# EFFECT OF ADDITION MILLED GLASS FIBERS ON TENSILE AND THERMAL PROPERTIES OF METAL MATRIX COMPOSITE

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***Abstract*—The biggest advantage of composite materials is the stiffness and strength and light weight. Metal matrix composites (MMC) are interested in the potential applications of the automotive industry due to their excellent weight ratio. In the present work, an attempt has been developed for the production of aluminum (Al) based milled glass fiber composites in order to produce economical methods for obtaining high strength MMC (metal matrix composite). As the base material used as a matrix aluminum (Al6061 alloy) and milled glass fiber as reinforcement by mixing the preparation of different volume fraction of 2%, 6%, 10%.The cast composite specimens are processed according to the test standard. The mechanical and thermal properties have been evaluated and compared with Al6061 alloy. With the increase in the volume of the glass fiber, a significant improvement in tensile properties. In this observed that decrease in thermal conductivity of metal matrix composites with increase in milled glass fiber.***

***Keywords*— Milled glass fiber, Al6061 alloy composite, MMC's (metal matrix composite), mechanical and thermal properties, stir casting.***

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## 1. Introduction

In response to unprecedented demands from technology due to rapid activities in the field of aircraft, aerospace, automobile industry and transportation and construction, overall material plays an important role in the field of engineering as well as in advance manufacturing. These materials have less specific gravity, which makes their properties especially powerful for many traditional engineering materials such as metals in strength and modulus. These new materials include high performance composites, such as reinforced composites. Continued progress leads to the use of composites in more diverse applications. From the beginning of the 20th century, the early 1940's E glass or phenol random structure to the space shuttle orbit instrument for the development of graphite or polyamide composite materials, advanced composite materials development progress is remarkable. Recognizing the potential weight savings that can be achieved through the use of advanced composites, which means reducing costs and improving efficiency is the reason for this growth in aerospace technology. Over the past two decades, manufacturing methods have improved the physical and fracture mechanics of systematic research in the 1960s. Since then, the aerospace, transportation, automotive and construction industries are increasingly demanding new, more robust, harder and lighter materials. Due to the rapid development of aircraft, aerospace and automotive industry, the emergence of composite materials is mainly due to the unprecedented demand for technology. Due to the low specific gravity of these materials, their properties are particularly excellent in modulus and strength in many conventional engineering materials such as metals. Through in-depth study of the basic properties of materials, a better understanding of its structural properties, can be developed with improved physical and mechanical properties of the new composite materials.

### 1.1 Metal Matrix Composite

Metal matrix composites (MMCs) have turned out as a helpful development which has an extensive variety of utilization. This material gathering can be utilized for functional and constructional purposes in the current era MMCs have created a varied interest in research because of their properties like stiffness, high quality, material toughness and light weight which are far superior when contrasted with the polymer matrix composites (PMCs).Compared with PMC, MMCs has resistant to high temperatures in corrosive atmospheres.

### 1.2 Aluminum alloy 6161

Aluminum alloys are the preferred engineering materials for the automotive, aerospace and mineral processing industries for a variety of high performance components, which are used in a variety of applications due to their light weight and excellent thermal conductivity.Al6061 alloy has a high degree of corrosion resistance, excellent performance, superior performance, in the construction (building and High way) field. Aluminum has been widely used in the field, the car has a large number of aluminum alloy series, the Al6061 and Al7075 heat treatment carried out a lot of exploration, And ship applications.

**Chemical composition**

The alloy composition of 6061 is:

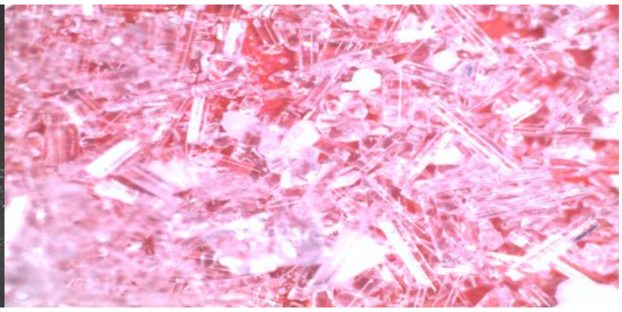
- Silicon, minimum 0.4%, maximum 0.8% by weight.
- Iron, on minimum, maximum 0.7 %
- Copper, minimum 0.15%, maximum 0.40%
- Manganese, minimum, maximum 0.15 %
- Magnesium, minimum 0.8%, maximum 1.2%
- Chromium, minimum 0.04%, maximum 0.35%
- Zinc, on minimum, maximum 0.25 %
- Titanium, on minimum, maximum 0.15%

- Other elements no more than 0.05 % each, 0.15% total
- Remainder aluminum

### 1.3 Milled Glass Fiber

The Milled e-glass fibers are of size 300microns in length and 13.5microns in diameter these are considered as the reinforcement in composite. The properties of these glass fibers are good as per the required application. These fibers are less cost with high strength to weight ratio.


Figure : 1.3 Milled Glass Fiber


Microscopic view of milled e-glass fibers

| Sl. No | Chemicals | Compositions (%) |
|---|---|---|
| 1 | SiO2 | 52-56% |
| 2 | Al2O3 | 12-16% |
| 3 | CaO | 16-25% |
| 4 | MgO | 0-3% |
| 5 | B2O3 | 8-13% |

Table: 1.1 Chemical composition of milled e-glass fibers.

| Sl. No | Tensile Strength(kg/$mm^2$) | 28000-38000 |
|---|---|---|
| 1 | Elastic coefficient (kgf/$mm^2$) | 7400 |
| 2 | Specific gravity | 0.756 |
| 3 | Softening temperature(◦c) | 845 |
| 4 | Index of refractive (nd) | 1.55 |
| 5 | Thermal conductivity($10^{-3} Ca/ms{\circ}C$) | 2.48 |
| 6 | Elongation percentage (%) | 4.8 |
| 7 | Coefficient of linear expansion ($10^{-6}/{\circ}c$) | 4.9 |
| 8 | Specific heat (Cal/g$\circ c$) | 0.19 |

Table: 1.2 Average properties of milled e-glass fibers.

## 2. Literature Review

**Arun Kumar M. B and R. P. Swamy(May 2011)**

Flyash-eglass-Al6061alloycomposites having 2wt%, 4wt%, 6wt% and 8wt%of fly ash and 2wt% and 6wt% of e-glass fiber were fabricated by liquid metallurgy. The casted composite specimens were machined as per test standards. Significant improvement in tensile properties, compressive strength and hardness are noticeable as the wt% of the fly ash increases. [1]

**Paul Philip and Layi Fagbenle (September 2014)**

In this research paper thermal properties are essential property of material for designing and determination of materials of insulation. In this paper they have determined the thermal conductivity of insulating materials and compared with the available values of other. [2]

**Liu Jiang (2011)**

In this paper, the casting process and device optimization of Al3Fe/Al in-situ composites formed by Al-Fe stirring casting were studied. The results can help technology designers shorten the development time and cost of new products, similar to the solid-liquid stir casting method to form Al3Fe/Al in situ composites.[3]

## 3. Methodology

The methodology adopted to carry out the project is as follows:

- Material selection
- Composite fabrication (Stir Casting)
- Mechanical and thermal testing.

| Sl. No. | Volume Fractions | Composition |
|---|---|---|
| 1 | 1st | 98% Al 6061 + 2% Fiber |
| 2 | 2nd | 94% Al 6061+ 6% Fiber |
| 3 | 3rd | 90% Al 6061+ 10% Fiber |

Table: 3.Detailed table of MMC's Composition.

**4. Experimental Procedure**

As per the calculation a known quantity of the Al6061 alloy poured into the clay graphite crucible and then it's placed in the casting muffle furnace which is connected with the electric motor. Al 6061 alloy melts under the temperature of $770^0$C. Then the melt was stirred using a mild steel stirrer. When it reaches its melting point we take out the clay graphite crucible from the muffle furnace and poured into the die. The casting die made by high stainless steel as per the required dimensions. As shown in the figure:5.1. We get the matrix(Al 6061 alloy) specimens. The experiment is repeated for 2%,6%,10% of milled glass fibers are mixed in the aluminium composite(matrix).

**5. Specimen Preparation**

The sample is machined from a cylindrical rod casting machine. Each sample was prepared with an X60 mm standard size of 8mm for tensile testing and a 20mm diameter of 20mm for compression testing. The surface of the sample was polished with 1 μm diamond paste. Samples were examined by Keller Reagent Etching Microscopy. The specimen is washed with distilled water, then with acetone and dried thoroughly.

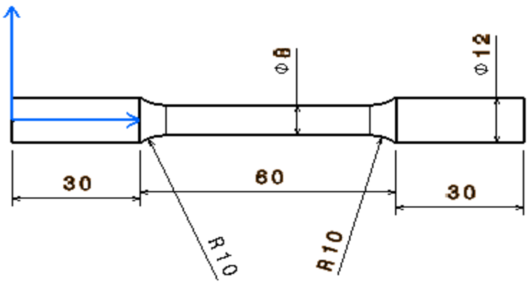



Figure-5.1: Tensile test specimen (Dimensions in mm)

The specimen for the thermal conductivity test are prepared as per the ASTM. The diameter and thickness of the composite specimen is 11.36mm and 3mm respectively.

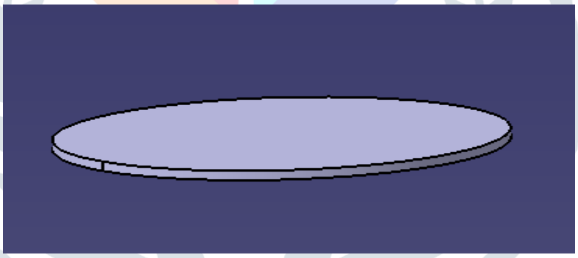


Figure 5.2 : For thermal conductivity test specimen

**6. Tensile Test**.

Test specimens were prepared according to ASTME8-82standards,each specimen having 8mm in diameter and 60mmgauge length, as shown if Figure-1. The specimen was loaded in Universal Testing Machine until the failure of the specimen occurs. Tests were conducted on composites of different combinations of reinforcing materials and ultimate tensile strength were measured.

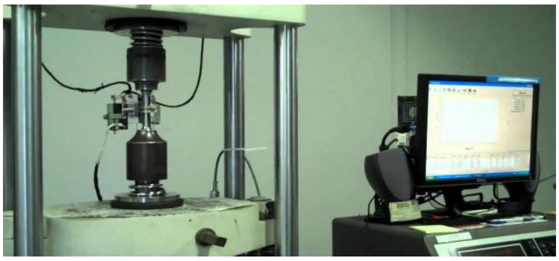


Figure 6.1: Universal testing machine.

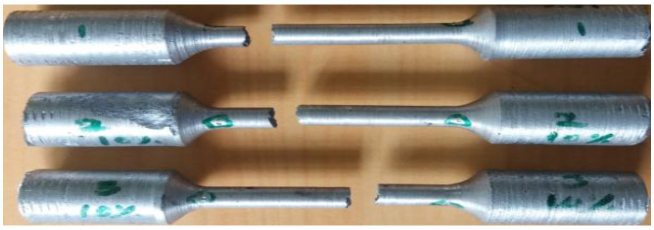


Figure-6.1: Composite specimen for 2%,6%,10% of volume fractionafter tensile test.

**7. Thermal Conductivity Test**

Here, the volume fraction of milled glass fibers has an effect on the thermal conductivity of Al 6061 alloy matrix composites. Milled glass fiber has a different fiber volume fraction of 2%, 6% and 10%, respectively. The samples were made of Al 6061 alloy reinforced with milled glass fibers. In this study, Lee's disc method was used to measure the thermal conductivity of composite.

Figure-7.1 : Lee’s disc apparatus

Figure-7.2: Composite specimen for 2%,6%,10% of volume fraction of thermal conductivity test

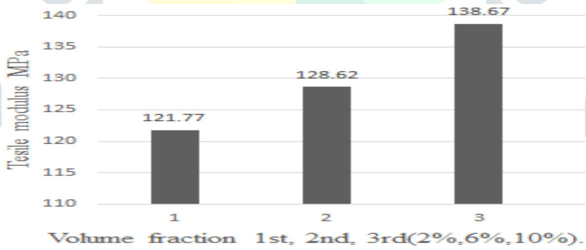
**8. Results and Discussions**

**8.1 Tensile strength**

The graph 8.1 shows that the addition milled glass fiber increase in the tensile strength.

| specimen | Tensile Strength for 1st vf (2%) MPa | Tensile Strength for 1st vf (2%) MPa | Tensile Strength for 1st vf (2%) MPa |
|---|---|---|---|
| 1 | 127.712 | 129.988 | 139.16 |
| 2 | 114.25 | 128.92 | 137.27 |
| 3 | 123.33 | 127.98 | 139.60 |

Table-8.1 Tensile results for each specimen of volume fraction.



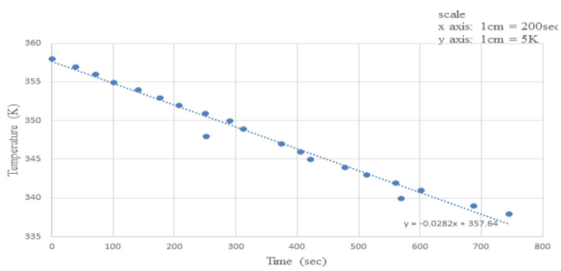

The graph 8.1ternsile strength for 2%,6%,10%.

**8.2 Thermal Conductivity**

The readings noted from the experiment are tabulated below (we tabulated example)

| | | | | | |
|---|---|---|---|---|---|
| **Temperature(K)** | 358 | 354 | 350 | 346 | 337 |
| **Time (sec)** | 38 | 142 | 291 | 404 | 819 |

Table:8.2 The tabulated values of 3rd volume fraction.




Graph 8.2 Temperature vs Time

**Observation**

Steady temperature of steam chamber (T1) = 368K
Steady temperature of the metallic disc (T2) = 351K
Mass of metallic disc (m) = 0.9 Kg
Specific heat capacity of metallic disc(C) = 380 $JKg^{-1}K^{-1}$
Thickness of specimen (d) = 0.3cm = 0.003m
Thickness of metallic disc (h) = 1.36cm = 0.0136m
Radius of specimen (r) = 5.68cm = 0.0568m
Mean rate of fall temperature at mean temperature T2 (dT/dt) = 0.028. It is taken from the graph.

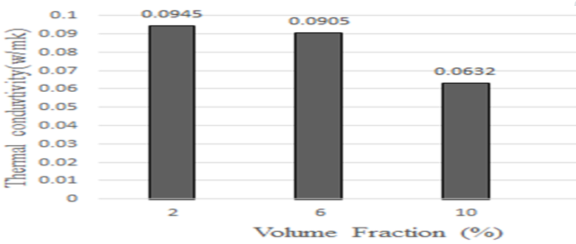
$$K = \frac{mCp\left(\frac{dT}{dt}\right)d(r+2h)}{\pi r^2(T_1 - T_2)2(r+h)}$$

$$K = \frac{0.9 \times 380 \times 0.028 \times 0.003 \times (0.0568 + 2 \times 0.0136)}{\pi \times 0.0568^2(368 - 351)2(0.0568 + 0.0136)}$$

$$K3 = 0.099 \text{ Wm} - 1K - 1$$

| specimen | Thermal conductivity for 1st vf (2%) | Thermal conductivity for $2^{nd}$vf (6%) | Thermal conductivity for $3^{rd}$vf (10%) |
|---|---|---|---|
| 1 | 0.103 | 0.0905 | 0.0632 |
| 2 | .0817 | 0.0905 | 0.0632 |
| 2 | 0.099 | 0.0905 | .0632 |

Table-8.2.1 Thermal conductivity result for each specimen of volume fraction.




The graph 8.2.1 Thermal Conductivity Result for 2%,6%,10%.

## 9. Conclusion

- The milled glass fiber can be successfully introduced into the Al6061 alloy matrix by the stirring casting method to prepare the composite material
- Standard specimens are prepared as per the ASTM standards for tensile test and thermal conductivity test.
- The tests were conducted for all the samples the result of these tests indicated that there is increase in the tensile strength were better than the base metal(Al 6061alloy).
- 4. When Al 6061 is reinforced with 2%,6% and 10% of Milled glass fiber there we observed decrease in thermal conductivity of metal matrix composite.

**Future scope of the work**

The accompanying exploration work might be proceeded later on advancement:

- In future we can use other reinforcement make it as hybrid composite the result may get better than the present work.
- The mechanical properties were evaluated by changing the size of the aluminum (Al6061 alloy) and keeping the milled glass fiber constant.
- The mechanical properties were evaluated by maintaining the size of the aluminum (Al6061 alloy) constant and changing the milled glass fibers.

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