International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 3 Mar. 2021, pp: 1055-1063 www.ijaem.net ISSN: 2395-5252

Experimental Investigation of Effect of Rubber Ash and Molybdenum Disulphide on Al6081 Based Hybrid Mmc

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Submitted: 10-03-2021 Revised: 30-03-2021 Accepted: 01-04-2021

ABSTRACT: Composite materials are substituting the conventional materials, because of their superior properties as they are being used in aeroplane wings, wind blades, automobile industries etc. Hybrid composite is a type of composite having a combination of more than two material. Nowadays hybrid mmc attracts lot of researchers due to its multifunctional features like heat resistance, high specific strength, lower wear rate, light weight. The purpose of the project is to develop a hybrid metal matrix composites by using aluminium Al6081 as base metal and molybdenum disulphate (mos2) and processed silicon rubber ash as its reinforcement metal. And to verify its material properties by conducting various test at varied proportions and obtain result to determine the best composition for the above developed material.

Keyword :AL6081-Molybdenum Disulphide,Rubber Ash.

I. INTRODUCTION

Composite materials (composites) are made when two or more materials with different properties are combined to produce a new material. The physical and chemical properties of each of the constituent materials remain distinct in the new material. These constituent materials work synergistically to produce a composite material that has improved properties when compared with the individual constituent materials. The demands made on materials for better overall performance are so great and diverse that no one material can satisfy them. This led to a resurgence of the ancient concept of combining different materials in an integral composite material system that results in a performance unattainable by the individual constituent, and offers great advantages. Composites are materials in which two phases are combined, usually with strong interfaces between them .

Aluminum matrix composites (AMCs) are emerging as advance engineering materials due to their strength, ductility and toughness. The aluminum matrix is getting strengthened when it is reinforced with the hard ceramic particles like SiC, Al2O3, and B4C etc. Aluminium alloys are still the subjects of intense studies, as their low density gives additional advantages in several applications. These alloys have started to replace cast iron and bronze to manufacture wear resistance parts. MMCs reinforced with particles tend to offer enhancement of properties processed by conventional routes. The alloys primarily utilized today in transport aircraft are 2024-T4 and the alloys having still higher strength (2014-T6, 7075-T6, 7079-T6 and 7178-T6). Aluminium alloy 2024 has good machining characteristics, higher strength and fatigue resistance than both 2014 and 2017. It is widely used in aircraft structures, especially wing and fuselage structures under tension. It is also used in high temperature applications such as in automobile engines and in other rotating and reciprocating parts such as piston, drive shafts, brake- rotors and in other structural parts which require light weight and high strength materials Feng YC et al (2008).

1.1 Objectives Of The Work

- To develop a material with better mechanical characteristics.
- To obtain results of material under different compositions.
- To provide a cost effective alternate to pre-existing metal composites.
- To study the tribological aspect of the composite material.
- To analyze the performance of metal under varied tests

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1.2 Materials And Methods

1.2.1 Aluminium Al6081

Aluminium alloy 6081, one of the most popular alloys in the 6000 series, provides good extrudability and a high quality surface finish. produce 6081 for use in standard architectural shapes, custom solid shapes and heatsinks, as well as seamless and structural tube and pipe. this alloy is often used for electrical applications in the extreme conditions due to its good electrical conductivity. in the heat-treated condition, alloy 6081 provides good resistance to general corrosion, including resistance to stress corrosion cracking. it is easily welded or brazed by various commercial methods . since 6081 is a heat-treatable alloy, it can be used for various industrial applications commercially available. The chemical composition of the matrix aluminium alloy is given in the table .

Table 1: Composition of matrix metal

Con	Cu	Mg	Si	Fe	Mn	Zn	Ti	Cr	Al
%	4.29	1.29	0.07	0.20	0.54	0.03	0.06	0.01	Rem

1.2.2 Molybdenum Disulphide

Molybdenum disulfide (or moly) is an inorganic compound composed of molybdenum and sulfur. Its chemical formula is MoS2.The compound is classified as a transition metal dichalcogenide. It is a silvery black solid that occurs as the mineral molybdenite, the principal ore for molybdenum. MoS_2 is relatively unreactive. It is unaffected by dilute acids and oxygen. In appearance and eel, molybdenumdisulfide is similar to graphite. It is widely used as a Dry lubricant because of its low friction and robustness. Bulk MoS_2 is a diamagnetic, indirect bandgap semiconductor similar to silicon, with a bandgap of 1.23 eV. Molybdenum disulfide (MoS_2) is a ubiquitous solid lubricant along with graphite. These two materials have been used for decades and centuries, respectively, and the concept that they reduce friction because of their intrinsic two-dimensional nature has long been widely appreciated.

1.2.3 Rubber Ash

Disposal of rubber tires is an environmental challenge in many countries. Recently we introduced a new technology to use rubber as a source of zinc (Zn) for crops. According to the previous results, rubber particles size is a key factor determining the rate of nutrient release from the rubber wastes. In this study, nano-particles were prepared from waste tire rubber by applying different treatments. The suitable approach for the preparation of nano-particles from waste tire rubber was milling them inside ball mill for 5 h in the presence of silicon wastes.

Table2. Chemicalcompositionofrubberash.

Material	Rubberash
CarbonDioxide,CO_2(%)	0.10
SulfurTrioxide SO_3(%)	16.90
SiliconDioxide SiO_2(%)	12.70
Calciumoxide,CaO(%)	3.54
Iron(III)OxideFe_2O_3(%)	1.38
Aluminiumoxide,Al_2O_3(%)	0.51
Pottassiumoxide,K_2O(%)	0.36
Bromine,Br(%)	0.34
Copper(II)Oxide,CuO(%)	0.21
Chlorine,Cl(%)	0.19

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Cobalt(II)Oxide,CoO(%)	0.14
Carbon,C(%)	—
TitaniumDioxide,TiO_2(%)	—
ZirconiumDioxide,ZrO_2(%)	—
ZincOxide, ZnO(%)	14.60

Table3 .Compositionofsamples.

Sample	RubberAsh (%wt.)	MoS_2 (%wt.)	Al6061 (%wt.)
1	3	3	96
2	5	3	92
3	7	3	90
4	3	5	92
5	3	7	90

1.2.4 Method

In stir casting we use stirrer to agitate the molten metal matrix. The stirrer is generally made up of a material which can withstand at a higher melting temperature than the matrix temperature. Generally graphite stirrer is used in stir casting. The stirrer is consisting of mainly two components cylindrical rod and impeller. The one end of rod is connected to impeller and other end is connected to shaft of the motor. The stirrer is generally held in vertical position and is rotated by a motor at various speeds. The resultant molten metal is then poured in die for casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement.

Factors Affecting Process

1. Speed of stirring
2. Time duration of stirring
3. Stirring temperature

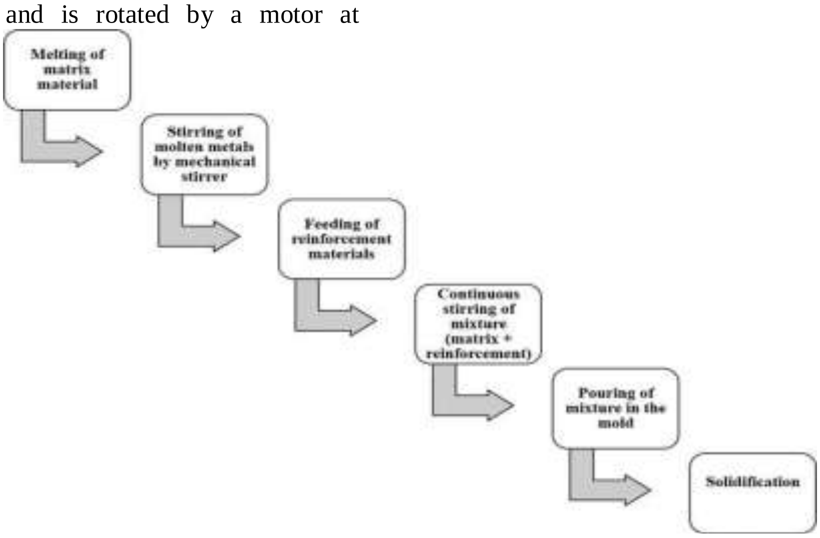

Fig.1 Fabrication Flow Chart

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II. FABRICATION PROCEDURE

The step by step procedure for making composite plates is presented as follows

- Rubber ash and molybdenum disulphide are preheated to 300°C and 800°C in a ceramic crucible inorder to remove any type of water vapour content in the reinforcement material,
- Using a muffle furnace Al6081 was melted in a graphite crucible at 700°C meanwhile degassing agents, flux was added to improve proper mixing of materials
- After the melting of aluminium, Now the preheated rubber ash and molybdenum disulphide are added in the respective weight combinations as shown in table below into the aluminium melt.
- After adding the reinforcement materials , it is stirred well using a graphite rod at 1000rpm.
- Now the reinforced aluminium melt is poured into mould of required Size and shape.

III. COST CALCULATION

Material Cost

Aluminium Al6081 (2 kg) =Rs.555.
Molybdenum Disulphide MoS2 (150g) =Rs.4362.
Rubber Ash (200g) =Rs.2788. **Casting Cost**
Casting =Rs.6000.

Machining& Testing Cost

Tensile Test =Rs.1820.
Hardness Test =Rs. 1410.
Sem Test =Rs. 5000.
Wear Test =Rs. 2340.
Corrosion Test =Rs. 1260.
Total Cost =Rs. 25,535.

Table.2 Volume Of Composition Materials

Sample	Volume of Al2O3 (cm^3)	Volume Of MoS2 (cm^3)	Volume Of Rubber Ash (cm^3)
A	149.646	4.775	4.775
B	146.462	4.775	30.247
C	143.278	4.775	11.143
D	146.462	7.959	4.775
E	143.278	11.143	4.775

Table.3 Mass Of Composition Materials

Sample	Mass of Al2O3 (gms)	Mass Of MoS2 (gms)	Mass Of Rubber Ash (gms)
A	404.044	24.162	18.145
B	395.447	24.162	30.247
C	386.851	24.162	42.346
D	395.447	40.277	18.145

E	386.851	56.387	18.145

IV. TESTING

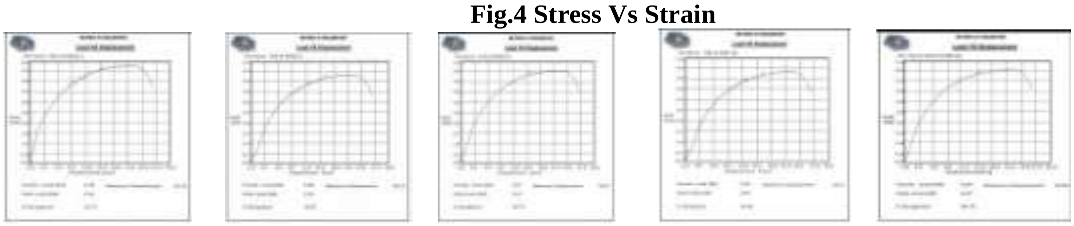
4.1 Tensile Test

Sample A **Sample B** **Sample C** **Sample D** **Sample E**

Fig.3 Tensile Specimen

Sample A **Sample B** **Sample C** **Sample D** **Sample E**

Fig.4 Stress Vs Strain



Sample A **Sample B** **Sample C** **Sample D** **Sample E**

Fig.5 Load Vs Displacement

TABLE.4 STRESS VS STRAIN

Sample	Max Strain (%)	Tensile Strength (mpa)
A	87.17	193.81
B	87.37	203.89
C	88.57	212.76
D	89.03	224.87
E	90.07	237.76

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4.2 Sem Test

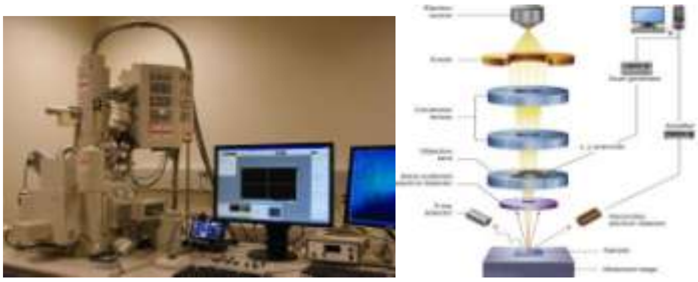
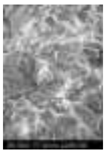
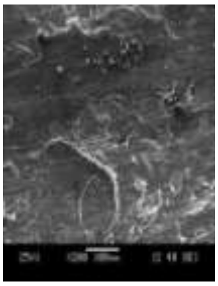
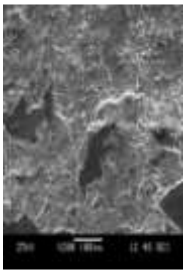


Table.5 Scanning Electron Microscope

D







ABC1

E

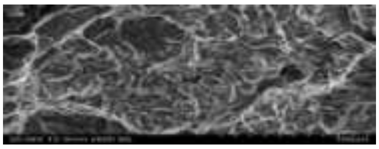


Fig.6 Sem Image Of Samples

4.3 HARDNESS TEST

Fig.7 Hardness Testing Machine

Hardness test were carried out on the composite metal samples by using standard Rockwell hardness test machine. Rockwell hardness measurements were carried out in order to investigate the influence of particulate weight fraction on the matrix hardness. Load applied was 1 kg and indenter used was 1/16'.

Table.5 Hardness Value

SAMPLE	H.V @ 1Kg LOAD
A	**45.3**
B	**53.2**
C	**61.7**
D	**63.3**
E	**72.4**

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4.4 CORROSION TEST

Five aluminium composite specimen was subjected to salt spray corrosion test as per ASTM B117-14.

The sample was loaded in the chamber for 24 hours and the details are given below,

- Humidity: 98% as measured by hygrometer during the test.
- Temperature of the test: 33 Degrees centigrade (continuously indicated).
- Pressure of Air for atomizing: 2 to 3 bar continuously by pressure oregulator
- Composition of the salt solution: For 1 liter of solution.

1% of Magnesium chloride 94% of De-ionized water

- pH of the solution: Maintained at 7.2 by addition of buffer solution.
- Measurement of pH: Measured once in 8 hours.

The tool after cleaning with organic solvents and degreasing solution washed with distilled water dried and weighed. The initial weight before loading and the final weight after 24 hours exposure were measured and given below.

Table.6 Corrosion Rate Values

Sample	Initial Weight (gms)	Final Weight (gms)	Weight Loss (gms)	Loss In Mils Per Year
Sample A	5.971	5.950	0.021	0.00051
Sample B	5.982	5.965	0.017	0.00042
Sample C	5.987	5.972	0.015	0.00033
Sample D	5.994	5.981	0.014	0.00027
Sample E	5.995	5.984	0.011	0.00019

4.5 WEAR TEST

Sample A Sample B Sample C Sample D Sample E

Fig.8 Wear Specimen

4.5.1WEAR RATE CALCULATION

Wear rate is calculated by using the following equation,

W.R=(WL)/2*π*r*n*t

Whereas, wl = weight loss (gms), n = sliding speed (rpm), r =radius of specimen (mm)

t =time of machining (min), by using the above formula we calculate the wear rate values of the samples as follows

Samples	Wear Rate(G/Min)
A	0.00146780
B	0.00157258
C	0.00168326
D	0.00011327
E	0.00095659

Table.7 Wear Rate Of Samples

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V. RESULTS AND DISCUSSION

- **Tensile Test** The tensile test conducted on composite metal sample reveals that the tensile strength increases with increase in the percentage of molybdenum disulphide and the highest tesnsile strength in achieved at 7% of molybdenum of 237.76mpa, the reinforcements are added, the particulate reinforcements form greater bonding which results in greater number of grain formation. Thus the movement is restricted further, which results in greater strength. The increased tensile strength is due to the grain refinement and strong multidirectional bond. The samples are tested by UTM under ASTM standards and the tensile strength increases with increased MoS_2 reinforcement thus changing from 3%,5%,7%.

- **Sem Analysis** The morphology, density, type of reinforcing particles and its distribution have a major influence on the properties of particulate composites.The specimens were prepared for microstructure analysis by thoroughly polishing and etching. Then the specimens were observed under an optical microscope for studying the microstructure. The optical micrograph is shown in fig 6.2.3 which shows the even dispersion of the reinforcement in the matrix is high for molybdenum samples due to its high density face and better bonding than that of high rubber ash content samples.

- **Hardness Test** The tests revealed that, the hardness of the composite specimen had increased gradually with increase in the wt. % of MoS_2 powder incorporated in the metal matrix up to 7% wt .The transfer of load from the softer matrix to the harder rubber ash particulates offers more resistance to plastic deformation the increament in hardness is due to lesser porosity does not possess any hardness and contributed to overall hardness improvement.

- **Corrosion Rate** The corrosion rate of the material decreases with increased amount MoS_2 content of the material . This is due to the high concentration molybdenum disulphide due to its better density and form micro insulation property due to which the corrosion rate of the material gets improved with percentage of 5%,7% of $MoS_{2.}$

- **Wear Property** The wear test is conducted on a specimen in which the wear roller is meant to roll at a certain rpm at a cumulative time frame time frame with that of the certain load it is seen that the wear rate is high for silica rubber ash particle which is due to its high grain structure and lowest for the molybdenum component due to its better cohesity and adherence to one another.

VI. CONCLUSION

Aluminium al6081 composite have been prepared using molybdenum disulphide and processed silicon rubber ash as reinforcement materials using stir casting process. reinforcements are added at five different proportions by which various test samples have been obtained and they are subjected to various mechanical and tribological tests .and the result obtained are as follows.

- The tensile strength of al 6081with 7% mos2 showed highest value.
- The hardness was found to be the maximum MoS_2 composite compared to that of rubber ash samples
- The sem image reveals that the MoS_2 particles were well distributed in the aluminium matrix due to less porosity and better bonding capability within the fine grain level.
- Corrosion samples are etched and places in a salt solution and the corrosion rate of each sample are verified and the sample with less reinforcement is subjected to higher corrosion.
- The wear rate of the material is tested by applying abrasive wear material to that of the sample one and it is found out that sample E is found to be wear resistance

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