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Fabrication and Electrical Discharge Machining of Al-SiC-Mg Composite with Mechanical Characterisation

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ABSTRACT

Composites are the materials obtained by combinations of different materials, with greater and better properties that are not present in the individual parent material. Due to its outstanding properties like light weight, corrosion resistance, higher strength and better thermal and electrical properties it is widely used. More than 40000 products of composite materials are used across the Globe. In this work Aluminium Metal Matrix Composite is formed with varying percentage of SiC and Mg. The electrical discharge machining (EDM) of the fabricated composite material has done to observe the material removal rate (MRR) and surface roughness along with different tests such as XRF, hardness test, tensile test and compression test. This paper represents the information that are observed after conducting various tests on composites casted by varying the percentage of Sic and Mg.From Various tests it is observed that with increase in percentage of SiC and Mg hardness, Young's modulus and MRR increases.

Keywords— Composite, EDM, MRR, XRF

I. INTRODUCTION

Now a days everyone wants the material which are having high strength, greater stiffness, better wear resistance, good machinability, desired hardness with superior toughness and attractive look.

But all of these properties are not present in a single metal or material, In order to get these properties in a single piece of metal or material we are using some advanced Engineering processes, by applying these processes different parent materials having different properties are combined together either Mechanically or Metallurgically and the combined product shows the superior and better properties that are not present in the parent metals, these combined materials or product with greater and better properties are called as Composite Materials.

From the historical back ground we can know that the man kind first learn how to create the fire and how to control the fire. Then the man kind invented the wheel and the most important development was spinning of continuous yarn which enables them to survive outside the tropical climatic zones and spread over the maps of the earth. Cotton and Jute and more natural resources were used as flexible Fabrics then and this process had resulted in the First Composite. Then Wood and straw were used to make the wallswith mud and wood layers were used to make the Roofs.

From some sources it is known that towards the second half of the 20th Century in order to avoid the technical problems due to the use of heavier materials, some light weight composites were used.

Nowadays we are focusing on cost reduction during manufacturing and operation, with a more Environmental friendly Design, which leads to the more use and production of Composite Materials.

Nowadays in every field the application of composite is increased by numbers and by volumes starting from the use of a shaving blade to the space suits for Astronauts.

Fibres or Particles Embedded in materials of another material are the best example of Modern Day composite materials. When different layers of Fibrous composite materials are combined one above another it

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forms the Laminates. Laminates are the composite materials having a specific function to perform. The Individual layers consist of high modulus and high strength fibres in matrix materials. Fibres like Silicon Carbide , cellulose, graphite glass and Boron are used. Matrix materials like Aluminium , Titanium and Alumina are used.

Generally the Composite Materials are consist of Two Phases. One Of Its constituents is called reinforcing Phase . The materials in this phase are in the forms of Fibre, PrticlesOr Flakes. The Other phase is known as Matrix phase in which reinforcing phase materials is embedded. The matrix phase materials are generally Continuous. The Reinforcing phase is strong and hard and may not be light in weight. The matrix but is light but weak.

Work Of the reinforcement Phase:

It provides high strength, stiffness and other improved Mechanical Properties to the Composite. Also Contributes Towards the Properties of a Co Efficient of Thermal Expansion, Conductivity, Etc.

Work of The Matrix phase:

The required shape is achieved by matrix phase. The Fibres are Kept in place by Matrix Phase. Matrix phase also transfers Stresses to the fibres . The protection from the Environment , Chemicals, Moisture To the Reinforcement is Provided by the Matrix Phase. Mechanical Degradation of Fibres surface are also protected. It also act as shielding from damage caused due to handling.

When the matrix of the composite material is a metal or an Alloy , the Composite is known as Metal Matrix Composite or MMC.

Aluminium Metal Matrix Composite (AMCC) used Aluminium or its Alloys as their Matrix Phase. Generally Aluminium metal matrix composites are refer to the class of light weight and high performance composite materials.

Continuous and dis continuous Fibres can be used as reinforcement in AMCC. According to the need of Industrial applications the properties of AMCC can vary by suitable combination of Matrix, Reinforcement and Processing Methods.

For an given composite material it is desired that the reinforcement should stable in the given working Temperature and should not react.

In order to Increase the Tensile Strength, Hardness, Density and Wear Resistance of Aluminium and its Alloys most commonly Silicon Carbide(SiC) is used as reinforcement. Aluminium Oxide ($Al2o3$) also used as Reinforcement for AMMC.

Aluminium is a chemical element with symbol Al and Atomic Number 13. It is a ductile Material having Melting point of 660.3℃ and Boiling point of 2470℃ with a density of 2830 Kg/m3. It is a Silvery-White , soft, non magnetic and Ductile Metal in the Boron Group. By Mass Aluminium makes up about 8% of the Earth's Crust. It is the Third Most Abundant Element After Oxygen and Silicon and the most abundant metal in the crust. The Pure form of Aluminium is relatively highly corrosion resistance. The Mechanical strength achieved by suitable alloying and heat treatment process. It is having low density. These three main properties increases the importance of applications of Aluminium in the whole World.

With the above main properties the Aluminium also includes some important properties like High Electrical and Thermal Conductance, Good Reflectivity, High Ductility, Low working cost, magnetic Neutrality, high scrap value and non-poisonous and colourless nature of its corrosion products which makes it suitable for use in Chemical and food processing Industries.

In its Pure State Aluminium is relatively a soft metal with a Yield Strength of 34.5 N/mm2 and a Tensile Strength of 90 N/mm2. By the development of wide range of alloys varied strength and ductility can be achieved. So its use is ranges fromuse of very thin foil material in the packaging industry, ductile material for Drink Containers, highly conductive alloys for Electrical Purpose, Relatively low strength alloys for Building Industry and High Strength Materials for Air Craft and Armoured Vehicles.

The main classes of Aluminium Alloys are the 2000 Series (Al-Cu Alloys) which are high strength materials used in aircraft Industry. The 3000 series (Al-Mn Alloys) used mainly in the canning Industry, the 5000 series (Al-Mg Alloys) which are used unprotected for structural and architectural purposes. The 6000 series (Al-Mg-Si alloys) which are the most common extrusion alloys and are used particularly in the Building Industry and the 7000 series (Al-Zn-Mg alloys) which are again high strength alloys for aircraft and military vehicle applications.

Silicon Carbide Also known as carborundum is a Semi-conductor containing Silicon And Carbon With Chemical Formula SiC. Silicon Carbide Occurs naturally as the rare mineral moissanite. Silicon Carbide is prepared by Acheson Method in which pure silica sand ($SiO2$) and Finely Ground Coke (Carbon) are mixed together and heated to very high temperature in an Electric Furnace. It is having an High Melting Point Of 2,730℃ with a Density of 3,210 Kg/m3.

Silicon Carbide has been recognized as an important ceramic material because of its uniqe combination of properties such as Excellent Oxidation Resistance, Strength Retention to High Temperature, High wear Resistance , high thermal conductivity and good thermal shock resistance. Such Properties are obtained by Highly Covalent (upto 88%) Chemical Bonding between Silicon and Carbon Atoms.

Silicon Carbide is widely used to make various materials such as sand papers, grinding wheels, cutting tools, hard ceramics, refractory linings, high temperature

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bricks, wear resistant parts of pump and rocket engines and also in Jewellery. It is also used to Manufacture Light Emitting Diodes(LEDs) and Semi-conductor Devices.

Magnesium Belongs to Group 2 of the Periodic Table. The Element has an Atomic Number of 12 and Atomic Mass of 24. Magnesium is a Chemical Element With Symbol Mg. Magnesium is the Eighth abundant element in the Earth's Crust with an average of 2.76%. The Mg2+ ion is the second Most Abundant Cat ion in Sea Water after Na+. It is having the Melting Point of 650℃ and Boiling Point of 1,090℃ with a Density of 1.74 g/cm3. Magnesium appeared as a silvery- white metal that ignites easily in air and burns with a bright light. Magnesium is one third less dense than Aluminium. It improves the Mechanical , Fabrication and Welding Characteristics of Aluminium when used as alloying agent. These Alloys are useful in Aeroplane and Car Construction. Magnesium is used in Products that benefits from being light weight such as Car Seats, Luggage, Laptops. Cameras and Power Tools. Magnesium Hydroxide is added to plastics to make them fire retardant. Magnesium Oxide used to make Heat Resistant Bricks For Fire Places and Furnaces.

Nowadays composites are widely used materials. In manufacturing of Automobile Parts. In Heavy Transport Vehicles and Commercial Aircraft Applications. Used For Manufacturing of Bearings, Rotors and Compressors.

Typical Applications in Air Craft Industry:

Landing Gear Doors, Elevators, Rudder Fairings, Trailing Edge Flaps, Turbine Blades, Turbine Shafts, Fly Wheels and Rotor Shafts in Helicopters.

Typical Structural Applications:

Door Shutters, Doors, Window Frames, Ceilings, Door Hinges, Panelling, Roofing, Pipes, Water Storage Tanks, Tunnel Supports, Roads, Bridge Structures, Marine and Offshore Structures and Concrete Slabs.

Applications in Power Transmission:

Composite Power and Lighting Poles, High Voltage Electrical Transmission Towers.

Miscellaneous:

Automobile Engines, Piston, Cylinder, Connecting Rod, Crankshaft Etc. Also Used To Manufacturing The Plumbing Components.

Today More than 40000 products of Composite Materials are used across the Globe.

Composites are versatile Product. Their Properties are:

High strength to weight ratio, Light Weight, Fire Resistance ,Good Electrical Properties, Chemical And Weathering Resistance, Desired Colour, Translucency ,Design Flexibility, Manufacturing Economy, High Fatigue Resistance ,High Impact Strength, Thermal Insulating Properties

Mao [1] has studied the dependent of gear performance on load. He noted that a sudden transition to high wear rates when the transmitted torque is increased to a critical value. This happens because the gear surface temperature of the material is reaching its melting point. He observed that for a given geometry of actual gear, a critical torque can be decided from its surface temperature calculation

Mao [2] adopted the numerical approximation using finite different method for the analysis of the flash temperature for polymer composite gears. Also he has compared the results obtained by using semi-analytical method assuming no internal hysteresis and the material properties are constant.

Yakut et al [3] has investigated the Load carrying capacity and occurring damages of gears which are made of PC/ABS blends. In this study, usability of PC/ABS composite plastic materials as spur gear was investigated.

Moya and Machado [4] performed a theoretical analysis of the procedure to determine the Lewis Factor and also performed the contact analysis of spur gears to find the stress distribution between gear teeth.

Tsai brothers [5] established a characterization method for seven polyamide (PA) grades to determine the major material to manufacture an automotive worm gear. They measured the properties of the composite according to the worm gear loadings: tensile strength, Young's modulus, abrasion and impact resistance. The properties were also correlated to the PA moisture absorption and its glass fiber (GF) reinforcement.

Acilar and Gul [6] investigated a composite with Al–8.7 wt. % Mg matrix alloy reinforced with SiCp. It was added as dispersed particles by Vortex method. Better distribution of SiCp was obtained in matrix

Dong et al [7] studied the as-cast microstructures, the evolution of the microstructures during reheating, and the mechanical properties of thixoformed products of 7075 Al alloy cast by liquid us semi continuous casting (LSC).

Mitra et al [8] prepared the Al matrix composites reinforced with unoxidized or oxidized SiC and varying Mg concentrations were prepared using stir casting technique. The alloying of Al matrix with 0.5 or 1 wt.% Mg and its segregation at the interfaces has been found to be effective in restricting the formation of the Al_4C_3 at the interfaces during casting.

Mondal and Mukhopadhyay [9] studied the Al alloys, encompassed by AA 7055 alloy composition, having the nominal zinc content (i.e., 8 wt.%) but varying copper and magnesium contents across the alloy composition range they were examined in the as-cast form by a combination of light microscopy, scanning electron microscopy (SEM), electron probe microscopic analysis (EPMA), and X-ray diffraction (XRD).

HUDA Z et al [10]The heat treatable 2024-T3 Al alloy were characterized by the use of modern metallographic and material treated techniques (e.g., EPMA and SEM). The micro structural characterization of the metallographic specimen involved use of an optical

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microscope linked with a computerized imaging system using MSQ software.

J.Hasihm [11] Successful fabrication of aluminium matrix composite by using the stir casting method has added a new dimension to the processing of cast composites. The porosity level was reduced by preheating the ceramic particles to burn off the any moisture. Micro structural observation revealed that the reduction in grain size due to the stirring action of the slurry strengthen the composite more as compared with the unreinforced alloy.

Alpas and Zhang [12] At low load, corresponding to stresses lower than the particle fracture strength, SiC particles were the load bearing constituents and their abrasive action successfully transferred the rich iron layer on to the contact surface. However, wear rate of the composite was found to be lower than the unreinforced alloy in this regime. Above a critical load, the SiC particles got fractured and the delamination wear was due to de-cohesion of SiC-matrix interfaces. The wear behaviour of the composite was similar to the unreinforced matrix alloy in this regime. With the continuous increase of load, there was an abrupt increase in weak rate by a factor of 100. The SiC reinforcement was proved to be very effective in suppressing the transition to severe wear regime

Martin et al.[13]The addition of the SiC particulates improved the wear resistance by a factor of two in the mild wear region, and the transition temperature was raised by approx. 50 °C. This higher transition temperature was due to the retention of the mechanical properties in the composite at elevated temperature. Heat treatments (either natural or artificial aging) did not modify substantially the wear resistance of either the composite or the unreinforced alloy.

Wilson and Alpas [14] Mild to severe wear delay was observed in the composites with the addition of Al2O3 and SiC but a hybrid A356 Al composite containing SiC and graphite remained in a mild wear regime even at the highest test temperature of 460°C. The absence of severe wear phenomena in this composite contributes to the inhibition of commination and fracture by graphite entrained in the surface tribolayer. .

Shipway et al [15]Particle additions have reduced the wear rate of the composites and hence delayed the transition with load from low wear coefficients to high wear coefficients. The addition of higher amount of reinforcement resulted in a reduction in wear rate and further led to the retardation of the load at which wear coefficient increases.

II. FABRICATION

In this chapter the process of Fabricating the Aluminium, Silicon Carbide and Magnesium (Al-SiC-Mg) Composite is Explained. Various instruments are used to prepare the composite material. This is the important stage as the operations and testing are to be done on the composite that is fabricated in this stage. The materials used are Aluminium, Silicon Carbide and Magnesium. The Details of the fabrication process are explained in the following sections.

Electric Arc Furnace and the Molten Metal

To fabricate the composite bar of required shape and size the solid state metals first converted into Molten state or Liquid State. In order to convert the solid metals into liquid state high temperature is required, so one Furnace is used which provides High Temperature and area as melting chamber to melt the solid metals. In this Fabrication Process An Electric Arc Furnace, 240 Volt of Zephyrs Interprices Was used as Shown in the Figure 2.1.

The Required Percentage Of Weights of Aluminium, Silicon Carbide and Magnesium were taken as Constituents For The composite Materials. The Weights Of The Various Components Taken for Two Samples as Shown in the Table 2.1.

Sample no	Al (gm)	Sic(gm)	Mg (gm)
1	1000	5	6.5
2	1000	10	12

Table 2.1 Percentage of weights of Aluminium, Silicon Carbide and Magnesium

The Electric arc Furnace is switched on before Five Hours of Starting of the Melting process in order to reach at a Temperature of 650℃. After observing the Temperature of the Furnace On the Temperature Indicator Fitted With The Furnace small pieces of the Aluminium Sheets are put in the Furnace. Then The Temperature is Maintained at 700℃ to Melt The Aluminium Completely. After That The Silicon Carbide And Magnesium Powder are added to the Molten Aluminium to Prepare the mixture of different constituents. Then a temperature of 800℃ is maintained inside the Melting Chamber of the Electric Arc Furnace, in order to ensure the proper mixing of the Three Constituents. Now The Molten Metal Is Ready To be Poured Into The Mould Cavity.

Sand Casting, Mould and Mould Cavity

The Composite bars are formed by using the Sand Casting Process. The right proportion of sand and soil are mixed together to prepare the Mould. To increase the Elasticity Property of the soil the Bulk Clay Is Added. Then The Wooden Mould Box is filled with sand above the sand and soil mixture. To make the mixture very tight Rammer, Strike of the bar for label of the soil and Hammer are used. The Figure of the Mould is Shown in Figure 2.2. A pattern of 180mm long and 27mm diameter is used to make the mould cavity. The Mould Cavities and the Gate System are created by Compacting the sand around the Patterns inside the Wooden moulding Box.

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Ladle and Pouring of Molten Metal

After Preparation of the mould cavity the molten metal is stirred and transferred into the Mould Cavity. For this Purpose a Stainless Steel Oval Ladle is used. First the Pattern is Removed and the molten metal is taken from the Melting Chamber and poured into the mould cavity as quick as possible to avoid the incomplete fill up of the Mould Cavity. This Process is shown in figure 2.3. This Process is repeated till the required shape and size of the bar is formed.

Solidification

After pouring of the mixture of Molten Metal Into the Mould Cavities, it is allowed to cool to room temperature for Solidification of The Molten Metal. If the solidification is not proper then internal cracks may appear in the composite bar. When the solidification process over then the solid forms of the composite bars are formed in the mould cavity. Then the mould caviyies are broken and composite bars are removed. The Final casting product of composite bars are shown in figure 2.4.

Figure 2.1. Electric Arc Furnace For Preparation Of Molten Metal

Figure 2.2. Patterns for Producing Mould Cavities

Figure 2.3. Pouring of Molten Metal Into The Mould Cavity

Figure 2.4. Final Product Of Composite Bar of Sand Casting Process

III. CHARACTERISATION

In this chapter the formed composite of Aluminium, Silicon Carbide and Magnesium have been under gone a series of tests. These tests includes X-Ray Fluorescence Test, Hardness test, Tensile Test And Compression Test. These tests are conducted by the equipment present in the laboratory. The details of Each Test are described in the following sessions.

X-Ray Fluorescence Test

Before fabricating the composite material of Al-SiC-Mg the pure forms of the constituents of the composite are taken. But these parent materials are pure or not is examined by using this X-Ray fluorescence test. This test provides us the information regarding the true chemical compositions of the formed composite material.

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X-ray fluorescence (XRF) is the emission of characteristic "secondary" (or fluorescent) X-rays from a material that has been excited by bombarding with high-energy X-rays or gamma rays. The phenomenon is widely used for elemental analysis and chemical analysis, particularly in the investigation of metals, glass, ceramics and building materials, and for research in geochemistry, forensic science, archaeology and art objects such as paintings and murals.

To conduct this test two sample specimens have been cut from the two composite bars. After testing the two prepared samples of the composite material the different elements with their percentage of sample 1 and sample 2 have been observed. Figure 3.1 shows the XRF testing machine.

From the test it is observed that the specimen 1 contains 88% of Aluminium, 4.3% of Silicon Carbide and 4.8% of Magnesium. Similarly specimen 2 contains 88% of Aluminium, 8.7% of Silicon Carbide and 9.4% of Magnesium.

Figure 3.1. XRF testing machine

Hardness Test

Hardness is one of the most important Mechanical Properties of the Metals. Different Properties Such as resistance to wear, scratching, deformation and machinability etc depends upon the Hardness of the material. The hardness is usually expressed in numbers which are depedent on the method of making the test. In this test the Rockwell Hardness Testing machine is Used.

Rockwell Hardness Test

The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload. There are different scales, denoted by a single letter, that use different loads or indenters. The result is a dimensionless number noted as HRF, where the last letter is the respective Rockwell scale (shown below). When testing metals, indentation hardness correlates linearly with tensile strength. This important relation permits economically important non-destructive testing of bulk metal deliveries with lightweight, even portable equipment, such as hand-held Rockwell hardness testers.

To conduct this test two sample specimens of diameter 25mm and thickness 5mm have been cut from the composite bars. Here the ball point indenter with diameter 1.5875mm has been considered for indentation. After testing sample 1 and sample 2 the hardness values obtained are presented in the table 3.1.

Sample no	Composition	Hardness (HRF)
1	88%Al-4.3%Sic-4.8%Mg	54.2
2	88%Al-8.7%Sic-9.4%Mg	64.2

Table 3.1.Hardness Values of Two Specimens

From the hardness test it is observed that with increase in Sic And Mg Percentage in the composite material hardness value also increases. The Rockwell Hardness testing machine is shown in figure 3.2 and figure 3.3.

Figure 3.2 Hardness of specimen 1

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Figure 3.3 Hardness of specimen 2 Rockwell Hardness Testing Machine

Tensile Test

Tensile test is very important as it provides the information regarding tensile strength of the metal to withstand the tensile load without failure. It also provides some critical measurements like Ultimate Tensile Strength, Strain, Young's Modulus and Percentage of Elongation at breaking point.

The tensile test of both the specimens is conducted on universal testing machine as shown in figure 3.4. The dimensions of the specimens are measured using vernier caliper. In the software is set to the tensile test mode provided on the graphical display on computer. Then the specimens are fixed up in between upper cross head and lower cross head with the help of jaws on the loading side. The required data of specimens are feed in the controller. During the test the required data is measured and noted till the specimens are break. The Breaking of The Specimen is shown in Figure 3.5.

Figure 3.4. Universal Testing Machine

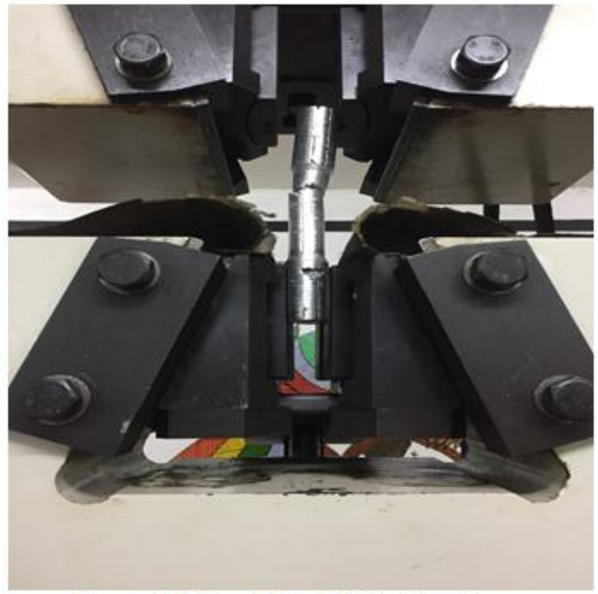

Figure 3.5. Breaking Of The Specimen

The Figure 3.6 and Figure 3.7 represents the Stress-Strain Curve obtained From Tensile Test of Specimen 1 and Specimen 2.

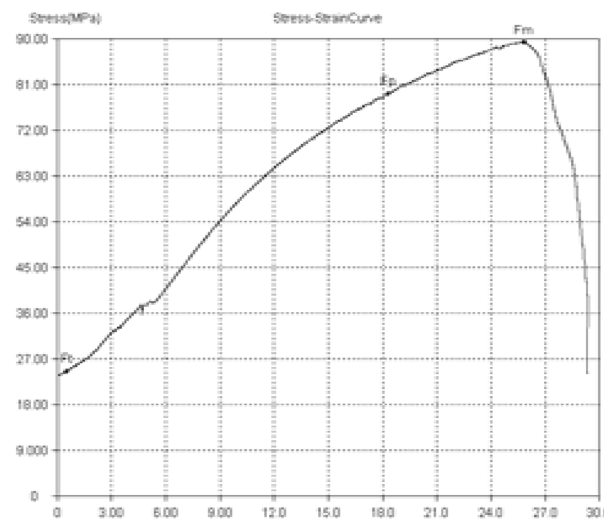

Figure 3.6. Stress-Strain Diagram For Specimen 1 from Tensile Test

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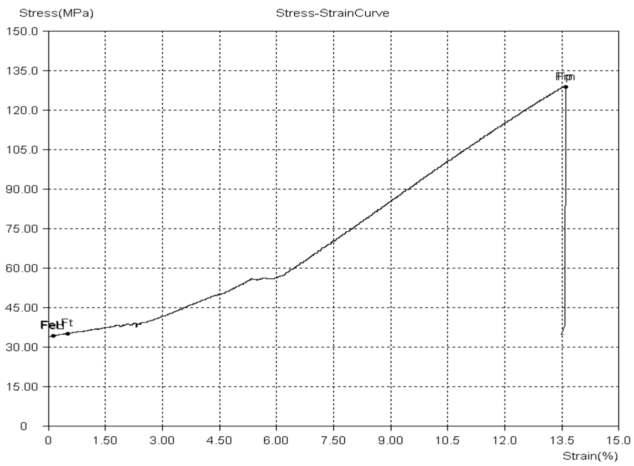

Figure 3.7. Stress- Strain Diagram for specimen 2 from Tensile Test

The Young's Modulus obtained for Tensile Test of both the specimens are shown in table 3.4.

Specimen no	Test	Composition	Young's Modulus (MPa)
1	Tensile	88%Al-4.3%Sic-4.8%Mg	10.7
2	Tensile	88%Al-8.7%Sic-9.4%Mg	25

Table 3.4Young's Modulus from Tensile Test

From the table it is observed that the Young's modulus of specimen 2 is more than specimen 1 due to presence of more Silicon Carbide which decreases the Elasticity property of the composite material.

Compression Test

The compression is also important as it determines the behaviour or response of a material while it experiences a compressive load. Some fundamental variables such as Stress, Strain and Deformations are also measured.

The Compression Test Is also carried out by using the Universal Testing Machine. The Figure 3.9 and figure 3.10 shows the stress –Strain Diagram obtained from the compression test of the specimen 1 and specimen 2 respectively.

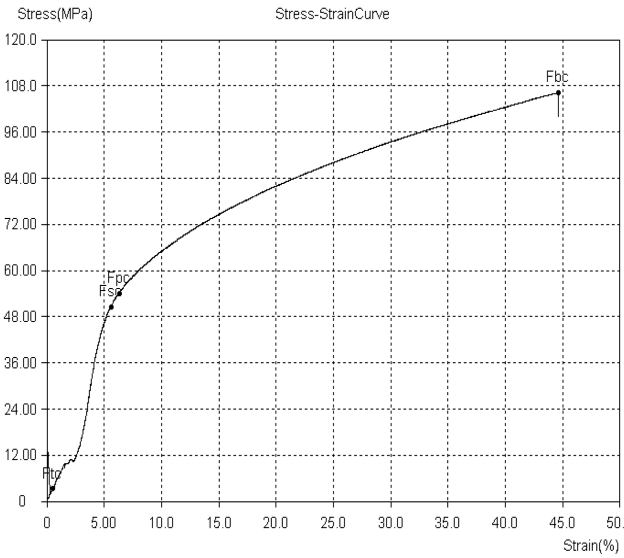

Figure3.9. Stress-Strain Diagram from Compression Test of specimen 1.

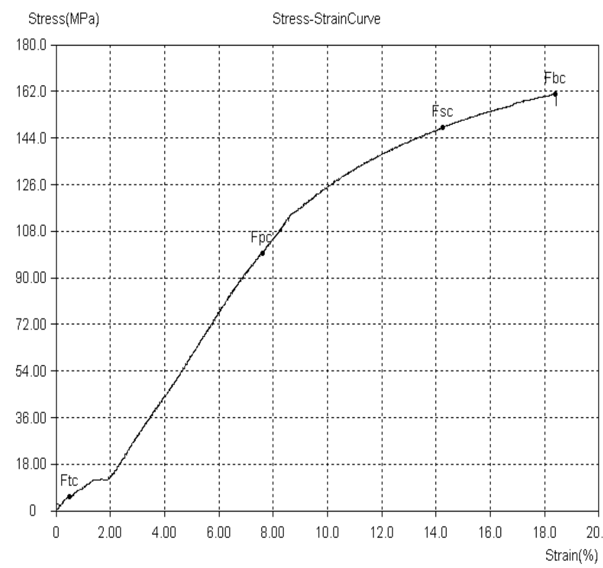

Figure 3.10 Stress- Strain Diagram from Compression Test of specimen 2

The Young's Modulus Obtained for the sample 1 and sample 2 are shown in table 3.5.

Specimen no	Test	Composition	Young's Modulus (MPa)
1	Compression	88%Al-4.3%Sic-4.8%Mg	9.12
2	Compression	88%Al-8.7%Sic-9.4%Mg	12.19

Table3.5. Young's Modulus From Compression Test

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From the table it is observed that Young's Modulus of specimen 2 is more than specimen 1 due to presence of more Silicon Carbide which decreases the Elasticity of the Composite.

IV. ELECTRICAL DISCHARGE MACHINING (EDM)

In this chapter the fabricated Al-SiC-Mg Composite Material have been under gone a Non-Conventional Machining Process i.e, Electrical Discharge Machining (EDM). The material removal rate (MRR) and surface roughness (SR) of the Casted composite material with different composition has observed.

The process of Machining Electrically Conductive Materials by using precisely controlled sparks that occurs between an Electrode and a Work Piece in the Presence Of a Dielectric Fluid is Known as Electrical Discharge Machining. It is also Known As Spark Erosion Machining or Spark Machining. Material of the work piece removed due to erosion caused by Electric spark. The Electrical Discharge Machining is classified into various types like Wire EDM, Sinking EDM, Micro EDM, Powder Mixed EDM and Dry EDM.

Working Principle Of Electrical Discharge Machining

Electrical Discharge Machining process is carried out in presence of Dielectric fluid which creates path for discharge. When potential difference is created across the two surfaces of dielectric fluid it gets ionized. An electric spark or discharge is generated across the two terminals. The potential difference is developed by a pulsating direct current power supply connected across the two terminals. One of the terminal is the positive terminal given to work piece and tool is made negative terminal. Two Third of the total heat generated is generated at positive terminal so work piece is given positive polarity. The discharge developes at the location where two terminals were very close. So tool helps in focusing the discharge or intensity of generated heat at the point of metal removal. Application of Focused heat raise the Temperature of Work Piece Locally at a Point, this way two metal is melted and evaporated. Figure 4.1 Shows the EDM machine used for this Test.

Main Components Of EDM

1. Power supply Unit – Used to provide the Direct Current to produce spark between the tool and work piece.
2. Dielectric fluid reservoir, pumps, filters and control valve – Used to supply dielectric to the tool and work piece. The tool and work piece are immersed in dielectric fluid.
3. Work piece holder, Tool holder and table –Used to hold tool and work piece firmly so that the vibrations are reduced.
4. Servo control Mechanism – Used to provide a constant gap between tool and work piece.

This EDM process is highly economical for machining of very hard materials. Also used for broach making, making holes with straight or curved axes and for making complicated cavities. It is widely used for Die Making as complex cavities are to be made in the die making.

Specification Of The Edm Machine Used

MODEL	ZNC25
OPERATING PLATFORM(MM)	28×450
OPERATING GROOVE(MM)	820×500×280
X AXLE RANGE Y AXLE RANGE Z AXLE RANGE	250MM 250MM 250MM
ELECTRIC POLE CARRYING CAPACITY	30 KG
MAXIMUM CAPACITY OF THE OPERATING PLATFORM	200 KG
MAXIMUM DIMENSION(MM)	1920×1480×2010
WEIGHT OF THE MACHINE TOOL	1000KG
MOTOR	3 PHASE, ½ HP, 50 HZ

Table 4.1. Specification of the EDM machine used for this test

Process Parameters Of Electrical discharge Machining

The Electrical Discharge Machining process depends upon mainly on input parameters. Basing upon this input parameters, the output parameters varies.

Process Parameters:

1. Spark on time (Ton): The time duration for which current is allowed to flow per. It is measured in µs. For this test it is 320 µs.
2. Spark off time (Toff): The time duration between each spark . It is measured in µs. For this test 10 µs.
3. Arc gap: The distance between the electrode and work piece. It may be called as spark gap. It is maintained by servo system.
4. Discharge current (Pulse current Ip): It is the most important machining parameter in EDM. It is related to power consumed in EDM.It is measured in Ampere. For this test it is 10 Ampere.
5. Voltage (V): It is the potential difference that can be measure by volt. For this test it is 50 V.
6. Polarity: Polarity is either positive or negative. For higher MRR work piece is connected with positive polarity.
7. Diameter of the electrode (D): It is the Diameter of the Electrode used for Machining. For this test Cu electrode of diameter 10mm is used.
8. Dielectric Fluid: The dielectric fluid acts as an electrical insulator to carry out the spark. It cools down the electrode and also provides the high pressure to remove the eroded metal. Most

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commonly used dielectric fluids are paraffin, de-ionized water, kerosene, and EDM oil etc. For this test EDM oil of GRADE 2 is used.

9. Flushing pressure: This pressure helps in supplying the Dielectric fluid and cleaning the machining zone. For this test the Flushing Pressure of 0.5 kg/cm2 is used .

Performance Parameters

These are the output parameters which is obtained from the EDM basing upon the input parameters.

4.1 Material Removal Rate (MRR)

It is calculated as the ratio of difference of weight of the work piece material before and after the machining to the machining time.

$$MRR\ (gm/min) = \frac{Wi - Wf}{T}$$

Where MRR= Material removal rate in gm/min
Wi= Weight of the work piece before machining in gm.
Wf= Weight of the work piece after machining in gm.
T= Time of machining in Minute.

The table 4.2. contains the details obtained for MRR of specimen 1 and specimen 2 after the EDM.

From the table 4.2. it is observed that the Material Removal Rate (MRR) for the specimen 2 is higher. The material removal rate of the casted composites increases with increase in percentage of Silicon Carbide and Magnesium.

SAMPLE NO.	COMPOSITION	WI (GM)	WF (GM)	T (MIN)	MRR (GM/MIN)
SPECIMEN 1	88%AL-4.3%SIC-4.8%MG	145.9945	144.4593	10	0.154
SPECIMEN 2	88%AL-8.7%SIC-9.4%MG	61.2090	59.628	7	0.226

Table 4.2 MRR of specimen 1 and specimen 2

4.2 Surface Roughness

Roughness plays an important role in determining how a real object will interact with its environment. Generally it is observed rough surfaces usually wear more quickly and have higher friction coefficients than smooth surfaces. Roughness is often a good predictor of the performance of a mechanical component, since irregularities on the surface may form nucleation sites for cracks or corrosion. On the other hand, roughness may promote adhesion.

A roughness tester shows the measured roughness depth (Rz) as well as the mean roughness value (Ra) in micrometers or microns (µm).

Different international standards and surface texture or surface finish specifications recommend the use of different roughness filters. For example, a Gaussian filter often is recommended in ISO standards. Roughness can be measured by manual comparison against a "surface roughness comparator" (a sample of known surface roughness), but more generally a surface profile measurement is made with a profilometer.

A TAYLOR HOBSON roughness checker machine is used to conduct the surface roughness test of the specimen 1 and specimen 2. The figure 4.4 shows the The figure 4.7 shows the waviness profile, average roughness and horizontal distance of the specimen 1 obtained from the roughness test. Similarly other two tests have been conducted on the same surface at different locations of the surface of the specimen 1. The figure 4.8 shows the waviness profile, average roughness and horizontal distance of the specimen 2 obtained from the roughness test. Similarly other two tests have been conducted on the same surface at different locations of the surface of the specimen 2. The average roughness values obtained from the roughness test for both the specimens are listed in the table 4.3.

Specimen	Average roughness			Average
	Observation 1	Observation 2	Observation 3	
1	**1.93**	**1.97**	**2.05**	**1.98**
2	**1.95**	**2.01**	**2.15**	**2.02**

Table4.3. Average roughness of the specimens 1 and 2

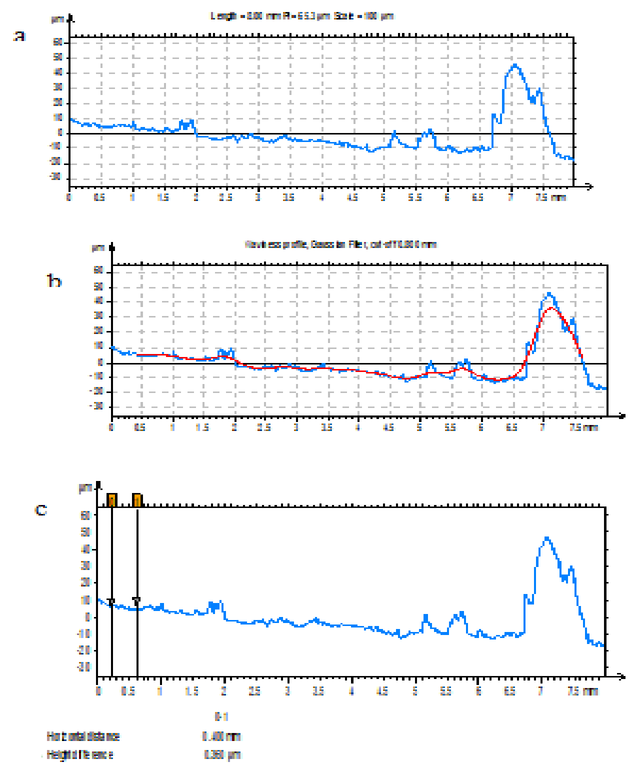

Figure 4.7. (a) Waviness profile of the surface (b) average roughness of the surface and (c) horizontal distance of the specimen 1

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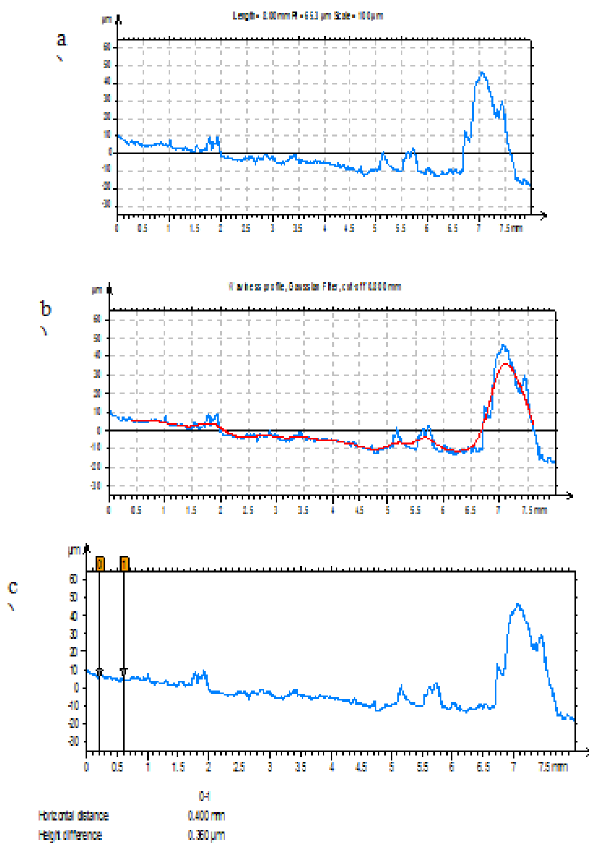

Figure 4.8. (a) Waviness profile of the surface (b) average roughness of the surface (c) horizontal distance of the specimen 2

From the table 4.3. it is observed that the average of roughness average values of specimen 2 is more than that of the specimen 1. It is due to the presence of more percentage of silicon carbide in specimen 2 compare to the specimen 1. With increase in percentage of silicon carbide in Aluminium the hardness of the composite increases.

V. CONCLUSION

After conducting different tests for the casted Al-SiC-Mg Composite material it is concluded that:

1. The hardness of the composite material increased with increase in the percentage of SiC and Mg as the constituents in the composite material. For more hardness the amount of SiC and Mg should be increased.
2. From the tensile test and compression test it is observed that with addition of more amount of SiC and Mg in the composite material, the Young's Modulus of the composite material increases. But the ductility of the composite material decreases. So in order to increases the Young's Modulus the percentage of SiC and Mg should be increased as constituents for the composite material. To increase the ductility of the composite material the amount of SiC and Mg should be reduced.
3. By using the same process parameters like Pulse Current, Voltage, Dielectric fluid and electrode for different compositions of Al,SiC and Mg composite material, it is observed that material removal rate (MRR) is higher for the composite having higher percentage of SiC and Mg .So MRR is depends upon the composition of SiC and Mg percentage.
4. From the surface roughness test it is observed that the composite material containing more percentage of SiC and Mg have more surface roughness average value. It shows that with increase in MRR, the surface roughness also increases. Also with increase in the hardness of the composite material the surface roughness increases.

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