# CHARACTERISATION OF ALUMINIUM REINFORCED WITH GRAPHITE MMC'S

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**Abstract:** *The global technical market's demand trend for high strength, high performance, better quality, reduced cost and reduced weight materials has led to an emerging development in research and utilization of composite materials over conventional monolithic materials in various industrial applications. Aluminium –graphite composite has been developed by stir casting technique. Al-Graphite composites having 2%, 4%, 6%, 8% of pure aluminium is prepared. Tensile strength, Hardness test, Impact strength as a function of graphite performs and metal matrices have been determined. The tribological properties were varied significantly with addition of solid lubricant-graphite. The hardness test of composites is carried on Brinell hardness Tester and tensile strength is measured using a Universal testing machine and Charpy and Izod tests are conducted to find the impact energy. Around 15% increase is observed in the hardness of the composite compared to the hardness of pure aluminium and no significant increase is found in the impact energy of the composite, but more than 21% increase is found in the tensile strength of the composite.*

**Keywords:** *Pure Aluminium, Graphite, Composites, Stir-Casting, Metal Matrices, Mechanical Properties.*

## 1. INTRODUCTION

In the current world scenario of high demand for Metal Matrix Composite because of its notably improved properties like tensile strength, specific strength, specific modulus, good damping capacity, better wear resistance over the properties of unreinforced alloys and monolithic materials. Metal Matrix Composite (MMC) is a composite material with at least two constituent parts, one being a metal, the other maybe a metal or any other material such as ceramic, organic compounds. The matrix is generally monolithic light materials like aluminium, magnesium, titanium providing a compliant support for the reinforcement [4][8]. Even there are numerous natural composites in nature such as wood with cellulose fibres, human bone, teeth, pearls and even shell structures. MMC persists enormous applications in sports equipment to jets, aircraft, missile, automobiles, mechatronics, spacecraft building panels, linings [6][7]. The reinforcement has a considerable impact over the physical properties of MMC such as tensile strength, hardness and so on [1][3]. These properties are studied and analysed for different composition and a substantial task has been carried to analyse these properties variations.

Among the various techniques available for the manufacturing of MMC, stir casting was opted because of the ease of reach and procedure and its ability to manufacture a considerably uniform distribution [2]. Also there are practical applications that prove the possibility of altering different physical properties of aluminium alloy by adding appropriate reinforcement in suitable volume fraction [5]. Also, the appealing characteristics of stir casting are the isotropic nature of properties. Even the cost of the component production by solid state processing route was still high, hence making stir casting an important technique to highly economical-minimizing the cost of final product [8]. Also it permits the fabrication of very large sized components. Stir casting is best suited for manufacturing composites with up to around 30% volume fractions of reinforcement [5].

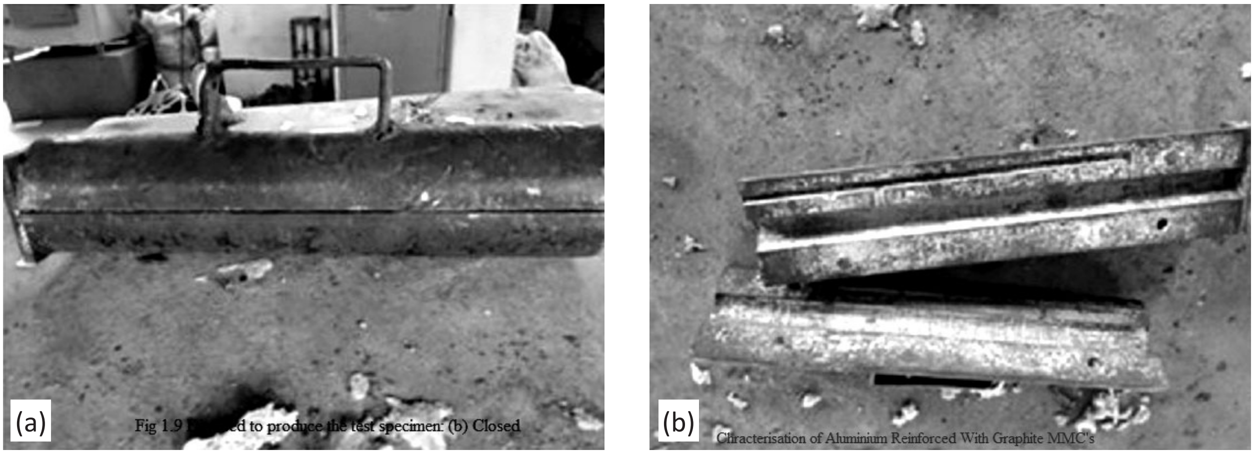



**Fig 1. Die Used to Produce the Test Specimen**

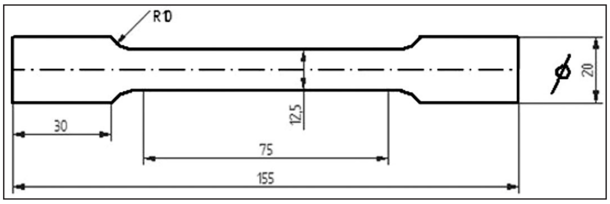



**Fig 2. ASTM Standard for Dimensioning Tensile Specimen**

**Table 1: Composition of Materials Considered for Testing**

| Sl.no. | Al7075 | Graphite |
|---|---|---|
| 1 | 100% | 0% |
| 2 | 98% | 2% |
| 3 | 96% | 4% |
| 4 | 94% | 6% |
| 5 | 92% | 8% |

## 2. EXPERIMENTAL METHODOLOGY

Here, specimens are prepared as per ASTM standards after reinforcing graphite into aluminium at various proportions. Various tests are conducted on the test specimen and mechanical properties are obtained.

### Die casting

The aluminium ingots are placed in the furnace and heated up to 800 degree Celsius. After the metal has reached its molten state, calculated percentage of graphite powder is added and stirred using a zirconium coated spoon to ensure uniform distribution. The molten metal is then forced into mould cavity at high pressure and allowed to

**Fig 3. Tensile Specimen**

solidify. The castings were then machined to ASTM standards using lathe and tests were performed on the same. Tests were carried out to get yield strength, ultimate strength, impact strength, Brinell hardness and % increase in strength.

### Machining

The cast specimen is then machined with the help of a lathe for sophisticated shape and dimension, as per ASTM standard, the tensile test specimens are prepared as shown in Fig 2.

### Testing

The following tests are conducted on the specimens

1. Yield strength
2. Ultimate tensile strength
3. Hardness
4. Impact strength

### Tensile Test

Universal Testing Machine is used for conducting

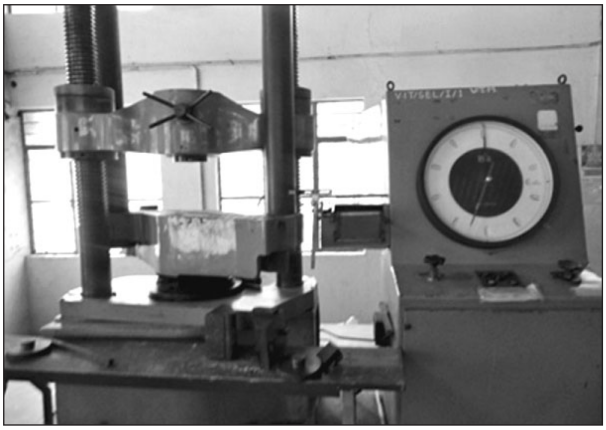
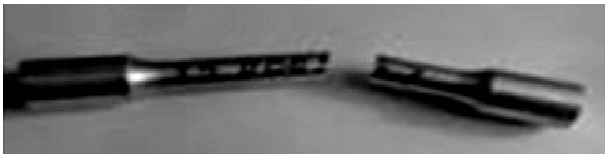


Fig 4. Universal Testing Machine

(a)



(b)

**Fig 5. Tensile Specimens Before and After Testing**

the tensile tests on specimens prepared. Extensometer measures the key parameters of force and deformation, which can also be presented in graphical mode in case of computer operated machines. The specimen tested is shown in figure.3.

## Hardness Test

Brinell hardness test is considered for determining the hardness number in this work. Brinell hardness is determined by forcing a hard steel or carbide sphere of a specified diameter under a specified load into the surface of a material and measuring the diameter of the indentation left after the test. The Brinell hardness number is obtained by dividing the load used by the actual surface area of the indentation. The result is a pressure measurement, but the units are rarely stated.

The BHN is calculated according to the following formula:

**Fig 6. Brinell Hardness Tester**

**Fig 7. Hardness Test Specimen**

$$BHN = \frac{F}{\frac{\pi}{2} D * \left(D - \sqrt{D^2 - Di^2}\right)}$$

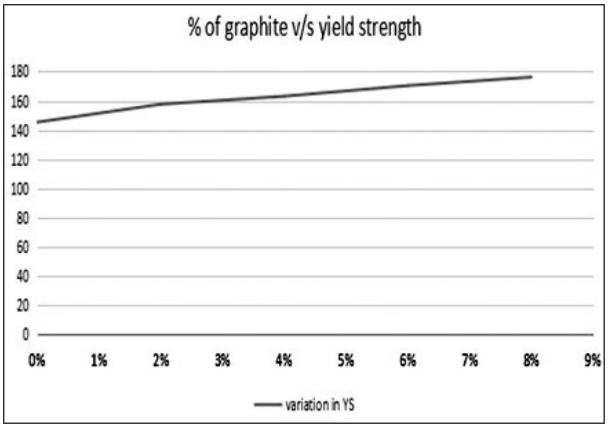
Where ;

BHN = Brinell hardness number, F = Imposed load in kg, D = the diameter of the spherical indenter, in mm, Di = diameter of the resulting indenter impression, in mm

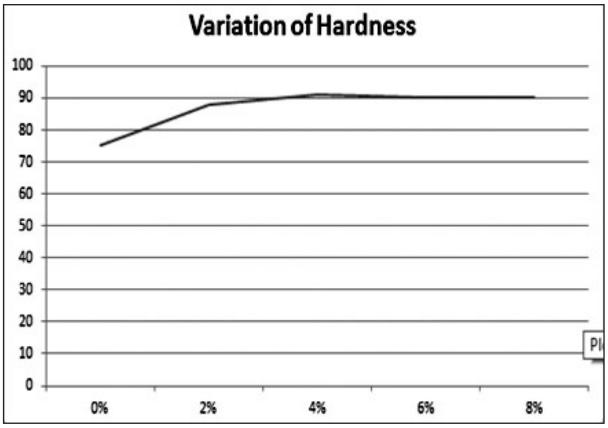
Specimen used for the test is shown in the figure 7.

**Table 2: Results Obtained During Various tests Conducted on the Specimen**

| Specimen No. | Combination of materials | | Yield strength $N/mm^2$ | Ultimate tensile strength $N/mm^2$ | % increase in yield strength | Hardness BHN AVG |
|---|---|---|---|---|---|---|
| | Al | Graphite | | | | |
| 1 | 100% | 0% | 145.3 | 148.2 | - | 75.06 |
| 2 | 98% | 2% | 157.6 | 160.1 | 8.465 | 88.06 |
| 3 | 96% | 4% | 163.1 | 167.5 | 12.25 | 91.2 |
| 4 | 94% | 6% | 170.4 | 175.5 | 17.27 | 90.33 |
| 5 | 92% | 8% | 176.2 | 185.3 | 21.26 | 89.93 |




(a)




(b)

**Fig 9. Variation of Yield Strength and Hardness of the Tested Specimen with Variation in Graphite Percentage**

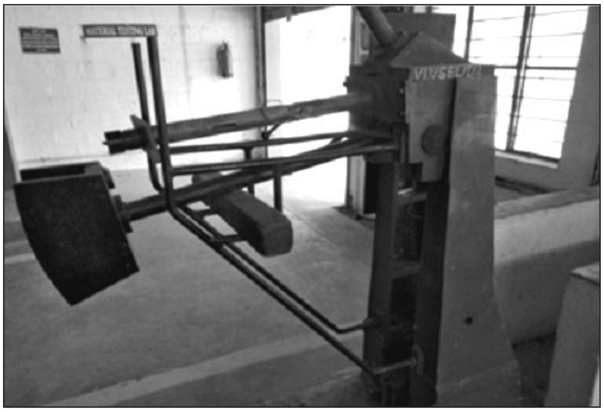


**Fig 8. Impact Tester**

## Impact strength

The Charpy Impact Test, also known as the Charpy V-notch Test, is a standardised high strain -rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition. It is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply. A disadvantage is that some results are only comparative.

According to ASTM A370, the standard specimen size for Charpy impact testing is 10 mm × 10mm × 55mm. Sub size specimen sizes are: 10 mm × 7.5 mm × 55mm, 10 mm × 6.7 mm × 55 mm, 10 mm × 5 mm × 55 mm, 10 mm × 3.3 mm × 55 mm, 10 mm × 2.5 mm × 55 mm. Details of specimens as per ASTM A370 (Standard Test Method and Definitions for Mechanical Testing of Steel Products).

## 3. RESULTS AND DISCUSSION

Results obtained during the various tests are discussed in this section. The readings taken during the stated tests are tabulated in table 2.

(a) Consists of graphs that are plotted by varying the % of graphite in aluminium graphite composite. The variation of tensile property of the matrix with increase in graphite composition is as shown. - It was inferred that there is a considerable increase in the yield strength from around 145.3 to 157.6 N/mm2 accounting for about 8.456% increase in the yield strength for variation of graphite composition from 0% to 2% graphite composition and it was found that there was furthermore in increase in the yield strength to 163.1 N/mm2 accounting for 12.25% increase for 4% graphite composition. Similarly for 6% graphite composition 170.4 N/mm2 was the yield strength g accounting for 17.27% increase, for 8% graphite in the MMC yield strength increased to 176.2 N/mm2 that is around 21.26% increase. So the increase in graphite composition has an appealing role in increasing the yield strength significantly.

(b) Depicts the variation in the hardness of the matrix with increase in graphite percentage. The hardness of aluminium matrix without graphite is found to be 75.06 BHN. It can be inferred that with increase in graphite composition to 2% results in an increase in hardness to 88.06 BHN from 75.06BHN. The hardness further increases up to a maximum value of 91.2 BHN for 4% graphite composition and then the hardness begins to decrease to 90.33 BHN for 6% graphite composition and further decreases to 89.93 BHN for 8% graphite composition in MMC.

It was observed that Impact strength remained constant at around 2J for different composition of graphite in the matrix.

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