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# Mechanical Behavior of Aluminium-7075 Reinforced with Boron-Carbide ($B_4C$) and Graphite (Gr) Synthesized by Stir Casting.

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**Abstract -** *The paper is the result of investigations made on microstructure and mechanical behavior of Al7075, Al7075-4% B4C, Al7075-4% Graphite and Al7075-4% B4C+4% Graphite. The microstructure of the composites was examined by scanning electron microscopy. Further, mechanical behavior of composites was studied. Mechanical properties like hardness, ultimate tensile strength; yield strength were evaluated as per ASTM standards. Microstructural observation revealed uniform distribution of reinforcement particles in the matrix. The analysis disclosed hardness, ultimate tensile strength, and yield strength of composites increased due to addition of reinforcements.*

***Key Words***: Composites, Al-7075, B4C, Gr, Microstructure, Tribological Behaviour.

## 1. INTRODUCTION

As there a trend in advancement in the technology there is more demand for the materials which saves energy in the areas of aerospace and also light weight and economical and in the areas of defense, aviation, automation, and many of the aircraft industries. So major applications are about Reducing Weight and also maintaining the mechanical and other tribological properties improves because of which composites of Aluminium are found most suitable. Aluminium is applicable because it is corrosion resistance material also when its layer reacts with air to form oxides on surface which offers resistance to the metal erosion due to the rubbing action against two surfaces in an application. Hence it widely used in the applications of aerospace which don't have considerable wear resistance by itself. Therefore, there is need for development in the properties is much needed.

Al-7075 is alloys of which contains zinc as their major alloying element, and is combined with copper and magnesium. Aluminum alloys got highest strength in comparison with other alloys. As these are wrought alloys secondary machining is possible. When further heat treatment is done it has highest mechanical strength. Aluminium alloys used in manufacturing of automotive components and various aircraft structures (extrusions, forgings, sheets). These also found in high stressed parts fabrication.

### 1.1 Materials

**Al-7075** is an alloy with zinc as the primary alloying element. It has good strength comparable to many sheets of steel and average machinability but has high resistance to corrosion than many other aluminium alloys. It's relatively high-cost limits and used in applications where cheaper alloys are not suitable.

**Table1. Chemical Composition of Aluminium alloy**

| Element | Content (%) |
|---|---|
| Aluminum, Al | 90 |
| Zinc, Zn | 5.6 |
| Magnesium, Mg | 2.5 |
| Copper, Cu | 1.6 |
| Chromium, Cr | 0.23 |

### 1.2 Preparation of Aluminium alloy Composites

The stir casting method was used develop the reinforcement metal matrix composites with the temperature of stir casting furnace was maintained at 700$^0$C. AL 7075 is first put into the crucible and furnace is closed. After twenty minutes, the metals were verified for their molten state and after the confirmation, the metals such as boron carbide and graphite were put inside and the furnace was closed. After 15 to 20 minutes, the boron carbide and graphite was added and the aluminium stirrer was set to 550 rpm and it rotates. After the stirrer is rotated for about five minutes, the stirrer was stopped and the molten metal was taken out. It was kept in cooling nature for about two hours.

| Base Material | B4C (%) | Gr (%) | Stir Speed (rpm) | Stir Time (mins) | Pouring Temp. (C) | Preheated Temp. (C) |
|---|---|---|---|---|---|---|
| Al-7075 | 4 | 4 | 550 | 5 | 700 | 350 |

## 2. Testing of Composites

Microstructure study has been carried out on the prepared composite using Vegas Tescan made scanning electron microscope. Basically the test samples of 10-12mm in diameter are cut from the prepared castings using lathe machine and are polished thoroughly as already mention methods it is etched using reagent for better results. The polished specimens which looks like mirror. The specimens are characterized for various magnifications (100X, 200X, 800X) to indicate distribution of reinforcements in metal matrix. The microstructures of samples i.e. as cast, 4 wt% $B_4C$ and 4wt% of Graphite are also examined.

Tensile test specimens were machined from the cast samples. The tensile specimens of circular cross section with a diameter of 9 mm and gauge length of 45mm were prepared according to the ASTM E8 standard testing procedure using Instron made Universal Testing Machine. All the tests were conducted in a displacement control mode at a rate of 0.1 mm/min. Multiple tests were conducted and the best results were averaged. Various tensile properties like ultimate tensile strength, yield strength and percentage elongation were evaluated for as cast Aluminium alloy. Figure 1 showing the tensile test specimen dimensions used to conduct the experiments.

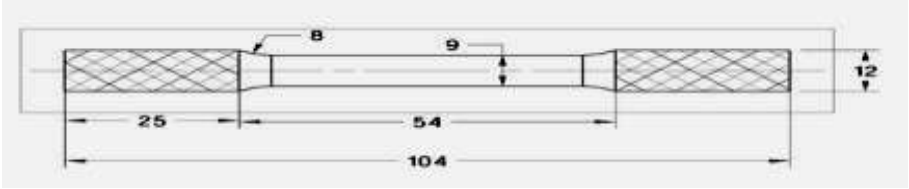
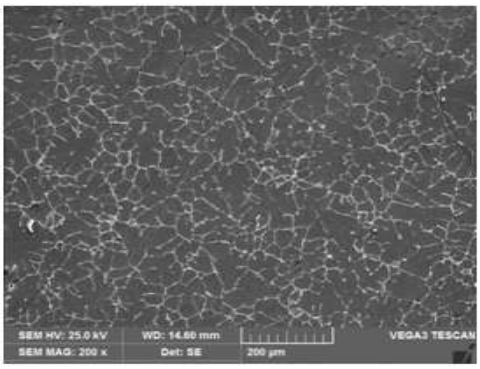


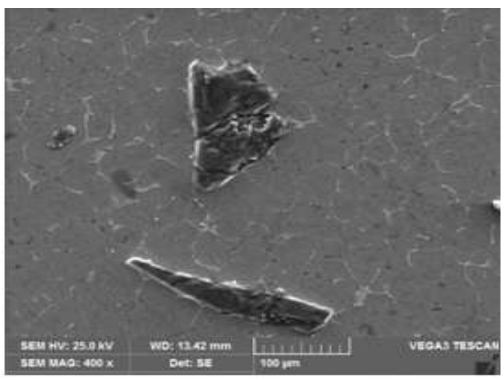

**Figure 1: Tensile specimen and its dimensions in mm**

### Results and Discussion

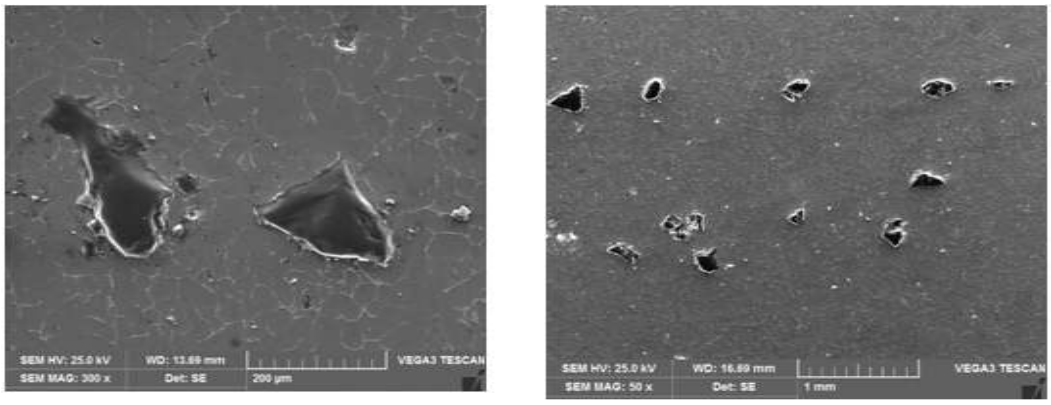
### Microstructure Study



**(a)**



**(b)**




**(c)** **(d)**

**Figure 2: Showing the Scanning Electron Microscope image of Al-7075alloy(a) and 4%$B_4C$+4%Gr (b)**

Figure 2 (a) shows the SEM microphotographs of Aluminium alloy as cast. Fig. 2 (b) clearly shows and even distribution of $B_4C$ in the Aluminium alloy matrix. similarly ,Fig 2 (c) clearly shows and even distribution of Gr and Fig 2 (d) clearly shows and even distribution of Aluminium with 4 wt. % $B_4C$+4%Gr particulate. There is no evidence of casting defects such as porosity, shrinkages, slag inclusion and cracks which is indicative of sound castings. In this, wetting effect between particles and molten Aluminium alloy matrix also retards the movement of the reinforcement thus, the particles can remain suspended for a long time in the melt leading to uniform distribution.

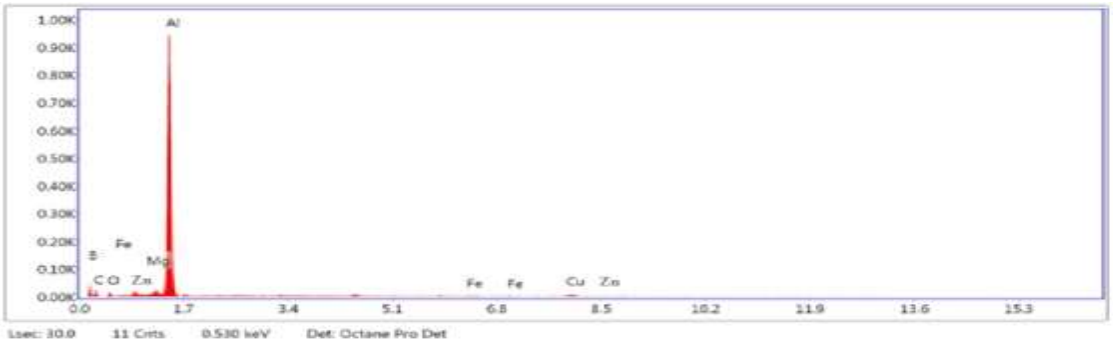



**Figure 3: Eneregy Dispersive Spectrograph of Aluminium Alloy**

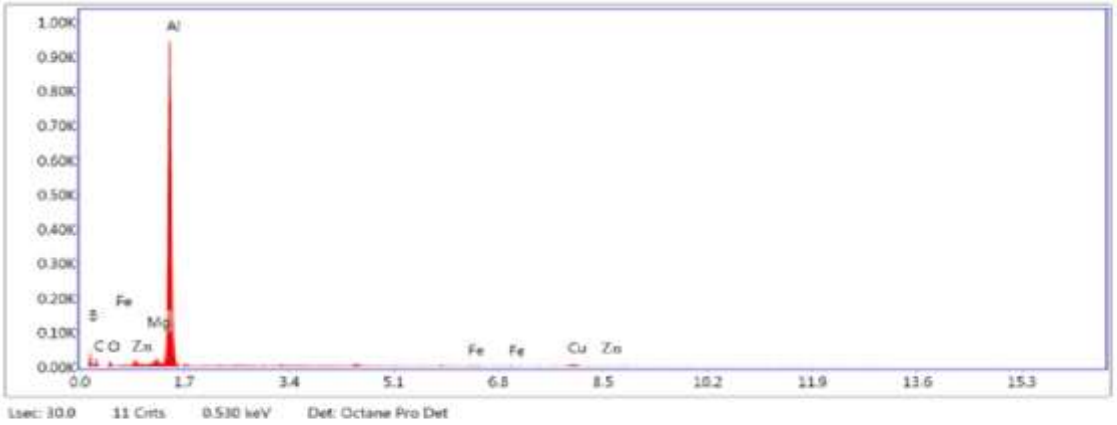



**Figure 3: Eneregy Dispersive Spectrograph of Hybrid Aluminium Alloy**

In order to confirm the presence of $B_4C$+4%Gr energy dispersive spectroscope analysis was carried out at the edge of the reinforcement particle and Aluminium alloy matrix. The EDS spectrum reveals the presence of Al, Zn, Cu and Mg in the interface reaction layer.

**Tensile Properties**

After the test is completed the results are taken on an average and mentioned. We see that the values are increasing as we add the reinforcements to the aluminium alloy. We achieve a maximum tensile stress of 248.88 MPa for Hybrid composite material. We can easily make out the difference that upon addition of reinforcements there is gradual increase in trend for yield strength. This is because reinforcements act as obstacles to the moment of dislocations and also upon adding the Graphite into molten metal it increases the elongation properties there by yielding more which in turn yield strength increased.

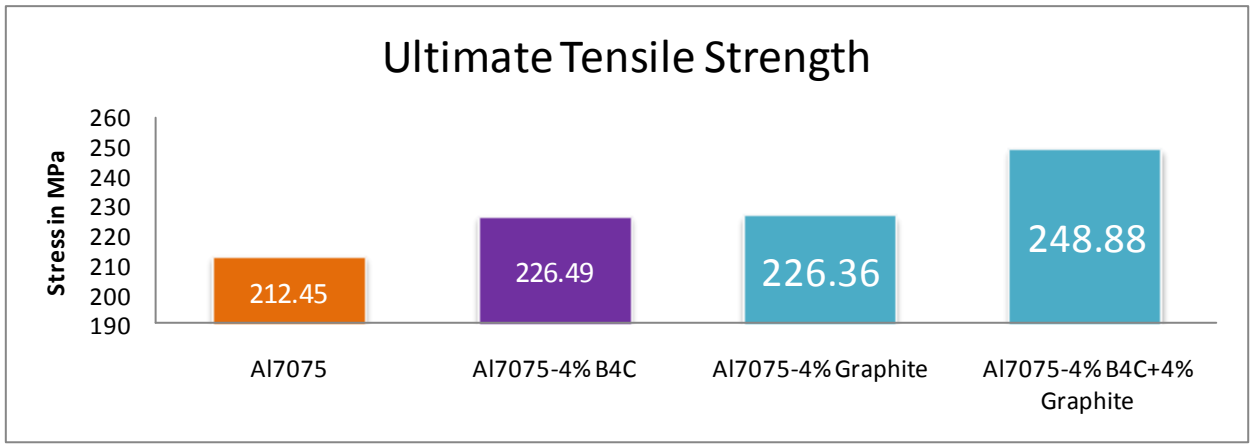



**Figure 4a: Ultimate tensile strength of Hybrid Aluminium alloy composites**

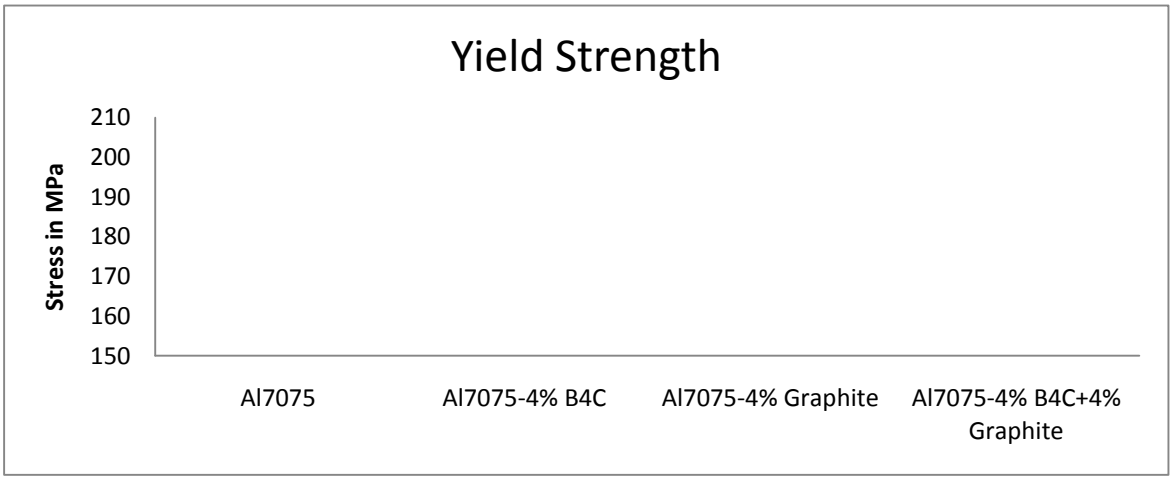



**Figure 4b: Yield strength of Hybrid Aluminium alloy composites**.

**Hardness Study**

The Brinell hardness test on all compositions was conducted using steel ball indenter at an applied load of 60kgf for time of 10 seconds to each sample at different locations. We can see that the hardness values are greater than that of its aluminium alloy. It is clear that hardness values are decreasing due to graphite contenting the alloy. Drop of hardness values due to softness of the graphite, which is soft do not contribute for hardness of the composite as they won't act as barriers for the dislocations moment within the matrix but Boron Carbides does contrary; since $B_4C$ particles which are ceramics having much higher hardness than the base matrix, they obstruct dislocations. The observations made are consistent Increased in the hardness of composites reinforced with $B_4C$ and Gr has been reported by several workers.


**Figure 5: Hardness of Hybrid Aluminium alloy composites**

## 3. CONCLUSIONS

The mechanical investigations of the Aluminium alloy composites materials produced by stir casting are remarked as below:

- The liquid metallurgy technique was successfully adopted in the preparation of Aluminium alloy composites.
- The microstructural studies revealed the uniform distribution of the $B_4C$ and Gr particulates in the Aluminium alloy matrix.
- The ultimate tensile strength and yield strength properties of the composites found to be higher than that of base matrix.
- Improvements in hardness of the Aluminium alloy matrix were obtained with the addition of B4C and Gr particulates.

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