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"Evaluation of Mechanical properties for Functionally Graded Material base metal Aluminum [AL - 6063] when reinforced with Silicon Carbide [SiC] and Titanium Dioxide [TiO2]"

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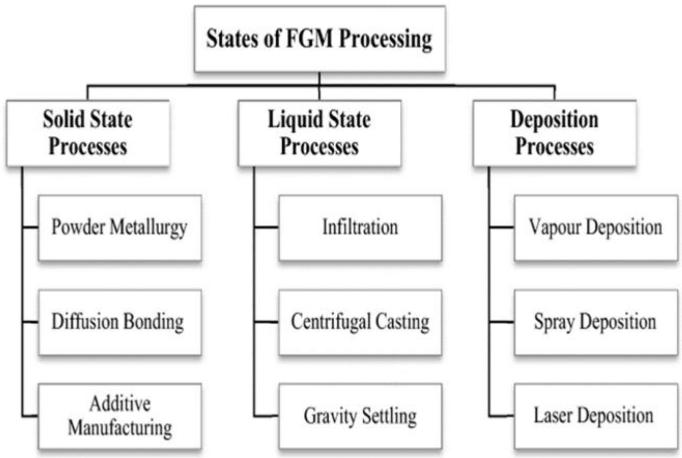
Abstract - *Functionally Graded Materials (FGM) belongs to a class of advanced composite materials i.e, characterized by variations in composition, microstructures as well as properties across the dimension of the materials. They have been developed as ultrahigh temperature resistant materials for biological, chemical, aerospace and other engineering applications. In this project, the preparation of metal alloy (Al-SiC-TiO2) functionally graded material using stir casting process. The silicon carbide and titanium Dioxide are added to aluminium-6063 and the samples in the ratios of 2%(SiC), 3%(TiO2) to 95%(AL6063) and 4%(SiC), 3%(TiO2) to 93%(AL6063) and 6%(SiC), 3%(TiO2) to 91%(AL6063) by weight percentage using powder metallurgy process for manufacturing casting. Since our major concentration here is to identify the microstructures and mechanical properties of Al-SiC-TiO2, the Stir casting process is selected for constant mixing at 60RPM of the mentioned elemental powders to produce alloy samples. Then they are examined with the help of metallurgical microscope to know about the porosity and fusion of the grains. The fabricated specimen is subjected to tensile, hardness, wear tests. As per result obtained from tensile test states that as Al-6063 decreases, the yield and ultimate strength increases due to increase in ductility of material. The result obtained from hardness test states that hardness increases with increase in reinforcement material. The result obtained from wear test states that with decrease in AL-6063 and increase in percentage of Sic, wear of the material also decreases.*

1. INTRODUCTION

FGMs (functionally graded materials) are one-of-a-kind materials with features and attributes that change in proportion to their size. It's a more advanced form of previously used composite materials that combines two or more elements to provide the desired properties for the application. FGMs have gotten a lot of interest from academics in the recent decade because of their graded properties at every single point in several dimensions. The features and attributes of a FGM differ from the elements that make it up.

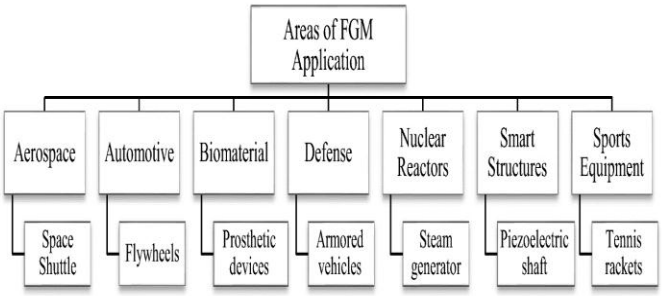
1.1 STATE OF FGM PROCESSING:-

According to the state of FGM processing, methods are separated into three categories: solid state procedures, liquid state processes, and deposition techniques. Figure 1.2 shows the many processing methods that fall into these groups. A large amount of research exists that spans all phases of processing in various FGM manufacturing techniques. Deposition techniques are cutting-edge technology for making small-scale, high-precision items. For highly stressed thermo-mechanical components, solid-state FGMS is used, where as liquid-state methods are used for big products with less property control. Temperature impacts, mechanical loading, pressure, and inertia forces that occur during production when FGM is made in various methods and states have an impact on the final product's quality.



1.2 FGM FIDELS OF APPLICATION:-

FGMs have been found and used in a variety of applications, including both severe working conditions and very sensitive applications. Examples include heat exchangers, heat-resistant materials in spacecraft or fusion reactors, and medical implants. Various combinations of typically incompatible activities can be employed to manufacture new materials for aero planes, chemical plants, nuclear energy reactors, and other purposes. Depending on their use, FGMs are classified as biomaterial aircraft, car, cutting tools, nuclear reactor, smart structure turbine blades, and sports equipment.



1.3 ALUMINIUM ALLOY 6063 (AL – 6063):-

AL-6063 is an aluminium alloy comprising the alloying elements magnesium and silicon. The Aluminium Association maintains the standard that governs its composition. It has strong mechanical qualities and may be heat treated and welded. It possesses three outstanding features that make it particularly valuable in the aviation business.

Ductility, non-corrosive, lightweight but robust, good heat and electric conductivity

The most prevalent alloy for aluminium extrusion is AL-6063. It is used for visible architectural applications like as window frames, door frames, and roofs because it permits complicated designs to be created with very smooth surfaces that are suitable for anodizing. Tensile strength (215MPa) and shear strength are mechanical qualities (152MPa).

Table -1: Sample Table format

Aluminum alloy 6063

Constituent element	Minimum (% by weight)	Maximum (% by weight)
Aluminium (Al)	97.5%	99.35%
Magnesium (Mg)	0.45%	0.90%
Silicon (Si)	0.20%	0.60%
Iron (Fe)	0	0.35%
Chromium (Cr)	0	0.10%
Copper (Cu)	0	0.10%
Manganese (Mn)	0	0.10%
Titanium (Ti)	0	0.10%
Zinc (Sn)	0	0.10%
(others)	0	0.15% total (0.05% each)

1.4 SILICON CARBIDE (SiC):-

Silicon carbide (SiC) is a hard chemical combination made up of silicon and carbon. It is also known as carborundum. They may contain some surplus silicon or carbon, as well as a small amount of oxygen, depending on the production method. Strong tensile strength, low weight, high chemical resistance, high temperature tolerance, and stiffness are all characteristics of silicon carbide. Elastic modulus is a mechanicalproperty(410GPa).

1.5 TITANIUM DIOXIDE (TiO2):-

Titanium dioxide is an inorganic substance having the chemical formula TiO2. It is also known as titanium (IV) oxide or titania. Titanium white is the name given to it when used as a pigment. Its melting and boiling points are both extraordinarily high. It occurs naturally as a solid, and it is insoluble in water even in particle form. TiO2 is an insulator as well. Young's Modulus (333MPa), Tensile Strength (230GPa).

1.6 METALLURGICAL MICROSCOPE

A specialized microscope used to examine metal target cross-sections (metallurgical mounts). These metallurgical microscopes are often inverted and use high-resolution objective lenses with low working distances. While these systems are effective for this sort of analysis, their range of applications is somewhat limited. Metallurgical microscopes, whether optical or digital, can be employed in practically any business or field of research that requires the observation of shiny metal surfaces. Metallurgy, mineralogy, and gemology are among them. Manufacturers also use digital or optical metallurgical microscopes to look for faults or wear on materials and components.

2. LITERATURE SURVAY

[1] Anuj Kumar et al [2017] were able to determine the wear characteristics of an aluminium matrix composite by reinforcing copper and silicon carbide in aluminium. The wear behaviour of Al- SiC-Cu MMC is investigated for various reinforcement content, load, speed, and distance.

[2] P Sivaiah and K Venkata Chalapathi [2014] investigated the attractiveness, wait ratio, and strength of AL-SiCp MMC, which is widely utilised in the aerospace and automotive sectors. The mechanical properties and microstructure of Al-alloys with 5 percent, 10%, and 15% Sicp weight are examined in this research. In an electrical furnace, the compositions were mixed to their final form and used to manufacture aluminium metal matrix composites. The fabricate material will be tested on bhn, rockwell, hardness, tensile, torsion, and impact at various sicp compositions to get mechanical properties.

[3] V. Daniel Jebin1 and D. Shivalingappa [2013] investigated wear behaviour of AL-6063 alumina metal matrix composites, which are often utilised in the automobile industry. The wear resistance of these materials is poor. The use of aluminium oxide as a reinforcing material has resulted in the creation of durable and wear-resistant composites. The goal of this research was to employ a pin-on-disc machine to investigate the wear behaviour of an Al 6063 aluminium alloy matrix composite with various parameters. When the weight percent of Aluminum oxide was raised, the wear rate was lowered.

[4] S.A. Balogun, S.O. Adeosun, and O.S. Sanni [2004] The strength and ductility of aluminium alloy 6063 reinforced with silicon carbide granules were investigated after cold rolling and heat treatment. To prepare samples for heat treatment and cold rolling, silicon carbide (SiCp) with a grain size of 100 m was added to 6063 aluminium in volume fractions of 0–30%. The findings reveal that rolled-and-tempered samples containing 10% SiCp may achieve an optimal combination of strength and ductility at 137.92 MPa and real strain of 0.173. This is a significant improvement over the 6063 aluminium alloy, which has a true strain of 0.18 and has an ultimate tensile strength of 100 MPa.

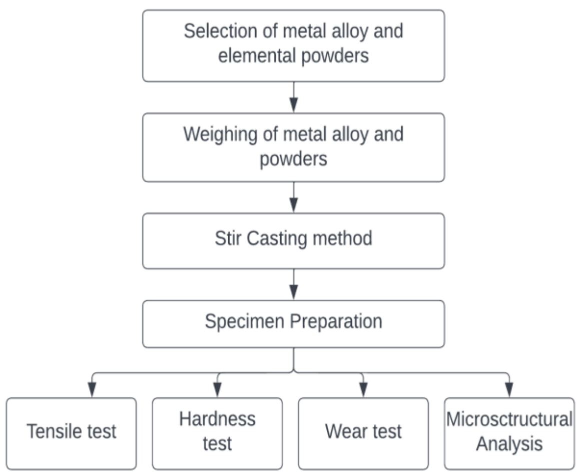
[5] P.V.Rajesh and S.Roseline [2016] The goal of this research is to look at the mechanical characteristics of an aluminium alloy (Al6063) based hybrid metal matrix composite reinforced with silicon carbide, magnesium, and fly ash that was made using the stir casting process. The sample specimens were created by altering the reinforcing fraction in relation to the aluminium alloy. Mechanical characteristics analysis reveals differences in tensile strength, hardness, and impact strength across composite combinations. The percentages of aluminium, silicon carbide, magnesium, and fly ash should be 90, 5, 5, and 0 accordingly to achieve optimal tensile, hardness, and impact qualities, according to the testing results.

[6] A. godwin Antony, V.Vijayan, S. Saravanan, S. Baskar and M.Loganathan [2018] performed research in the field of material science and engineering. That by fabricating aluminium matrix composites with titanium (Ti) and silicon carbide (Sic) by stir casting process and the wear characteristics are found out by carrying out "Pin on Disk" test. In the current study Aluminium is used as the basis metal and it is reinforced with silicon carbide and titanium particles using the stir casting process. The Edox test will be used to examine the aluminium scrap, which will then be stir cast with titanium and silicon carbide added as reinforcements. Later, a "pin on disc" test is carried out to determine the composites' wear qualities. The composites are put through a SEM test to determine their wear characteristics. Finally, a SEM examination is performed to examine the grain structure.

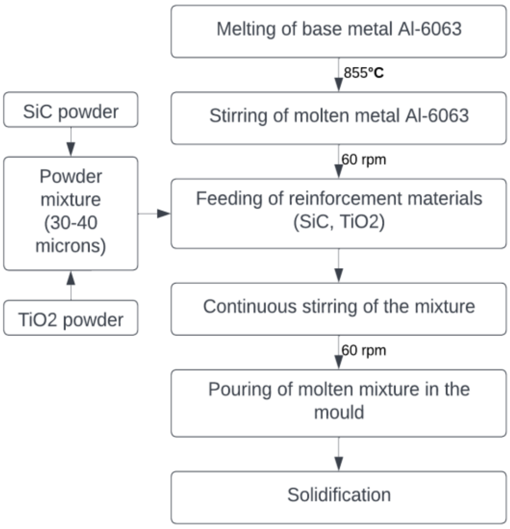
[7] B. Suresh Babu, P. Prathap, T. Balaji, D. Gowtham, S.D. Sree Adi, R. Divakar and Sanjeev Ravichandran [2020] In this study, the mechanical and metallurgical characteristics of Al 6063-Silicon Carbide and Al 6063-Silicon Carbide/Graphite hybrid metal matrix composite materials are fabricated and compared. The composites were made using stir casting procedures, with reinforcement amounts ranging from 5% to 15% in 5 wt.% increments each sample. Mechanical characteristics, density, and microstructural investigations are used to describe the composites, which are then tested according to ASTM criteria. The composites' optical microphotographs show a consistent distribution of hybrid particles in the composites, with few clusters. In all of the composites, the experimental densities were found to be lower than the predicted densities. The distributed Silicon Carbide and Graphite in the Al 6063 alloy improved the composites' tensile strength (MPa). The samples were found to have a homogeneous distribution of hybrid reinforcement particles (SiC.and Graphite) in the matrix, with no tunnel or void effects, according to scanning electron microscopy (SEM) investigation.

[8] k. k. alaneme and m. o. bodunrin [2013] researched where Aluminum-based matrices remain the most researched metal matrix material for the creation of MMCs among metallic matrices. This is owing to the wide range of qualities that aluminum-based matrix composites provide at a cheap processing cost. The mechanical behaviour of aluminium alloy (6063) - alumina particle composites made by two-step stir casting was studied. AA 6063 – Al2O3 particle composites with 6, 9, 15, and 18% Al2O3 by volume were created. It was discovered that AA 6063/Al2O3p composites with low porosity (3.51% porosity) and an excellent uniform dispersion of alumina particles in the AA 6063 matrix could be made. The tensile strength, yield strength, and hardness increased with increase in alumina volume percent while the strain to fracture and fracture toughness decreased with increasing volume percent alumina.

3. METHOD AND METHODOLOGY



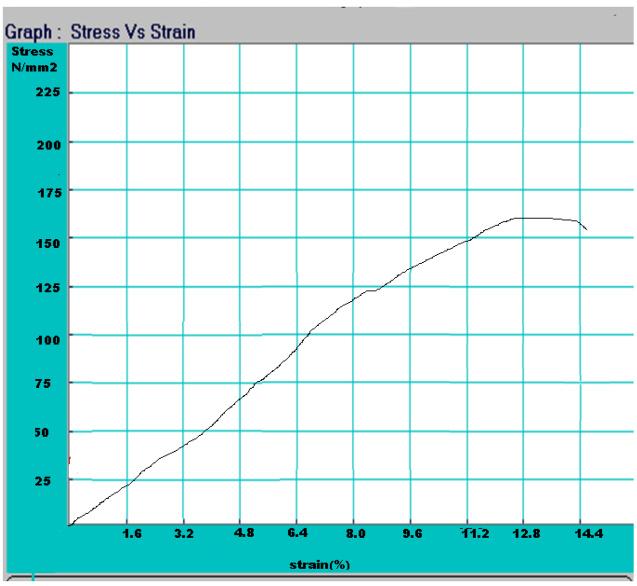
4. STIR CASTING



5. SPECIMEN PREPARATION

COMPOSITE 1:- 95% (AL – 6063) + 2% (SiC) + 3% (TiO_2)
COMPOSITE 2:- 93% (AL – 6063) + 4% (SiC) + 3% (TiO_2)
COMPOSITE 3:- 91% (AL – 6063) + 6% (SiC) + 3% (TiO_2)

7. TEST REPORT



8 .PREPARATION OF THE SPECIMEN

For this microstructural analysis hardness test specimen of dimensions of 20mm in length and 8mm in diameter is selected.Fine grinding of the specimen is carried out on water proof emery/ sand paper of grid size (220, 320, 400, 600) immersed in water.The specimen is rubbed back and forth od the entire paper immersed in water for 10 min in each paper, washed and rubbed again in the order of 220, 320, 400, 600.Once grinding is done the specimen is thoroughly washed in water. Now fine scratches are removed by using a rotary polishing machine. It is rubbed in a soft moist velvet cloth mounted on the rotating disc with aluminium oxide powder. This polishing process is done for 2 min straight. Once polishing is done specimen is cleaned with soap solution in ultrasonic cleaner. Before mounting on microscope etching reagents is added on to the surface of the specimen where the solution contains 10% picric acid + 90% alcohol. Now the specimen is mounted on the metallurgical microscope and is magnified to 100µm and the image is recorded. Now the recorded 3 image of different composite is compared for porosity and fusion of grains.

9. CONCLUSION AND FUTURE SCOPE

- We can come up to the following conclusions based on the tests performed. Through Wear test, we can conclude that the wear of the material decreases with the increase in SiC percentage. Hence, it is proved that the wear resistance can be improved reinforcing SiC. The yield strength and ultimate strength increases with decrease in percentage of Al-6063 and increase in percentage of SiC when TiO_2 is constant. Hardness decreases with decrease in the percentage of Al-6063 and increase in percentage of SiC when TiO_2 kept constant. Microstructure analysis shows that with decrease in Al-6063 percentage and increase in SiC percentage the change in grain structure and improvement in ductility. For future scope, we can keep SiC percentage constant and increase in TiO_2 percentage with base metal Al-6063 and perform different test.

10. REFERENCES

- [1] B. Suresh Babu *et al.*, "Studies on mechanical properties of aluminum based hybrid metal matrix composites," *Mater. Today*, vol. 33, pp. 1144–1148, 2020.

- [2] P. Harish, V. M. Srikanth, P. Ravindra Babu, M. R. Ch, and K. Kishore Kumar, "Characterization of mechanical and tribological properties of aluminum alloy based hybrid composites reinforced with cotton shell ash and silicon carbide.

- [3] X. Yao, Y. F. Zheng, J. M. Liang, and D. L. Zhang, "Microstructures and tensile mechanical properties of an ultrafine grained AA6063–5vol%SiC metal matrix nanocomposite synthesized by powder metallurgy," *Mater. Sci. Eng. A Struct. Mater.*, vol. 648, pp. 225–234, 2015.

- [4] B. Bakthavatchalam, K. Habib, N. Patil, and O. A. Hussein, "Microstructural analysis of Al6063/sic with calcium additives for hardness enhancement," *MATEC Web Conf.*, vol. 225, p. 03007, 2018.

- [5] P. V. Rajesh and S. Roseline, "Experimental investigation of mechanical properties of aluminium alloy al6063 based hybrid metal matrix composite.
- [6] P. Sivaiah, C. Reddy, and K. V. Chalapathi, "Fabrication and study of mechanical properties and microstructure of Al 6063-SICp mmc.
- [7] A. K. Srivastava, "Assessment of mechanical properties and EDM machinability on Al6063/SiC MMC produced by stir casting," *Mater. Today*, vol. 25, pp. 630–634, 2020.
- [8] K. L. Meena, D. A. Manna, D. S.S. Banwait, and D. Jaswanti, "An analysis of mechanical properties of the developed Al/SiC-MMC's," *Am. J. Mech. Eng.*, vol. 1, no. 1, pp. 14–19, 2013.
- [9] M. B. A. Shuvho, M. A. Chowdhury, M. Kchaou, B. K. Roy, A. Rahman, and M. A. Islam, "Surface characterization and mechanical behavior of aluminum based metal matrix composite reinforced with nano Al2O3, SiC, TiO2 particles," *Chem. Data Coll.*, vol. 28, no. 100442, p. 100442, 2020.
- [10] R. Ashok Kumar and T. S. Krishnakumar, "Casting and characterization of Al6063/SiC nano composites produced using stir casting method," *Mater. Today*, vol. 5, no. 11, pp. 23853–23862, 2018.
- [11] A. Karthikeyan and S. Nallusamy, "Experimental analysis on sliding wear behaviour of aluminium-6063 with SiC particulate composites," Int. j. eng. res. Afr., vol. 31, pp. 36–43, 2017.
- [12] N. Lokesh, B. Manoj, K. Srikanth, P. V. Kumar, P. K. V. Ramanayya, and M. V. Rao, "Mechanical characterization of stir cast Al 6063 TiO2-cu reinforced hybrid metal matrix composites," Mater. Today, vol. 5, no. 9, pp. 18383–18392, 2018.
- [13] K. Velavan and K. Palanikumar, "Effect of Silicon Carbide (SiC) on stir cast aluminium metal matrix hybrid composites – A review," Appl. Mech. Mater., vol. 766–767, pp. 293–300, 2015.
- [14] M. B. A. Shuvho, M. A. Chowdhury, N. Hossain, B. K. Roy, M. A. Kowser, and A. Islam, "Tribological study of Al-6063-based metal matrix embedded with SiC–Al2O3–TiO2 particles," SN Appl. Sci., vol. 2, no. 2, 2020.
- [15] J. Hindi, A. U. Kini, S. S. Sharma, B. M. Gurumurthy, and M. C. Gowri Shankar, "Mechanical characterization of stir cast Al 6063 matrix SiC reinforced metal matrix composites," 2015, pp. 69–73.