International Journal of Engineering and Applied Sciences (IJEAS)
ISSN: 2394-3661, Volume-4, Issue-5, May 2017

# Study Of Mechanical Properties Of Aluminium Lm25 Using Stir Casting Method

**A.balamurugan, G.Dhanasekar, T.kanagasabai, M.Mohamed Faiyas**

***Abstract*— The present study deals with the behaviour of aluminium hybrid alloy based composites, reinforced with fly ash particles and solid lubricants such as activated carbon .The first one of the composites consists of Al. with fly ash particles and activated carbon. The other composite has Al with fly ash and solid lubricant: activated carbon at solid state. Both composites are fabricated through 'Stir Casting Method'. Mechanical properties of the samples are measured by usual methods such as Hardness,Tensile .The tested samples are examined using Scanning Electron microscope (SEM) for the characterization of microstructure on the surface of composites. The Main Aim is to be results of the proposed Hybrid composites are compared with Al based metal matrix composites at corresponding values of test parameters.**

***Index Terms*—aluminum, SEM, SCM, MMC**

## I. INTRODUCTION

Composite materials are engineering materials made from two or more constituent materials that remain separate and distinct on a macroscopic level while forming a single component. There are two categories of constituent materials: matrix and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. A synergism produces material properties unavailable from the individual constituent materials. Due to the wide variety of matrix and reinforcement materials available, the design potentials are incredible.

The physical properties of composite materials are generally not isotropic in nature. For instance, the stiffness of a composite panel will often depend upon the directional orientation of the applied forces or moments. In contrast, an isotropic material has the same stiffness regardless of the directional orientation of the applied forces or moments. The relationship between forces/moments and strains/curvatures for an isotropic material can be described with the following material properties like Young's Modulus, the Shear Modulus and Poisson's Ratio.

**TABLE 1. FOR THE SAMPLE COMPOSITIONS**

| SAMPLE | AL ALLOY LM 25 (%) | FLY ASH(%) | A.CARBON(%) |
|---|---|---|---|
| A | 99 | 0.5 | 0.5 |
| B | 98 | 1 | 1 |
| C | 97 | 1.5 | 1.5 |

**A.balamurugan, G.Dhanasekar, T.kanagasabai, M.Mohamed Faiyas,** Mechanical Engg, MRKIT, Cuddalore India

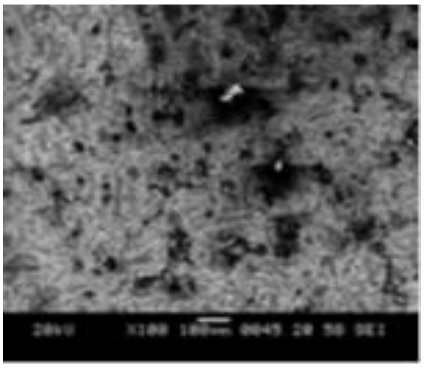

**Fig.1.1. Microstructure of Al 6061 with 15% weight fraction of fly ash (4-25 micron)**

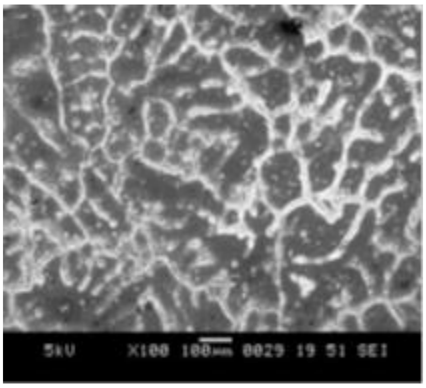

**Fig 1.2 Microstructure of Al 6061 with 20% weight fraction of fly ash (45-50 micron)**

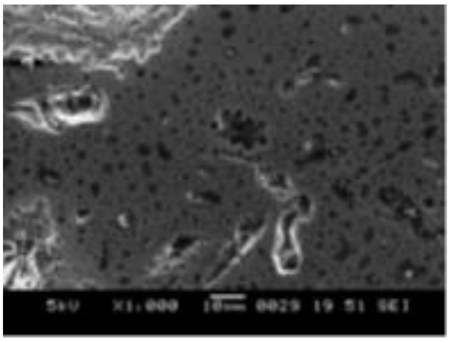

**Fig 1.3 Microstructure of Al 6061 with 10% weight fraction of fly ash (75-100 micron)**

**TYPES OF COMPOSITES**

- Fibrous composites
- Laminated composites
- Particulate composites

## II. REINFORCEMENTS:

MMC reinforcements can be divided into five major categories namely continuous fibers, discontinuous fibers, whiskers, particulates, and wires. With the exception of wires, which are metals, reinforcements generally are ceramics. Key continuous fibers include boron, graphite (carbon), alumina, and silicon carbide. Boron fibers are made by chemical vapor deposition (CVD) of this material on a tungsten core. Carbon cores have also been used. These relatively thick monofilaments are available in 4.0, 5.6, and 8.0-mil diameters. To retard reactions that can take place between boron and metals at high temperature, fiber coatings of materials such as silicon carbide or boron carbide are sometimes used.

Silicon carbide monofilaments are also made by a CVD process, using a tungsten or carbon core. A Japanese multifilament yarn, designated as silicon carbide by its manufacturer, is also commercially available. This material, however, made by pyrolysis of organo metallic precursor fibers, is far from pure silicon carbide and its properties differ significantly from those of monofilament silicon carbide.

Continuous alumina fibers are available from several suppliers. Chemical compositions and properties of the various fibers are significantly different. Graphite fibers are made from two precursor materials, polyacrilonitrile (PAN) and petroleum pitch. Efforts to make graphite fibers from coal-based pitch are under way. Graphite fibers with a wide range of strengths and moduli are available.

The leading discontinuous fiber reinforcements at this time are alumina and alumina-silica. Both originally were developed as insulating materials. The major whisker material is silicon carbide. The leading U.S. commercial product is made by pyrolysis of rice hulls. Silicon carbide and boron carbide, the key particulate reinforcements, are obtained from the commercial abrasives industry. Silicon carbide particulates are also produced as a by-product of the process used to make whiskers of this material.

A number of metal wires including tungsten, beryllium, titanium, and molybdenum have been used to reinforce metal matrices. Currently, the most important wire reinforcements are tungsten wire in superalloys and superconducting materials incorporating niobium-titanium and niobium-tin in a copper matrix. The reinforcements cited above are the most important at this time. Many others have been tried over the last few decades, and still others undoubtedly will be developed in the future. Composite material is the material having two or more distinct phases like matrix phase and reinforcing phase and having bulk properties significantly different from those of any of the constituents present in the matrix material. Composite materials are preferred over other metals and non metals because of some favorable properties they are having.

The favorable properties are, high stiffness and high tensile strength, low density, high temperature stability, and also in some of the applications electrical and thermal conductivity properties are also taken into consideration, the properties like coefficient of thermal expansion, corrosion resistance are also low with improved wear resistance. To improve fuel efficiency in automobiles the bodies are manufactured with the composite materials, So that the automobile body mass can be kept low by improving fuel efficiency. Nano carbon fiber reinforced aluminium composites are already in use. Mainly aluminium composite materials are having more scope because of its light weight and availability on earth. Because of all these possibilities with the aluminium composites the related studies are always on and our study is one among them. In every study the base material properties are altered by adding some reinforcements the resulted properties are analyzed and based on the properties, suitable application areas are suggested.

### 1.5.9 TYPES OF REINFORCEMENTS USED:

The three different types of reinforcements used in the project are

- LM 25
- Fly ash
- Activated carbon

Further the base metal used in the project is an alloy of Aluminum namely LM 25.

The results of an experimental investigation of the mechanical properties of fly ash and Alumina reinforced aluminium alloy (LM25) composites samples, processed by stir casting route are reported in this paper. Three sets of composites with constant weight fraction of fly ash (particle size of 3-100 µm) and Al2O3(particle size of 150 µm) with different wt% were used. Composite samples have the reinforcement weight fractions of constant 3% fly Ash and varying %wt of 5, 10 and 15% Al2O3 . The main mechanical properties studied were the tensile strength,ductilityimpact strength & hardness. Unreinforced LM25 samples were also tested for the same properties. It was found that the tensile strength & hardness of the aluminium alloy (Lm25) composites increases with the increase in %wt of Al2O3 upto certain limit. in addition of more amount of reinforcement the Tensile strength decrease due to poor wettability of the reinforced material with metal aluminium matrix .And the charpy test shows decrease in impact load absorption with increase in %weight reinforcement.The Microstructure study of the samples indicated near uniform distribution of the fly ash and Al2O3 particles in the matrix. LM25 alloy is mainly used where good mechanical properties are required in castings of a shape or dimensions requiring an alloy of excellent castability in order to achieve the desired standard of soundness.The alloy is also used where resistance to corrosion is an important consideration particularly where highstrength is also required.

### 1.5.10 ALUMINIUM LM25

Table 1.1:Aluminum LM 25(Al-Si7 Mg) means the composition (in%wt) of

| Cu | Si | Mg | Fe | Mn | Ni | Zn | Pb | Sn | Ti | Al |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.20 | 7.50 | 0.6 | 0.50 | 0.30 | 0.10 | 0.10 | 0.10 | 0.05 | 0.2 | Balance |

### 1.5.11. FLY ASH

Fly ash, also known as "pulverized fuel ash" in the United Kingdom, is one of the Coal combustion products, and is composed of the fine that are driven out of the boiler with the flue gases. Ash that falls in the bottom of the boiler is called bottom ash. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys ofcoal-fired power plants, and together with bottom ash removed from the bottom of the boiler is known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO2) (both amorphous and crystalline), aluminum oxide (Al2O3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.

Constituents depend upon the specific coal bed makeup, but may include one or more of the following elements or substances found in trace concentrations (up to hundreds ppm): arsenic, beryllium, boron, cadmium, chromium, hexavalent chromium, cobalt, lead,manganese, mercury, molybdenum, selenium, strontium, thallium, and vanadium, along with very small concentrations of dioxins.

In the past, fly ash was generally released into the atmosphere, but air pollution control standards now require that it be captured prior to release by fitting pollution control equipment. In the US, fly ash is generally stored at coal power plants or placed in landfills. About 43% is recycled, often used as a pozzolan to produce hydraulic cement or hydraulic plaster and a replacement or partial replacement for Portland cement in concrete production. Pozzolans ensure the setting of concrete and plaster and provide concrete with more protection from wet conditions and chemical attack.

Cementitious high carbon fly ash (CHCFA), a byproduct of coal-burning power plants, has self-hardening properties in the presence of moisture, but cannot be used in concrete paving since the high carbon content absorbs air in the concrete and affects durability. The current practice is to dispose of this fly ash in a landfill. However, laboratory testing and limited field trials have shown high carbon fly ash to be a viable stabilizing material for unbound layers in highway construction projects.

Mn/DOT entered into a partnership with Bloom Consultants to evaluate the long term engineering and environmental characteristics of fly ash stablized base materials and compare these to the performance of non-stabilized materials. To this effect three 375-ft test cells were constructed at MnROAD in 2007 including the following base types with a 4" HMA surface:

Cell 77 – Full depth reclamation of 50% HMA + 50% Class 4 gravel (non-stabilized)

Cell 78 – Class 6 crushed stone aggregate base (from on-site stockpile)

Cell 79 – Full depth reclamation of 50% HMA + 50% Class 3 gravel (stabilized with 14% CHCFA)

Construction Details

Stabilization of the reclaimed base with fly ash was completed in early August, following a precise sequence of events to ensure proper mixing and uniformity throughout the test cell. Mn/DOT waited one month prior to paving the test cells because of a separate agreement with an outside asphalt binder supplier. During that time an excessive amount of rain fell at MnROAD, soaking into the exposed base layers. When we attempted to pave Cells 77 and 78 on September 11, the HMA trucks sunk into the base and created ruts in excess of 4" and made it impossible to pave. The fly ash stabilized base showed no such deformation, and paving went on as scheduled. After several weeks of waiting for the rain to stop in order to dry out the base & subgrade, work continued under a Force Account Work Order. The contractor spent 3 days excavating the wet base layer, drying the subgrade, and replacing the base prior to paving on October 25. Field performance under traffic for two years has shown all three test cells to be performing well.

Successes and Concerns

For this project Mn/DOT spent an extra $10,282 per cell on the force account work to dry out the non-stabilized base materials. This is in comparison to the $8,970 for fly ash stabilization, or a 15% cost savings. A major benefit of the use of fly ash was that we were able to save six weeks of construction time by being able to pave immediately on a stable construction platform. Although the force account work will likely not be required on many jobs and although MnROAD paid a premium price for the fly ash because of the small quantity, this project serves as a useful illustration of what can happen in the real world.

The fly ash used for construction contains small amounts of mercury and other heavy metals. Lysimeters were installed in the three cells to collect and monitor leachate generated by water percolating through the pavement. The leaching analysis is ongoing to monitor whether or not trace elements are being leached out of the pavement layers. Several laboratory studies at the University of Minnesota are also investigating the leaching characteristics of fly ash stabilized material.

### 1.4.12 ACTIVATED CARBON

Activated carbon, also called activated charcoal, or activated coal, is a form of carbon processed to have small, low-volume pores that increase the surface area available for adsorption or chemical reactions. Activated is sometimes substituted with active.

Due to its high degree of micro porosity, just one gram of activated carbon has a surface area in excess of 500 m2 (5,400 sq ft), as determined by gas adsorption. An activation level sufficient for useful application may be attained solely from high surface area; however, further chemical treatment often enhances adsorption properties.

Activated carbon is usually derived from charcoal and, increasingly, high-porosity biochar.

One major industrial application involves use of activated carbon in the metal finishing field. It is very widely employed for purification of electroplating solutions. For example, it is a main purification technique for removing organic impurities from bright nickel plating solutions. A variety of organic chemicals are added to plating solutions for improving their deposit qualities and for enhancing properties like brightness, smoothness, ductility, etc. Due to passage of direct current and electrolytic reactions of anodic oxidation and cathodic reduction, organic additives generate unwanted breakdown products in solution. Their excessive build up can adversely affect the plating quality and physical properties of deposited metal. Activated carbon treatment removes such impurities and restores plating performance to the desired level.

## III. EXPERIMENTAL WORK

### 3.1. EXPERIMENTAL PROCEDURE FOR STIR CASTING:

The conventional experimental setup of stir casting essentially consists of an electric furnace and a mechanical stirrer. The electric furnace carries a crucible of capacity 2kg. The maximum operating temperature of the furnace is 1900ºC. The current rating of furnace is single phase 230V AC, 50Hz. The aluminium alloy (LM25) is made in the form of fine scraps using shaping machine. It amounts to about 1150 gm. The metal scraps are poured into the furnace and heated to a temperature just above its liquidus temperature to make it in theform of semi liquid state (around 650ºC). The mixing of aluminium alloy is done manually for uniformity. Then the reinforcement powder that is preheated to a temperature of 600°C is added to semi liquid aluminium alloy in the furnace. Again reheating of the aluminum matrix composite is done until it reaches complete liquid state. Mean while argon gas is introduced into the furnace through a provision in it for few minutes. During this reheating process stirring is done by means of a mechanical stirrer which rotates at a speed of 60 rpm. The aluminium composite material reaches completely liquid state at the temperature of about 950°C as the melting point of aluminium is 700ºC. Thus the completely melted aluminium metal matrix composite is poured into the permanent moulds and subjected to compaction to produce the required specimen.

3.2 TEST RESULTS

Figure 3.1 samples A,B,C

3.2.1 SEM-TEST RESULTS

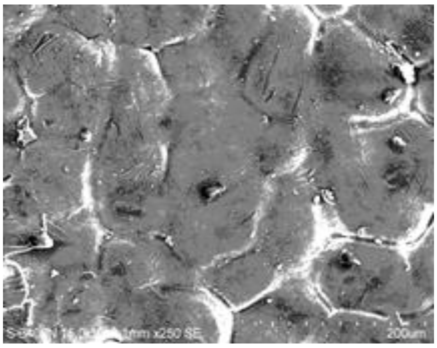

Figure 3.2-SAMPLE A ZOOM-x250

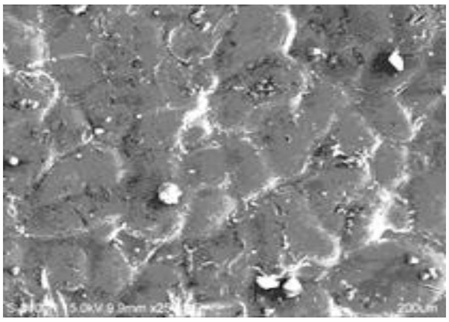

Figure 3.3 SAMPLE B ZOOM-x250

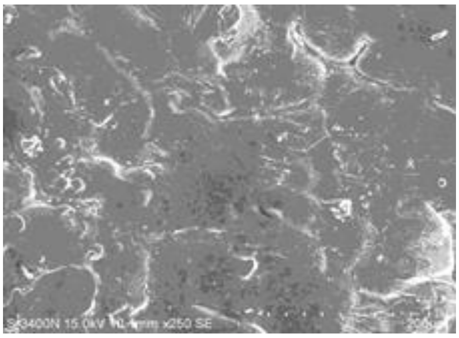

Fig 3.4-SAMPLE C ZOOM-x250

3.2.2 UNIVERSAL TESTING MACHINE RESULT:

| **Sample Identification** | **Observed Value** | | |
|---|---|---|---|
| | Tensile Strength ($N/mm^2$) | Yield Strength ($N/mm^2$) | Elongation (%) |
| Sample A | 277 | 275.7 | 18.2 |
| Sample B | 324 | 283 | 19.5 |
| Sample C | 316 | 279 | 18.4 |

Table 3.1 tensile strength test

Table 3.2 -Result of Wear Test

| **Type of Test** | **Sample ID** | **Observed Value** |
|---|---|---|
| **Wear Test Pin on disc** | Sample A | 0.0046mm3/m |
| | Sample B | 0.0037 mm3/m |
| | Sample C | 0.0039mm3/m |

3.2.3 BRINELL HARDNESS TEST

| **Type of Test** | **Sample ID** | **Observed Value** |
|---|---|---|
| **Brinell Hardness Test** | Sample A | 94.6 BHN |
| | Sample B | 96 BHN |
| | Sample C | 95.8 BHN |

Table 3.3-Result of Brinell Hardness Test

3.3 comparison of LM 25 between samples A,B,C

| SAMPLES | TENSILE STRENGTH ($N/mm^2$) | YIELD STRENGTH ($N/mm^2$) | ELONGATION (%) | WEAR RATE ($mm^3/m$) | HARDNESS (BHN) |
|---|---|---|---|---|---|
| AL LM25 | 250-280 | 230-250 | 5 | 0.007-0.0089 | 90 |
| A | 277 | 275.7 | 18.2 | 0.0046 | 94.6 |
| **B** | **324** | **283** | **19.5** | **0.0037** | **96** |
| C | 316 | 279 | 18.4 | 0.0039 | 95.8 |

Table 3.4 comparison table

## IV. CONCLUSION

The present study deals with the behavior of aluminium alloy based composites, reinforced with activated carbon particles and solid lubricants such as fly ash . Thiscomposites consists of Al with Fly ash and activated carbonare fabricated through ‘Stir Casting Method’. Mechanical properties of the samples are measured by usual methods such as Hardness, Tensile, wear test .The tested samples are examined using Scanning Electron microscope (SEM) for the characterization of microstructure on the surface of composites. The Main Aim is to be results of the proposed Hybrid composites are compared with Al based metal matrix composites at corresponding values of test parameters for next phase.