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# Experimental Analysis of Mechanical Behavior on AA 7075 Hybrid Composite

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***Abstract*—In this investigation, experiments have been conducted to analyse the mechanical properties of AA7075 with new combination of ceramic particles such as $Al_2O_3$, $TiO_2$, $B_4C$. Three different weight % of the innovative hybrid composites have been prepared by stir casting process. Various mechanical tests such as hardness, tensile, impact test have been conducted. It is found that the mechanical properties i.e. hardness, tensile strength and impact strength gets increases by increasing the weight percentage of $Al_2O_3$ as 3%, 6% &9% and keeping the weight percentage of $B_4C$ & $TiO_2$ as 5%.**

***Keywords—Aluminium Metal Matrix Composite (AMMC), AA7075,$B_4C$, $Al_2O_3$, $TiO_2$,mechanical properties***

## I. INTRODUCTION

Composite material is the most adaptable material which has superior and unique properties used in variable fields like aerospace, aeronautics, defence, automotive and medicine [1, 2]. Aluminium metal matrix composite is an advantageous material because of its weight ratio, high specific strength, corrosive resistance, high thermal conductivity, improved machinability [3]. Stir casting process is widely used in mechanical field because of its simple, efficient and the most economical liquid metallurgy route, in which the reinforcements can be added in the molten state of the matrix alloy [4]. Adel Mahmood Hassan et al. (2007) opinion was Rockwell hardness was increased with an increase in the SiC content due to its high hardness but decreases with the increase in graphite content [5].K. V. Mahendra (2010) demonstrated that HMMCs containing upto 15% fly ash and silicon carbide decreases the fluidity and density whereas increases the hardness by increasing the reinforcements [6]. The addition of hard ceramic particles such as $Al_20_3$ and graphite in aluminium alloy increases the wear resistance of the composite [7].

A. Baradeswaran concluded that the wear resistance of AA7075/ 6% Al2O3 composite is greater than the pure matrix material and The wear rate can be controlled by the MML formed on the worn surface[8].Hongya Xu concluded that AA7075 pre-aging at various retrogression temperatures improves the hardness, tensile properties and electrical resistivity [9]. Kim et al. reported that the hardness of aged AA7075 alloy increases [10]. V.C. Uvaraja et al. studied the influence of operating parameters such as applied load, sliding speed, percentage of reinforcement content and sliding distance on the dry sliding wear of 6061 aluminium with SiC and B4C particulate reinforced composite and concluded that the reinforced composite with higher concentration of SiC (15%) shows better decrease in wear rate [11]. S. Venkat Prasat observed that the addition of fly ash particles in aluminium alloy has the potential for conserving energy intensive aluminium, and thereby reducing the cost and the weight of the product [12]. Viney et al. compared with addition of a fixed quantity of 4% graphite with same volume percentage of fly ash in AA 6061 and concluded that specific wear rate decreases for graphite [13].J.I. Song et al. (1997) reported that the wear resistance of $Al/Al_2O_3/C$ composites was remarkably improved over Al/ $Al_2O_3$ composites by incorporating carbon fibres to $Al/Al_2O_3/C$ composites [14].Shang- nanchou concluded that thehardness and density decreases linearly with increasing the alluminium alloy content. The four –points bending strength and the fracture toughness of the composite also increases[15].

In this paper, attempt has been made to combine three different ceramic particles i.e., AL2O3, TiO2 AND B4C in the base matrix, AA 7075. The percentage of Al2O3 has been increased from 3 to 9%, TiO2 & B4C has kept fixed as 5%. Mechanical test like hardness test, impact test and Brinell hardness test have been carried out to determine the mechanical properties of AA7075 hybrid composites.

## II. EXPERIMENTAL APPROACH

### *A. Materials*

AA7075 was used as a matrix material and the reinforcements such as alumina, boron carbide and titanium oxide was used in powder form of particle size 44 microns, 210 microns and 180 microns respectively. The chemical composition of AA7075 is presented in the table1:

TABLE 1. CHEMICAL COMPOSITION OF ALUMINIUM MATRIX ALLOY (WEIGHT PERCENTAGE)

| Element | Al | Si | Fe | Cu | Mn | Mg | Cr | Ni | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Content | 90.8 | 0.219 | 0.219 | 1.582 | 0.043 | 2.306 | 0.205 | 0.037 | 5.403 |

### *B. Sample Preparation*

Three samples were prepared by stir casting. Table 2 shows the composition of $Al_2O_3$, $TiO_2$, $B_4C$ which were added in the base material alloy AA7075.

TABLE 2. COMPOSITION OF THE CERAMIC REINFORCEMENTS

| Sample no. | $Al_2O_3$ Wt % | $B_4C$ Wt % | $TiO_2$ Wt % |
|---|---|---|---|
| 1 | 3 | 5 | 5 |
| 2 | 6 | 5 | 5 |
| 3 | 9 | 5 | 5 |

$Al_2O_3/B_4C/TiO_2$ reinforced aluminium alloy 7075 composites, processed by stir casting route were used in this work. 750 g of aluminium 7075 was used as the base material. Different weight percentage of $Al_2O_3$ (3%, 6% & 9%), $B_4C$ (5% fixed) and $TiO_2$ (5% fixed) have been taken and weighed in electrical machine. The matrix alloy had been heated above its melting temperature of about 850°C. Magnesium alloy was added in the crucible to increase the wettability of the aluminium alloy. After the vortex formation, the reinforcements were added in the crucible which was preheated about 330 °C. It has been stirred continuously for one hour at 550 rpm. The molten alloy have been poured into the die and machined to attain the desired samples. Then the hybrid composites have been treated to T6 condition.

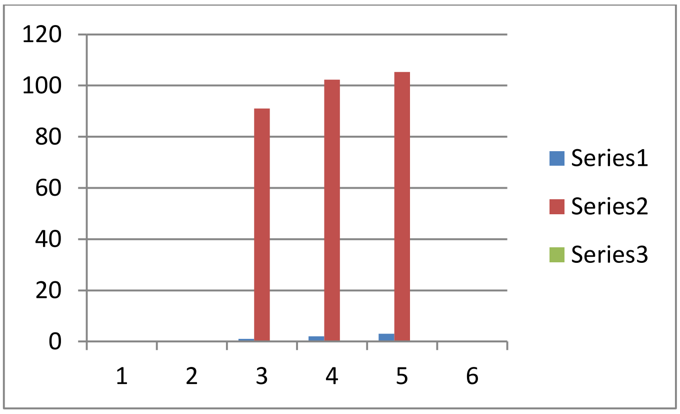
## III. TESTING AND RESULT

### A. *Brinell Hardness Test*

Hardness of the three stir casted hybrid metal matrix composite samples was tested by Brinell Hardness Tester. Readings on 2 to 3 locations were taken by applying a constant load of 100 kgf and average reading of each sample was considered. From the table 3, the hardness of AA7075/ 9% $Al_2O_3$/ 5% $B_4C$/ 5% $TiO_2$ was found to be greater than the other two samples due to the presence of high percentage of $Al_2O_3$.

TABLE 3. RESULT OF HARDNESS TEST

| SERIAL NO. | SAMPLE NO. | HV AVERAGE OF 3 READINGS |
|---|---|---|
| 1 | 1 | 91 |
| 2 | 2 | 102.3 |
| 3 | 3 | 105.3 |




Graph.1.HMMC Vs hardness value

### B. *ImpactTest*

The hybrid metal matrix composite samples were tested by Charpy impact Tester. The samples for impact test were machined as 55mm length and 10mm height. the impact strength of AA7075/ 6% $Al_2O_3$/ 5% $B_4C$/ 5% $TiO_2$ was found to be greater than the other two samples Fig.1 and 2 shows specimens before and after testing

Fig.1.Specimens before testing

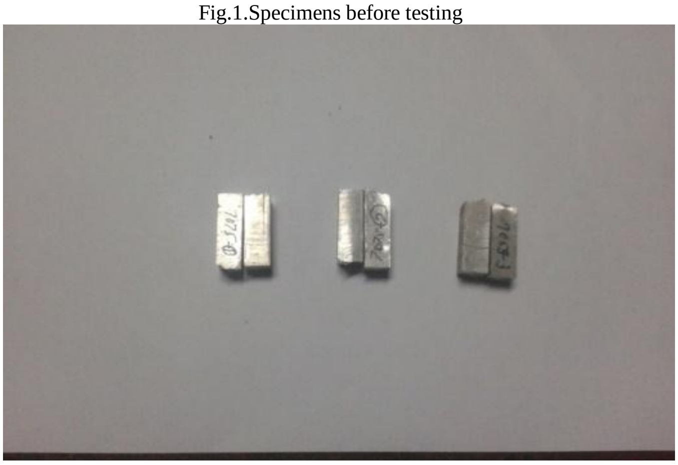
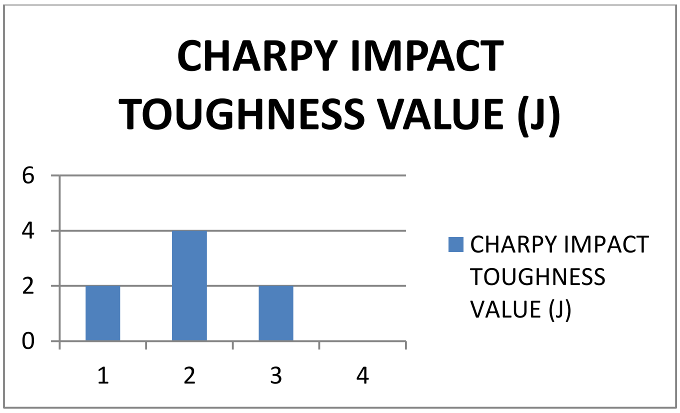


Fig.2.Specimens after testing

TABLE 4. RESULT OF IMPACT TEST

| SERIAL NO. | SAMPLE NO. | CHARPY IMPACT TOUGHNESS VALUE (J) |
|---|---|---|
| 1 | 1 | 2 |
| 2 | 2 | 4 |
| 3 | 3 | 2 |




Graph.2.HMMC VsCharpy impact toughness value

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*C. Tensile Test*

Tensile test was performed on Universal Testing Machine which was shown in fig 3. The samples for tensile test were machined as per ASTM standard. Tensile test was performed by holding and loading the specimen up to fracture. The tensile properties are tabulated in Table-4.From the graphs, it is concluded that the tensile strength is greater for AA7075/ 3% $Al_2O_3$/ 5% $B_4C$/ 5% $TiO_2$. Fig.4 and 5 shows specimens before and after testing

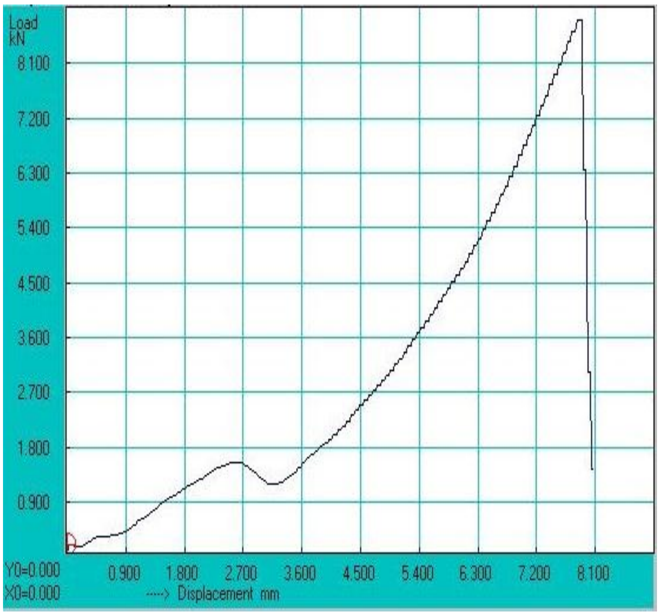
Fig.3.Universal Testing Machine

Fig.4.Specimens before tensile test

Fig.5.Specimens before tensile test

TABLE 5. RESULT OF TENSILE TEST

| Sa No. | Peak load (KN) | Ultimate Tensile Stress (Mpa) | Yield Stress (Mpa) | % of Elongation |
|---|---|---|---|---|
| 1 | 8.81 | 175 | 140 | 16 |
| 2 | 3.57 | 71 | 56 | 13 |
| 3 | 3.575 | 71 | 55 | 12 |




Graph.3. Load Vs displacement 7075-1

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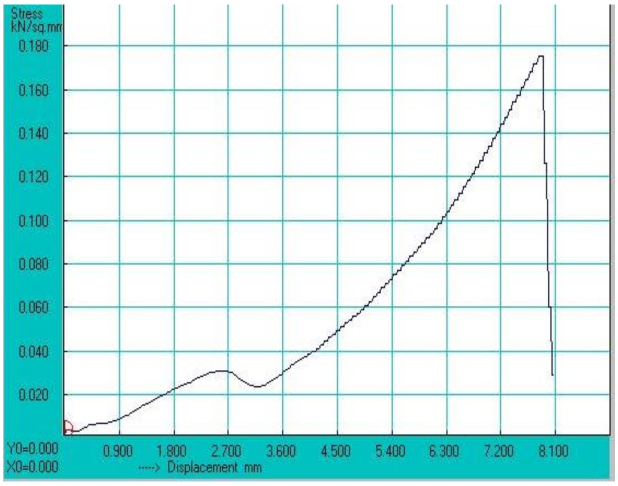
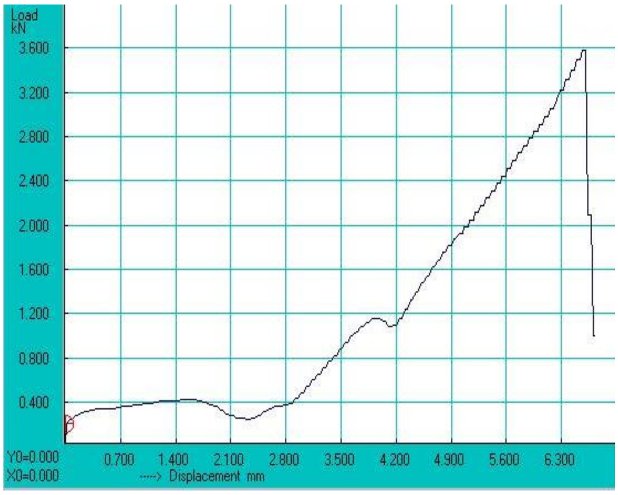
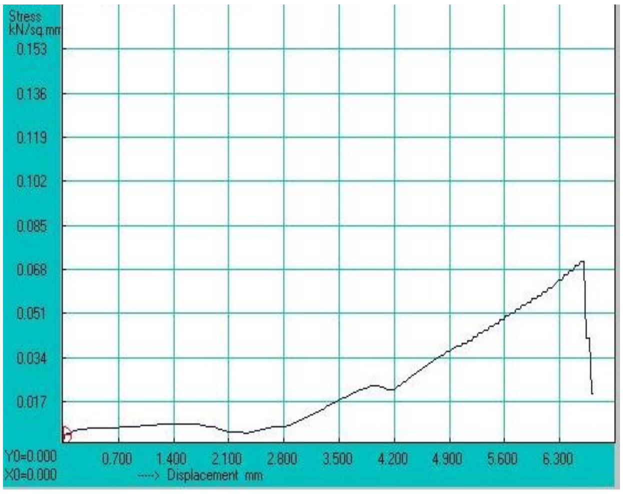


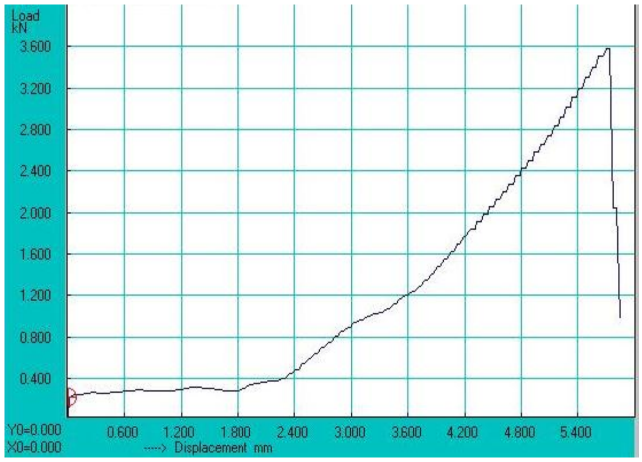

Graph.4. Stress Vs displacement 7075-1



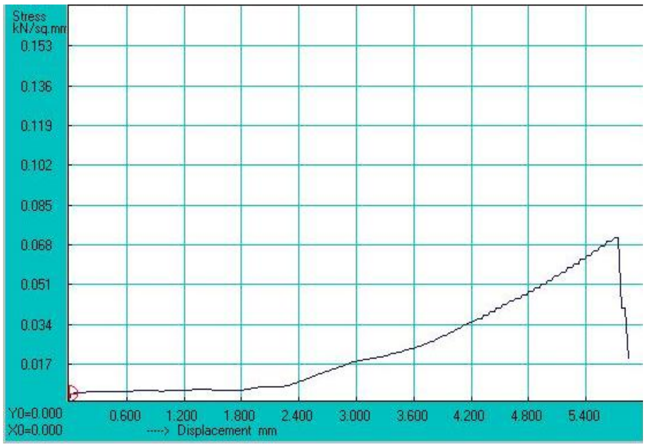

Graph.5. Load Vs displacement 7075-2




Graph.6. Stress Vs displacement 7075-2




Graph.7. Load Vs displacement 7075-3




Graph.8.Stress Vs displacement 7075-3

## IV. CONCLUSION

Three different percentages of $Al_2O_3$/ $B_4C$/ $TiO_2$ reinforced aluminium alloy 7075 composite have been successfully prepared by stir-casting method and treated to T6 condition. The hardness of AA7075/9% $Al_2O_3$/ 5% $B_4C$/ 5% $TiO_2$ was found to be greater than AA7075/ 3% $Al_2O_3$/ 5% $B_4C$ / 5% $TiO_2$& AA7075/ 6% $Al_2O_3$/ 5% $B_4C$/ 5% $TiO_2$.The tensile strength was found to be greater in AA7075/ 3% $Al_2O_3$/5% $B_4C$/5% $TiO_2$.The impact strength was found to be greater in AA7075/ 6% $Al_2O_3$/5% $B_4C$/5% $TiO_2$.

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