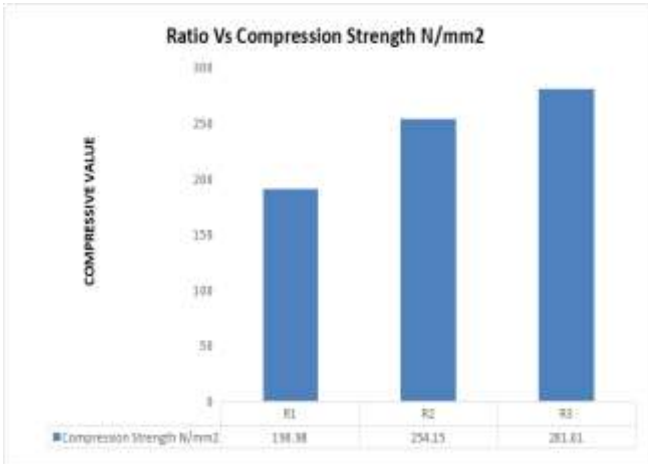
**COMPRESSIVE STRENGTH VALUES**

| S. No | Composition | Compressive load (KN) | Compression Strength N/mm$^2$ |
|---|---|---|---|
| $R_1$ | AA 6082-100% | 38.4 | 190.98 |
| $R_2$ | AA 6082+2.5 % WC +5% $AL_2O_3$ +2% MD | 51.1 | 254.15 |
| $R_3$ | AA 6082+5 % WC + 10% $AL_2O_3$ +4% MD | 56.5 | 281.01 |

When compared to other ratios, an R3 ratio of 281.01 N/mm2 yielded the maximum compressive strength. The higher volume of reinforcements induces the maximum compressive strength.

**Compressive Strength Specimen**

**After Compression Strength Specimen Image**




**Compression strength graph**

**Conclusion of Macro Test**

Many properties were enhanced after the mechanical properties investigation on the AA6082 metal matrix had been concluded. Tensile strength, compressive strength, and hardness properties were finally assessed. Compressive strength and hardness the variables were especially improved on R3. Tensile strength is larger when the % volume of reinforcements is medium.

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**WEAR TEST**

A tribometer is an instrument that measures tribological quantities, such as coefficient of friction, friction force, and wear volume, between two surfaces in contact. A tribotester is the general name given to a machine or device used to perform tests and simulations of wear, friction and lubrication which are the subject of the study of tribology. Often tribotesters are extremely specific in their function and are fabricated by manufacturers who desire to test and analyze the long-term performance of their products. An example is that of orthopedic implant manufactures who have spent considerable sums of money to develop tribotesters that accurately reproduce the motions and forces that occur in human hip joints so that they can perform accelerated wear tests of their products.

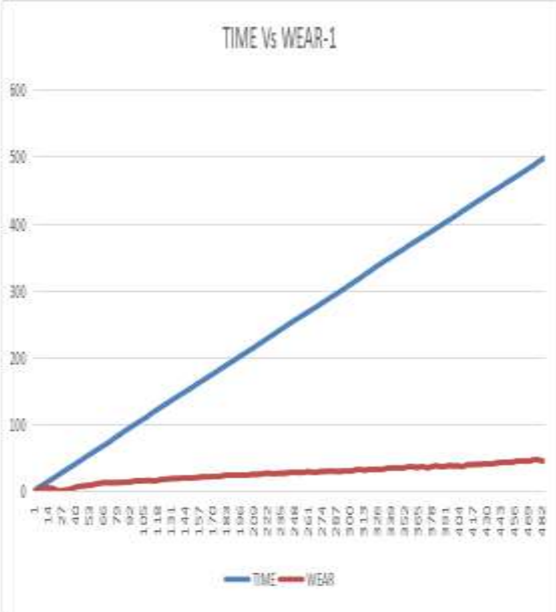
**WEAR RATE-sample-1**

**TEST RESULTS**

**7.4.1 Wear Test**

TECHNICAL SPECIFICATION OF WEAR MACHINE – PIN ON DISC

Test Speed: 637 RPM, Normal Load: 20N, Pin Dia: 10mm, Track Radius: 30mm



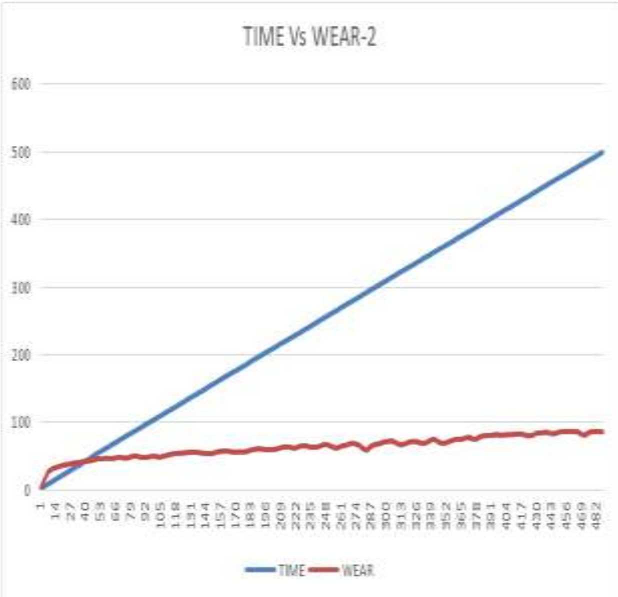

**WEAR RATE-sample-2**

**TEST RESULTS**

**WEAR TEST**

TECHNICAL SPECIFICATION OF WEAR MACHINE – PIN ON DISC

Test Speed: 637 RPM, Normal Load: 20N, Pin Dia: 10mm, Track Radius: 30mm



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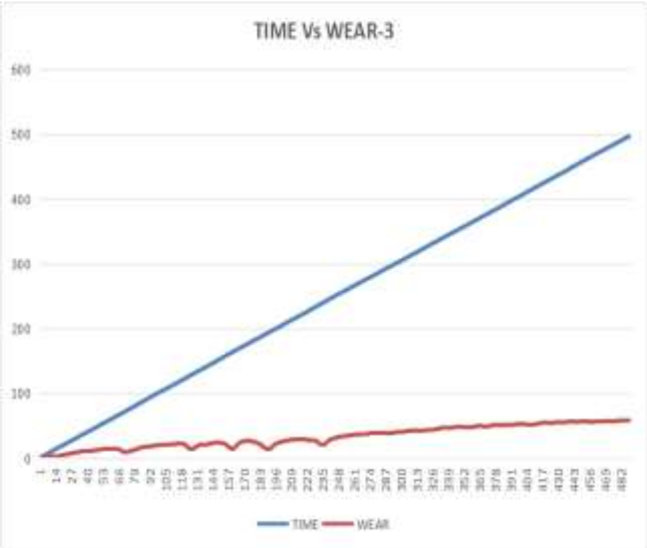
**WEAR RATE-sample-3**

**TEST RESULTS**

**WEAR TEST**

TECHNICAL SPECIFICATION OF WEAR MACHINE – PIN ON DISC

Test Speed: 637 RPM, Normal Load: 20N, Pin Dia: 10mm, Track Radius: 30mm




**Weight of testing specimen before and after**

**Table: 7.4 Wear rate of the different various composite**

| **RATIO** | **BEFORE WEIGHT** | **AFTER WEIGHT** | **DIFFERENCE** |
|---|---|---|---|
| AA 6082-100% | 3.923 | 3.916 | 0.007 |
| AA 6082+2.5 % WC +5% $AL_2O_3$ +2% MD | 3.905 | 3.899 | 0.006 |
| AA 6082+5 % WC + 10% $AL_2O_3$ +4% MD | 3.999 | 3.992 | 0.007 |

**SPECIFICATION**

| **LOAD** | **DURATION** | **DIA** | **RPM** |
|---|---|---|---|
| 10N | 500 Sec | 40 mm | 478 |

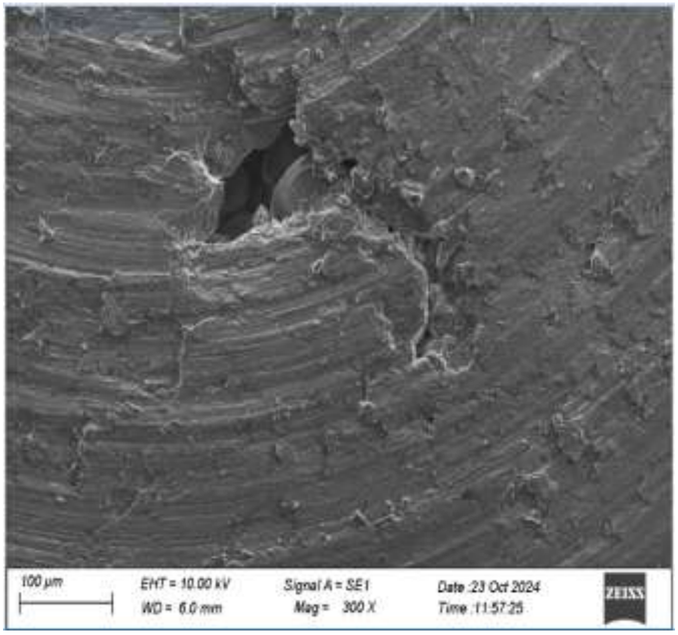
**Conclusion of wear test**

During the analysis the wear had been found the minimum wear rate occurred on the Ratio 2 - AA 6082+2.5 % WC +5% $AL_2O_3$ +2% MD is obtained very low wear rate.

**MICRO STRUCTURE ANALYSIS OF VARIOUS FSP WITH VARIOUS REINFORCEMENT**

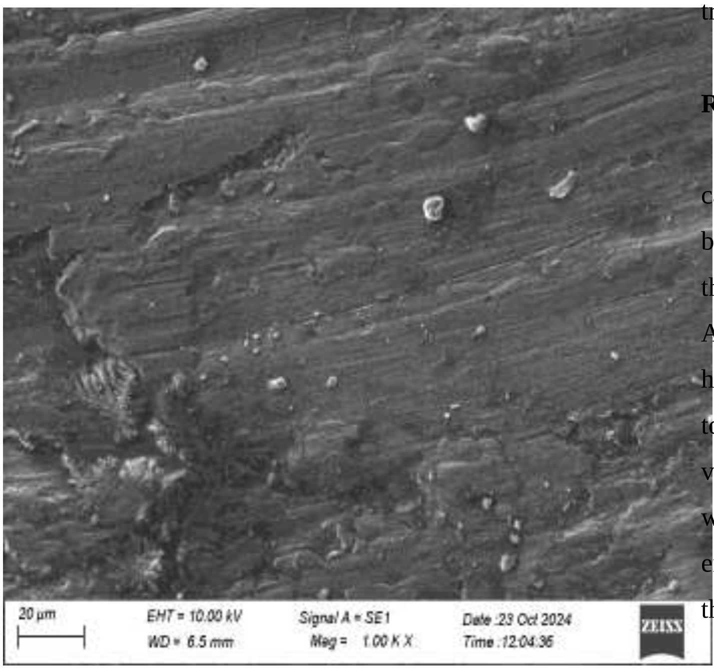
Microstructure of the casted sample by the help of SEM has been observed. Various AMMC processing samples are taken into consideration. The main objective is to find out the change in microstructure with change in various reinforcements which was taken as input parameters.

**R1- SEM IMAGES (AA 6082-100%)**



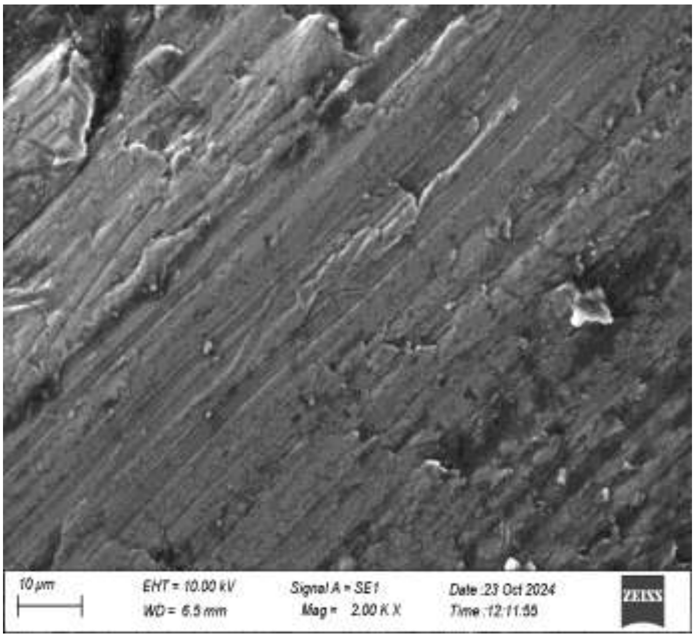

The nearly uniform alloy distribution shown by the R-1 SEM verifies the alloy's presence. There is some mild porousness visible in the structure.

**R2- SEM IMAGES (AA 6082+2.5 % WC +5% $AL_2O_3$ +2% MD)**




The casting specimen appears to show the precipitation behaviours in the bright and dark areas. Along the grain boundaries, no reinforcements were found to be segregated.

**R3- SEM IMAGES (AA 6082+5 % WC + 10% $AL_2O_3$ +4% MD)**




Since no reaction products were seen, it indicates the connection between the matrix and dispersed phase is transparent.

## RESULT

It is found that the Alumina oxide, Tungsten carbide and Marble dust ($AL_2O_3$, WC & MD) particles have been successfully incorporated in AA6082 matrix alloy through crucible casting technique. In this research work AA6082- $AL_2O_3$+WC & MD metal matrix Composites having good mechanical & tribological properties compared to the reinforcements aluminium alloy 6082. It is used in various industrial applications these materials having light weight along with high hardness. Many properties were enhanced after the mechanical properties investigation on the AA6082 metal matrix had been concluded. Tensile strength, compressive strength, and hardness properties were finally assessed. Compressive strength and hardness the variables were especially improved on R3. Tensile strength is larger when the % volume of reinforcements is medium. During the analysis the wear had been found the minimum wear rate occurred on the Ratio 2 - AA 6082+2.5 % WC +5% $AL_2O_3$ +2% MD is obtained very low wear rate. The SEM analysis were evaluated and identified the status of structure for the all ratios.

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