# DISCREPANCY IN MECHANICAL PROPERTIES OF ALUMINIUM GRAPHITE COMPOSITE WITH DIFFERENT GRAPHITE PROPORTIONS

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**ABSTRACT:** Aluminium Matrix Composite (AMC) was first developed in the 1960s and has since been used in various industries. The AMC has found an increasing number of applications in recent years due to their unique properties. These composites typically consist of an aluminium matrix with reinforcement in the form of particulate, fibers or both. High strength, great stiffness, high wear resistance, and superior conductivity are all characteristics they offer. making them ideal for a range of engineering applications. AMCs are used in a variety of industries, including aerospace, automotive, defence, electrical and electronics. This research study aims to examine the mechanical properties like (tensile strength, hardness value, impact strength, and thermal expansion) of the manufactured AMC which is reinforced in different mass fractions of graphite particulates via the stir casting technique. The range of the mass fraction of reinforcement was 1.5%, 3%, and 4.5%. It is observed that the composite with 4.5% of graphite proportion has the highest tensile strength and yield strength, whereas the composite with 3% of graphite proportion has the highest hardness value and the composite with 4% graphite proportion has the lowest coefficient of thermal expansion. However, the impact strength remains the same for all three developed composites.

**KEYWORDS:** aluminium matrix composite, graphite particulates, stir casting, impact strength, coefficient of thermal expansion.

## 1. INTRODUCTION

Composite materials are made up of two or more different materials that are combined to create a new material with enhanced properties. These materials are often used in applications where traditional materials are not up to the task, such as in aerospace and automotive engineering. Composite materials can be made from a variety of different materials, including metals, plastics, and ceramics. Composite materials can be useful for a number of reasons. For example, they can increase the strength of an object by allowing it to carry more weight without breaking (i.e., "load-bearing") or reducing its weight by combining lighter components together (i.e., "lighter weight"). They can also reduce friction between moving parts by creating a smoother surface over time than if it were made out of individual components alone, [1]. Composite materials have been used for centuries in many industries around the world, but they have only recently seen adoption in areas like aerospace and automotive engineering where traditional materials do not perform well enough (or at all) under certain conditions. The following two states are typically included in composite materials:

i. Matrix – Primary State.
ii. Reinforcement – Secondary State**.**

i. The Primary State (Matrix) is defined as a binding agent/continuous state of a composite material in which the discontinuous state (reinforcement) is embedded. It is used to bind together other materials to form a composite material. The composite component's net form, load distribution between fibers, binding of the fiber reinforcement, and surface quality are all influenced by the matrix, [2], A composite matrix can be made of carbon, metal, ceramic, or polymers. The most popular composite matrices in industrial and high-performance aerospace applications are polymer matrices. Usually, ceramic and metal matrices are employed in extremely hot conditions, such as engines. In extremely high-temperature applications like carbon/carbon brakes and rocket nozzles, carbon is used as a matrix.

ii. Secondary State (Reinforcement) typically increases stiffness and significantly slows the spread of cracks. They are mechanically well bonded to the matrix and have high strength, thin fibers can significantly enhance the qualities of a composite. The reinforcements that are generally used, are Fibers. Ex. Glass fibers, Carbon fibers, etc., Fillers. Ex. Calcium Carbonate, Kaolin, etc., Whiskers. Ex. Graphite, Alumina, SiC, etc., Flakes. Ex. Glass flakes, Mica, Silver, etc., and Particulates. Ex. Particles of any metals, Fibers, etc.

### 1.1 Classification Systems of Composite Materials…

- The Matrix State-based composite.
    i. Metal Matrix Composite.
    ii. Ceramic Matrix Composite.
    iii. Polymer Matrix Composite.
- The Reinforcement state-based composite.
    I. Fiber Reinforced Composites.
    II. Particulate Composites

**i. Metal Matrix Composite (MMC)**

The components of the Metal Matrix Composites are a scattered ceramic (Carbides, Oxides) or the metallic (Molybdenum, Tungsten, Lead) phase and the metallic matrix (iron, aluminium, cobalt, copper, magnesium), [3], Good corrosion and abrasion resistance are a couple of the benefits. high resistance to punctures. High fracture resistance High stiffness and tensile strength.

**ii.Ceramic Matrix Composite (CMC)**

A ceramic matrix and fibers of another ceramic material are combined to form ceramic matrix composites. ($Al_2O_3$, SiC and $SiO_2$), [4], The main Advantages of these composites are, Chemical inertness, High service temperatures, Low Density, and High strength and hardness

**iii.Polymer Matrix Composite (PMC)**

Polymer Matrix Composites are made of a thermoset (Unsaturated Polymer [UP], Epoxy [EP]) or thermoplastic [Polycarbonate [PC], Polyvinylchloride, Nylon, Polystyrene] matrix and fibers made of glass, carbon, steel, or Kevlar incorporated in it (dispersed phase), [5], These composites have the benefits of being lightweight, strong, strong in relation to weight, high impact strength, flexible in design, nonconductive, and low thermal conductivity.

**I.Fiber Reinforced Composites**

A composite material comprised of a polymer matrix and fibers is known as a fiber-reinforced composite (FRC). Although different fibers, like paper, wood, or asbestos, have been utilized, the most common fibers employed are glass, carbon, or aramid. Epoxy is frequently employed as the matrix, [6], however other thermoset or thermoplastic polymers, including polyester, vinyl ester, or nylon, may also be used.

**II.Particulate Composites**

A form of a composite material called a particulate composite consists of particles that are embedded in a matrix. The matrix can be made of any kind of material, and the particles can be of any size and form. Particulate composites have several advantages in material science, including the ability to be created to be both lightweight and strong, as well as corrosion and fire-resistant, [7].

### 1.2 Aluminium Matrix Composites (AMC)

Typically, alloys from the 2xxx and 6xxx family and aluminium-silicon (Al-Si) alloys serve as the foundation for aluminium matrix composites. (AMC) is a kind of composite material made of aluminium matrix that has been strengthened with fiber or particle material. Common reinforcements include carbon fiber, silicon carbide, and boron carbide.AMCs are typically used in aerospace and automotive applications where weight reduction is a primary concern. They are also used in other high-performance applications such as sporting goods and military hardware [8] The kind and quantity of reinforcement employed affect the characteristics of AMCs. For example, reinforcing with carbon fiber increases the stiffness and strength of the composite while silicon carbide increases the hardness and wear resistance.AMCs are typically manufactured using powder metallurgy or liquid metallurgy processes. Powder metallurgy involves mixing the reinforcement material with the aluminium matrix powder and then hot pressing the mixture to form the AMC. Liquid metallurgy involves mixing the reinforcement material with the molten aluminium matrix and then cooling the mixture to form the AMC, [9] The reinforcement materials for (AMC) include silicon carbide (SiC) or alumina (Al2O3) particles in concentrations of 15 to 70% by volume. Alumina, silicon carbide, and graphite fibers that are continuous (long fiber-reinforced composites). Alumina with sporadic fibers (short-fiber reinforced composites).

### 1.3. Aluminium Graphite Composite

Aluminium graphite composite is a type of composite material made from aluminium and graphite. It has several characteristics that make it useful for a variety of applications, including, corrosion resistance, high strength-to-weight ratio, wear resistance, electrical and thermal conductivity. Aluminium graphite composite is made by combining aluminium and graphite particles together to form a composite material, [10]. The resulting material has a number of benefits that make it reliable for a variety of industrial applications. For example, the material has a high strength-to-weight ratio, making it ideal for use in structural applications, [11], Additionally, the material is an excellent conductor of electricity and heat, making it useful for electrical and thermal applications. Additionally, the material is resistant to wear and corrosion, making it ideal for use in harsh environments.

## 2. MATERIALS AND EXPERIMENTAL METHODS

### 2.1 Matrix material

As a matrix material for this study, the aluminium alloy 6061 was chosen. One of the 6000 series aluminium alloys that are most frequently used is 6061. Due to its high strength and good toughness properties, this common structural alloy is well-liked for medium to high-strength needs. Aerospace and the automobile industries frequently employ the heat-treatable aluminium alloy 6061. In Table 1, AA6061's attributes are displayed.

**Table 1 Charechteristics of AA6061**

| S.No | Characteristics | Value |
|---|---|---|
| 1 | Young’s Modulus | 68.9 GPa |
| 2 | Density | 2.7 g/cm3 |
| 3 | Tensile Strength | 124-290 MPa |
| 4 | Thermal Expansion | 23.2 x 10-6ºC |

### 2.2 Reinforcement material

Here in this work, the graphite particulates are used as reinforcement material. The graphite element is a material made of carbon atoms arranged in a hexagonal lattice. It is an allotrope of carbon, and its molecular structure is similar to that of a diamond. Graphite is a good conductor of electricity and heat. The grain size of the graphite powder is 50 microns. The characteristics of Graphite are shown in Table 2.

**Table 2 Characteristics of Graphite**

| S.No | Characteristics | Value |
|---|---|---|
| 1 | Density | 1.3-1.95 g/cm$^3$ |
| 2 | Young's Modulus | 8-15 GPa |
| 3 | Compression Strength | 20-100 MPa |
| 4 | Thermal Expansion | 1.2-8.2 x 10-6ºC |

**2.3 Mass Proportion Calculation**

The size of the specimen which is to be prepared is, 35 x 10 x 1 cm$^3$. The density of AA6061 = 2.7 Kg/cm3.Weight of the specimen with 100% AA6061 = 945 g. ≈ 1000 g.

**1$^{st}$Sample** Mass proportion calculation:

- 98.5% of AA6061 and 1.5% of Graphite.
- Weight of 98.5% of AA6061 = 985 g.
- Weight of 1.5% of Graphite = 15 g.

**2$^{nd}$Sample** Mass proportion calculation:

- 97% of AA6061 and 3% of Graphite
- Weight of 97% of AA6061 = 970 g.
- Weight of 3% of Graphite = 30 g.

**3$^{rd}$Sample** Mass proportion calculation:

- 95.5% of AA6061 and 4.5% of Graphite
- Weight of 95.5% of AA6061 = 955 g.
- Weight of 4.5% of Graphite = 45 g.

The total amount of AA6061 required ≈ 3 Kg.

The total amount of Graphite powder required ≈ 100 g.

**2.4 Preparation of The Composite**

The Stir Casting method is used as a fabrication method to form the Aluminium – Graphite composite. Stir casting is the process in which the metal in a solid state is heated to its melting point and converted into a liquid state. Then while stirringthe reinforcement material is mixed with the liquid molten metal. The chamber of the mould is subsequently filled with the hot stirred molten metal. and it gives the casting product. The heating process takes place in a crucible placed in a furnace. Initially, the Aluminium alloy AA6061 rod is placed inside the crucible i.e., the container. Then the container is placed inside the stir-casting furnace in order to melt the metal in the crucible. Once the temperature reaches 600ºC due to heating in the furnace the AA6061 starts to melt. After the metal is completely melted, the graphite powder is poured inside the molten metal and is stirred with the help of the stirrer in the furnace. The stirring action continues for some amount of time at a speed of 600- 800 rpm to obtain a uniform scatter of the graphite in the AA6061. After the above processes, the molten metal alloy with graphite dispersion is poured inside the mould cavity to obtain the required shape of the composite

**2.5 Testing Methods**

The following are various tests that are carried out in the fabricated specimen,

**2.5.1Tensile Testing**

Tensile testing, commonly referred to as tension testing, is a crucial engineering and material science test in which a sample is put under controlled tension until failure.

**Figure 1 UTM Machine**

Initially, the specimen is cut into an ASTM standard size, here ASTM E8-16a is used. Then the specimen is placed in the UTM machine in such a way as to perform the Tensile testing. Then the tensile force is given to the specimen until the specimen breaks. During the process, the result is graphically recorded. We can get the Tensile strength as the outcome of this test.

**2.5.2 Hardness Test**

Here, we assess the specimen's hardness using the Brinell Hardness test.

**Figure 2 Brinell hardness machine**

Initially, the intender generally the ball intender is placed in its position of the Brinell hardness machine. Then the load is made to Sample, here the preset load is 1000Kgf. Now the specimen is placed in the anvil whose position is adjustable with the help of a screw. After making the adjustments the load is applied to the specimen through the intender by releasing the lever. This causes a hemispherical indentation in the specimen through which we can calculate the hardness of the specimen.

**2.5.3 Impact Test**

The Charpy technique is used to gauge the specimen's impact resistance.

**Figure 3. Impact Testing Machine.**

Initially, the V-notch is created in the specimen. The oscillating weight is held in its position with the help of the pin. Then the specimen is placed in its position i.e., in the anvil. Now the weight is released such that it strikes the specimen. Due to the sudden load, the specimen will tend to failure. The dial shows the amount of impact energy that the specimen absorbs before it fails.

**2.5.4 Thermal Expansion Test**

The specimen's linear expansion coefficient is calculated using the thermal expansion test. The following formula is used to compute the coefficient of thermal expansion:

$\alpha = 1\ L \times \Delta L\ \Delta T$ Where,

Where L is the original length of the Sample material in mm.

ΔL is the Change in length of the Sample material in mm.

ΔT is the Difference between the temperature range in K.

**Figure 4 Thermal Expansion Testing Machine**

Initially, the specimen is cut into a shape of 10 x 10 x 40 $mm^3$. Then the specimen is placed in the crucible. The linear variable sensor should be adjusted in order to obtain an appropriate value. Then the main and the furnace is switched on, and the temperature will start to increase at a rate of 1ºC/90 Seconds Due to the raise in the temperature there observed a change in the length of the specimen. These changes are recorded and the graph is taken as output.

**3. RESULTS AND DISCUSSION**

**3.1 TENSILE TEST**

A universal testing device is used to conduct the tensile test. The standard ASTM used for tensile testing is ASTM E8-16 a. A typical representation of the ASTM specimen for tensile testing is shown in Figure 5.

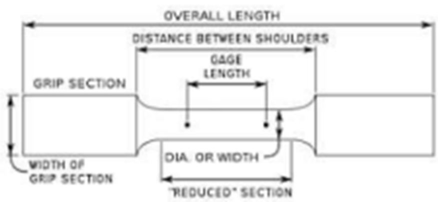


**Figure 5 ASTM Specimen.**

The specimen after the tensile test is shown in Figure 6.

**Figure 6 Specimen after Tensile Test**

The dimensions of the specimen used for the tensile testing are given below,

Gauge length = 50 mm, Thickness = 10 mm, Width = 13 mm

The results obtained from the tensile testing are shown in Table 3. and its plot is shown in Figure7. and Figure 8.

**Table 3 Results from the Tensile test.**

| S.No | Sample | Tensile strength in MPa | Yield stress in MPa |
|---|---|---|---|
| **1** | AA6061 | 150 | 83 |
| **2** | 1st Sample | 75.8 | 25.84 |
| **3** | 2nd Sample | 94.41 | 51.23 |
| **4** | 3rd Sample | 96.28 | 80.96 |

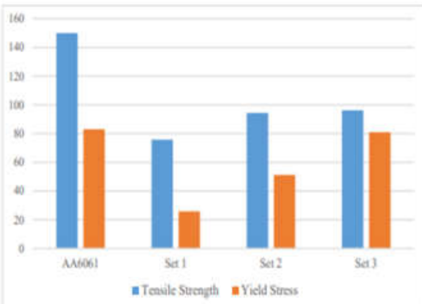


**Figure 7 Tensile strength and Yield stress plot-Bar chart**

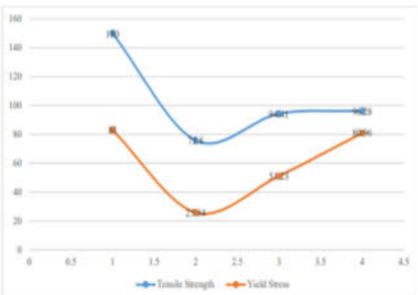


**Figure 8 Tensile strength and Yield stress plot-Line chart**

- From the graph as well as the table, we can find that the tensile strength of the 1$^{st}$Sample composite (98.5% of AA6061 & 1.5% of Graphite) is reduced to 49.47%, and the yield stress is reduced to 68.87% of that of the matrix metal i.e., AA6061. And, this reduction is because of the porosity of the specimen, which occurs due to the casting process, [12].
- Upon increasing the proportion of the graphite to 3% the tensile of the 2$^{nd}$Sample composite is increased by 19.7% and the yield stress is increased by 49.56% of that of the 1$^{st}$Sample composite.
- Further increasing the proportion of the graphite to 4.5% the tensile of the 3$^{rd}$Sample composite is increased by 1.94% and the yield stress is increased by 36.72% of that of the 2$^{nd}$Sample composite.
- From the above two points, the tensile strength, as well as the yield stress, increases by increasing the proportion of the graphite. [13].
- From the line chart i.e., Figure 8. the increment of the yield stress upon increasing the graphite proportion is linear and it has a uniform gradient, while the increment of the tensile strength upon increasing the graphite proportion is also linear but it has an un-uniform gradient, the slope between 150 75.8 94.41 96.28 83 25.84 51.23 80.96 0 20 40 60 80 100 120 140 160 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 Tensile Strength Yield Stress 25 1$^{st}$Sample and 2$^{nd}$Sample is greater than that between the 2$^{nd}$Sample and 3$^{rd}$Sample.
- And it is clear that the 3$^{rd}$Sample composite is the composite with the highest yield stress and thus has its elastic characterization till 80.96 MPa, while the other two composites are having comparatively lower yield stress than the 3$^{rd}$Sample composite, [14].
- And it is clear that the 3$^{rd}$Sample composite is the composite with the highest tensile strength thus it will not undergo failure till 96.28 MPa, while the other two composites are having comparatively lower tensile strength than the 3$^{rd}$Sample composite.

### 3.2 HARDNESS TEST

- The standard IS 1500-13 is used to perform this test. The intender of diameter 5 mm which is made of tungsten carbide is used and 1000 Kgf of the load is applied to carry out the test. In this, the load is applied for a period of 15 seconds. The typical representation of the Brinell hardness test is shown below in Figure 9.

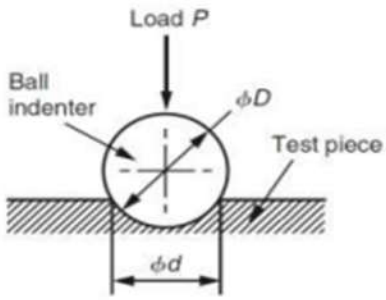


**Figure 9 Brinell Hardness Test**.

The specimen after the hardness test is shown below in Figure 10.

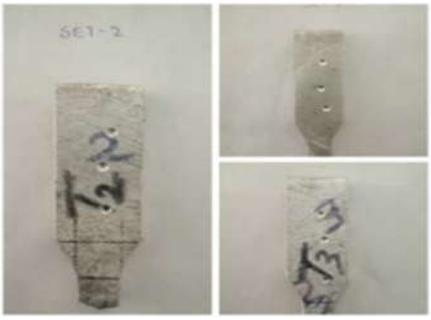

**Figure 10. Specimen After Hardness Test.**

The result which is obtained from the Brinell hardness test is given in below Table 4. and also, its plot is shown in below Figure 11. and Figure 12.

**Table 4 Hardness value.**

| S.No | Sample | Hardness Valve in BHN |
|---|---|---|
| **1** | AA6061 | 44.426 |
| **2** | $1^{st}$Sample | 63 |
| **3** | $2^{nd}$Sample | 73.3 |
| **4** | $3^{rd}$Sample | 58.3 |

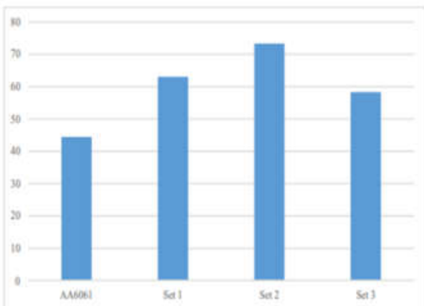


**Figure 11 Hardness Plot-Bar chart**.

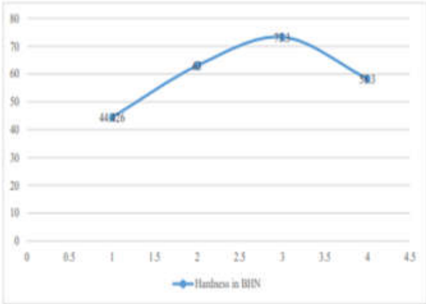


**Figure 12 Hardness plot-Line chart.**

i. From the graph as well as the table it is evident that the hardness value of the sample increases with the simultaneous increase in the proportion of graphite up to 3% and the hardness of the sample decreases when the proportion is further increased by 4.5%, [15].

**ii.** When the Graphite proportion of 1.5% is added with the metal matrix i.e., AA6061 the hardness of the 1$^{st}$Sample composite is increased by 42.3% of the hardness of the metal matrix. 0 10 20 30 40 50 60 70 80 AA6061 Set 1 Set 2 Set 3 44.426 63 73.3 58.3 0 10 20 30 40 50 60 70 80 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 Hardness in BHN 28

**iii.** When the proportion of the Graphite is increased to 3%, the hardness of the new composite i.e., the 2$^{nd}$Sample composite is increased by 16.35% of the hardness of the 1$^{st}$Sample composite.

**iv.** When the proportion of the Graphite is further increased to 4.5%, the hardness of the new composite i.e., the 3$^{rd}$Sample composite is decreased by 20.46% of the hardness of the 2$^{nd}$Sample composite. Even though, the hardness of the 3$^{rd}$Sample is 20.31% much more than the hardness of the metal matrix i.e., AA6061.

**v.** Thus, the composite with the 3% of graphite proportion has the highest hardness value and thus has the higher ability to withstand the friction loads and it has the highest abrasion resistance, [16].

### 3.3 THERMAL EXPANSION TEST

- This test is carried out in a Dilatometer. The specimen of size 10 x 10 x 40 mm$^3$ is used. The test is carried out between the temperature range of room temperature and the temperature of 100ºC. The specimen is heated inside the furnace at a rate of 1ºC/90 seconds, [17], A typical representation of the dilatometer for the CTE test is shown in below Figure 13.

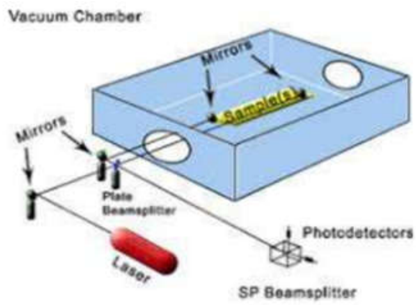


**Figure 13 CTE Measurement using Dilatometer**

The CTE is calculated using below formula,

$\alpha = 1 / L \times \Delta L / \Delta T$

Where L is before the length of the specimen in mm (L = 40 mm).

ΔL is the after length of the specimen in mm.

ΔT – Difference between the temperature range in K.

The expansion of the specimen is started when the temperature is 45°C, thus ΔT is calculated as follows,

$\Delta T = 100 - 45°C$ (or) $373 - 318$ K, $\Delta T = 55$ K.

The specimen after the thermal expansion test is shown in Figure 14.

**Figure 14 Specimen after Thermal expansion test**

The expansion of the specimen at the 100°C is given in Table 5.

**Table 5 Specimen after expansion**

| S.No | Sample | Expansion at 100° C in mm |
|---|---|---|
| 1 | 1st Sample | 0.049 |
| 2 | 2nd Sample | 0.048 |
| 3 | 3rd Sample | 0.044 |

The calculation of the coefficient of thermal expansion from the obtained expansion value is given below, Calculation of CTE for **1st Smaple:**

$\alpha = (1\ 40) X (0.049\ 55) = 22.3 \text{ X } 10\text{-}6 \text{ K}^{-1}$.

Calculation of CTE for **2nd Sample:**

$\alpha = (1\ 40) X (0.048\ 55) = 21.8 \text{ X } 10\text{-}6 \text{ K}^{-1}$.

Calculation of CTE for **3rd Sample:**

$\alpha = (1\ 40) X (0.044\ 55) = 20 \text{ X } 10\text{-}6 \text{ K}^{-1}$.

- The CTE value obtained from the test is shown in Table 6

**Table 6 Coefficient of Thermal Expansion value**

| S.No | Sample | CTE values in 10-6k-1 |
|---|---|---|
| 1 | AA6061 | 23.2 |
| 2 | 1st Sample | 22.3 |
| 3 | 2nd Sample | 21.8 |
| 4 | 3rd Sample | 20 |

The plot of the CTE is shown in below Figure 15 & Figure 16

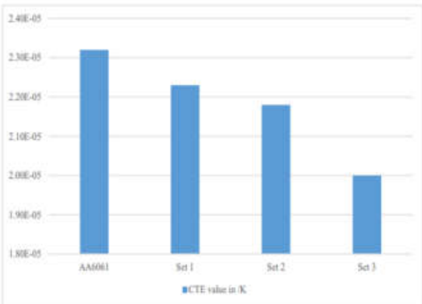


**Figure 15 CTE Value-Bar Chart**

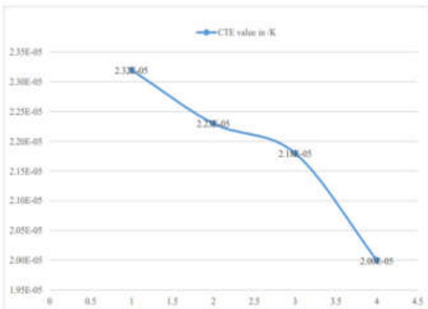


**Figure 16 CTE Value-Line Chart**

i. From the above graph, it is clear that the Coefficient of Thermal expansion decreases with a simultaneous increasing the proportion of the graphite, [18].

ii. When the Graphite proportion of 1.5% is added to the metal matrix i.e., AA6061 the CTE of the 1st Sample composite is decreased by 3.9% of the CTE of the metal matrix.

iii. When the proportion of the Graphite is increased to 3%, the CTE of the new composite i.e., the 2ndSample composite is decreased by 2.24% of the CTE of the 1stSample composite.

iv. When the proportion of the Graphite is further increased to 4.5%, the CTE of the new composite i.e., the 3rdSample composite is further decreased by 8.26% of the CTE of the 2ndSample composite.

v. From Figure 16. it is clear that the CTE decreases linearly with the increase in Graphite proportion, the slope between 1stSample and 2ndSample is comparatively smaller than that between 2ndSample and 3rdSample.

vi. The composite with the 4.5% of graphite proportion has the lowest CTE value and thus it expands less when subjected to temperature rise while the other two composites have a comparatively higher CTE value than the 1stSample composite.

### 3.4 IMPACT TEST

A typical representation of the specimen used for the Charpy impact test is shown in Figure 17.

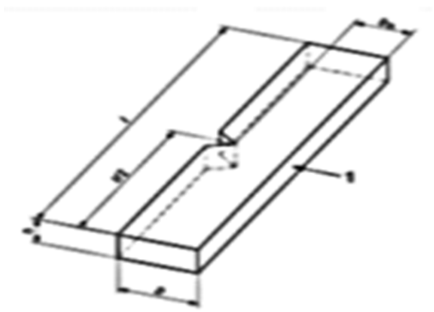

**Figure 17 Charpy specimen**

Here, b = 10 mm, h = 7 mm, l = 55 mm, $b-b_h$ = 2 mm

The specimen after the Impact test is shown in Figure 18.

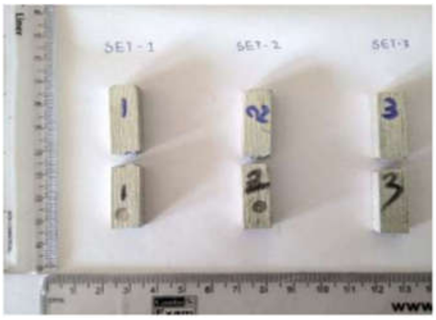

**Figure 18 Specimen after Impact test**

- The result which is obtained from the Charpy impact test is given in Table 7 and its plot is shown in Figure 19 and Figure 20.

**Table 7 Impact Strength**

| S.No | Sample | Impact strength |
|---|---|---|
| **1** | 1st Sample | 2.0 |
| **2** | 2nd Sample | 2.0 |
| **3** | 3rd Sample | 2.0 |

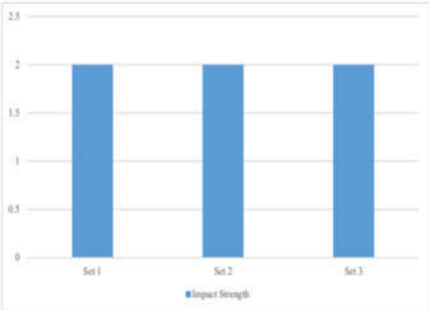

**Figure 19 Impact Strength plot - Bar Chart**

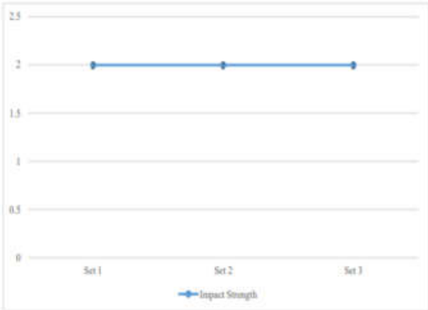

**Figure 20 Impact Strength-Line chart**

From the table as well as the graph it is clear that the addition of graphite to the metal matrix does not have any effect on the Impact strength.

## 4. CONCLUSIONS

i. Thus, the aluminium graphite composite with various proportions of graphite such as 1.5%, 3% and 4.5% are successfully developed through the stir casting method & the mechanical benefits such as Tensile strength, Hardness, Impact strength and the Coefficient of Thermal Expansion are determined for the developed composites.

ii. The composite with the 4.5% of graphite proportion, i.e., the 3rd Sample composite has the highest Yield stress and the Tensile strength of 96.28 MPa and 80.96 MPa respectively. While the other two composites have comparatively lower Tensile strength & yield stress than the 3rd Sample composite i.e., the composite with 4.5% of graphite proportion.

iii. The composite with the 3% of graphite proportion, i.e., the 2nd Sample composite has the highest hardness value of 73.3 BHN. While the other two composites have a comparatively lower hardness value than the 2nd Sample composite.

iv. The composite with the 4.5% of graphite proportion, i.e., the 3rd Sample composite has the lowest CTE value of 20X10-6 $K^{-1}$. While the other two composites have a comparatively higher Coefficient of Thermal expansion value than the 2nd Sample composite.

v. But the impact strength remains the same for all three developed composites. So, it is concluded that the addition of graphite does not have an effect over the Impact strength of the specimen.

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