EVALUATION AND COMPARISON OF MECHANICAL PROPERTIES OF REINFORCED ALUMINUM HYBRID MICRO AND NANO COMPOSITES

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Abstarct: *In this paper hybrid metal matrix composites of Aluminum were made using the high frequency induction furnace stir casting method. Micro and Nano sized particles of Titanium Di-boride(TiB_2) and Graphite (Gr) are added as the reinforcements with aluminum as the metal matrix. The samples are then evaluated for the mechanical properties like tensile strength, compression strengt , % Elongation, hardness and impact strength. Aluminum based Metal Matrix Composites are very valuable addition in the field of newer materials for high performance applications. These light weight metals providing high strength to weight ratio led to the development of metal matrix composites (MMCs)and metal matrix nano composites (MMNCs). The mechanical tests revealed that increasing the amount of TiB2 the Tensile strength, % Elongation, Compression Strength are improved significantly. The amount of TiB2 directly contributed to the strength of the composite. Gr has contributed to increase the hardness of the composite, though it lowered the strength of the composite. The amount of TiB2 and Gr, collectively contributed to the Impact Strength of the composite. 5 % of TiB2 and 2% of Gr is found to be a good combination for increasing the Strength, and hardness of the composite.*

Keywords: **Metal Matrix Composites, Hybrid Metal Matrix Composites, Metal Matrix Nano Composites, stir casting, Aluminum Alloy, Reinforcements**

1.INTRODUCTION

In the modern age, there is increasing demand for the materials which are stronger, lighter and stiffer in the automobile, aeronautics, aerospace and construction industries. Monolithic material cannot provide the required properties which meets the demand of the superior properties. This ever-increasing demand enabled for the development of composite material which increases the overall performance of the material. Composite materials are one of a kind material made from two different materials with different properties. Generally, a composite material is made of matrix and reinforcements. Matrix is the main material of a composite and reinforcements are fractions of material added to the matrix to improve the overall mechanical properties of the composite. Matrix is a continuous phase and reinforcements are discontinuous phase and stronger. Typically, the matrix materials used are metals, polymers and ceramics which form the major part of a composite and reinforcements are fibers, particles, flakes and fillers added to enhance matrix material. Hybrid matrix composites are the second generation of the composites with double reinforcements that can replace the composites with single reinforcement. Hybrid composites possess distinctive features comparative to conventional composites which can be used in a more economical way to meet various design requirements.

Aluminum based composite materials are used in aerospace and automobile industries because of their outstanding properties like light weight, good corrosion resistance and impact resistance. These composites are fabricated by using reinforcements such as Al_2O3, SiC, TiC, B_4C, TiB_2, Gr etc.The present work is aimed to fabricate Hybrid Aluminum metal matrix composites of

different compositions by using TiB_2 and Gr powders as reinforcements and Al7075 as the matrix material. The fabrication of composite is done by high frequency induction furnace stir casting technique. The fabricated composites are tested to evaluate the mechanical properties such as tensile strength, energy absorbed and hardness.

Fig1.1 Samples of Aluminum pieces, TiB_2 and Gr Powder

2. COMPOSITIONS:

Based on the literature reviews conducted it was found that taking the reinforcements in the order of 2-6% will improve the properties of the base material. Therefore various configurations of Al7075 with different amounts of TiB_2 and graphite were taken as shown in table 1

Sl. No	% of Al 7075	% of TiB_2	% of Gr
1	100	0	0
2	95.5	2	2.5
3	93	2	5
4	93.5	4	2.5
5	91	4	5

Table 1: Compositions

Both the micro and nano composite were taken in the same composition. One sample is taken with pure base metal. Later the TiB2 and gr were added to the base metal by taking the weights in accordance with the above table.

3. FABRICATION OF COMPOSITES

3.1 Stir Casting: It is defined as the process in which a mechanical stirrer is used to form vortex, which mixes reinforcement evenly in the matrix material. This process is adopted for mass production, which is cost effective, easier control of composite structure and net shaping.

3.2 Induction Furnace: These furnaces use high voltage currents to generate the magnetic field around the coil in the furnace. Due to high currents the coil gets heated and the heat is transferred to the metal through the crucible. Simultaneously, the magnetic field pushes the atoms of the metal, away from the crucible, which results in the movement of atoms. This movement of atoms causes the stirring action. In this project, high frequency induction furnace of capacity 125KW is used. The base metal Al7075 starts melting at the high temperature in the order of 710°c. The furnace is kept running for few more minutes until total metal is converted to liquid state. Now the reinforcements TiB_2 and Gr are taken in the required proportions. As discussed in the previous section

Fig 3.1 Induction Furnace Stir casting

3.3 Casting: It is the process in which the molten metal is poured into the mold cavity, which is a replica of pattern to be produced and then wait for the molten metal to solidify to obtain the required product. In the present work the molten metal is poured into a mold cavity of size 200mm x100mm x15 mm. The mould is kept aside for 10 minutes to cool down and solidify and then taken out of the mould.

4. SPECIMEN PREPARATION AND TESTING

To evaluate the mechanical properties of the fabricated composites tensile test, compression test, hardness test and impact tests

were conducted to know the yield strength, % elongation, compression strength, hardness and impact energy of the composites. The tensile test and compression tests were performed on the computerized universal testing machine and the specimens were cut according to ASTM-E8 standards. Hardness tests were conducted on the Brinellhardness measuring instrument and the specimens are cut according to ASTM-E10 standards. Impact tests were conducted on charpy machine and the specimens were cut according to ASTM-E23 standard. The specimens of the different tests after cutting to their respective ASTM standard sizes are shown below.

Fig 4.1 Tensile Test Specimens

Fig 4.2 Hardness Test Specimens

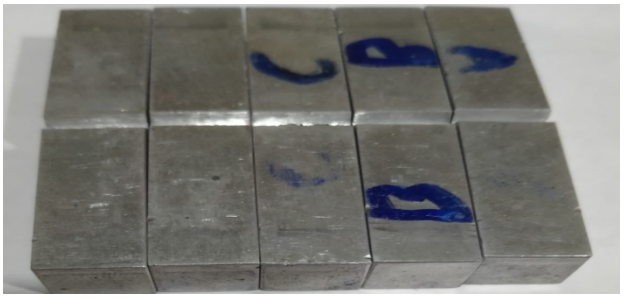

Fig 4.3 Impact Test Specimens

5. RESULTS DISCUSSION

5.1 Tensile Test:

The table 5.1 presents the results of yield strength, % elongation of samples with different compositions. The variation of the yield strength and the % elongation is depicted in the graph 5.1.

Sl. No.	% of Al 7075	% of TiB_2	% of Gr	Yield Strength (N/mm^2)		% Elongation	
				Nano	Micro	Nano	Micro
A	100	0	0	153.9	153.9	2.10	2.10
B	95.5	2.5	2	161.6	154.2	3.24	2.16
C	93.5	2.5	4	156.5	147.3	2.36	2.28
D	93	5	2	184.6	166.5	4.38	2.80
E	91	5	4	169.1	158.9	2.86	2.36

Table 5.1 Values of Tensile strength and % Elongation

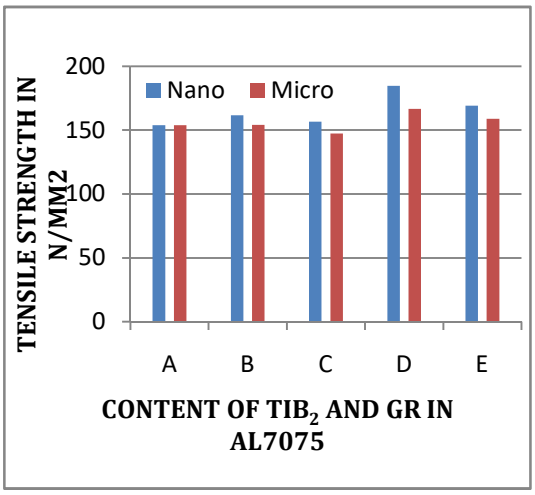

Fig 5.1 Variation of tensile Strength

It is observed that in both micro and nano composites, by adding 2.5% TiB_2 and 2% of Gr, there is slight increase in the yield strength of the composites, but the increase is higher in nano composites compared to the micro composites. Whereas the %elongation has improved significantly in nano composite, compared to the micro composites. By increasing the amount of TiB_2 to 5% the tensile strength has improved in both micro and nano composite, more change is observed in the nano composite compared to the

micro composite. The % elongation of the nano composite has increased more than the micro composite by increasing the TiB_2 to 5%. Keeping the amount of TiB_2 same and increasing the amount of Gr to 4% has shown the decrease in the tensile strength in both the micro and nano composites, but the decrease in nano composites is more compared to the micro composite. The %elongation has decreased more in the nano composite compared to the micro composite.

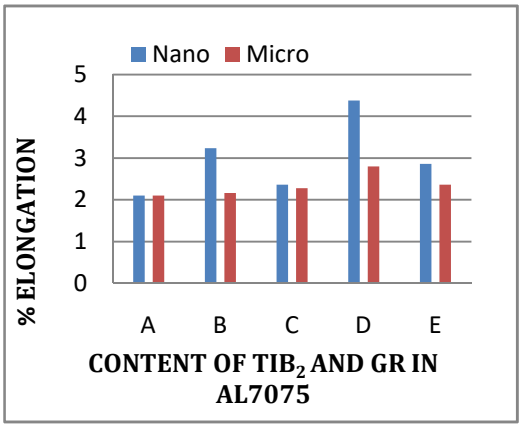

Fig 5.2 Variation of % Elongation

5.2 Compression Test:

The table 5.2 shows the values of compression strength for different compositions of TiB_2, Gr in the metal matrix of Aluminum 7075 alloy.

It is observed that by increasing the amount of TiB_2 and Gr has shown increase in the compression strength in both nano and micro composites. The change in micro composites is more compared to the nano composites. Further increase in the amount of Gr has shown only slight increase in the compression strength in both the composites. By increasing the amount of TiB_2 to 5% by keeping the Gr at 2.5% the compression strength has increased more in the nano composites compared to the micro composites. Keeping the amount of TiB_2 at 5% and increasing the amount of Gr to 4% has shown decrease in the compression strength in both the composites. But the decrease is higher in the micro composites.

Sl No.	% of Al7075	% of TiB_2	% of Gr	Compression Strength (N/mm^2)	
				Nano	Micro
A	100	0	0	422.386	422.386
B	95.5	2.5	2	431.515	424.728
C	93.5	2.5	4	439.827	428.488
D	93	5	2	451.187	440.129
E	91	5	4	448.272	431.961

Table 5.2 Compression Strength Values

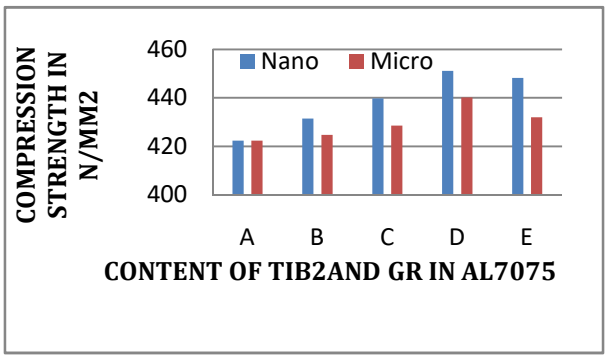

Fig 5.3 Variation of Compression Strength

5.3 Hardness Test:

The Brinell hardness numbers are shown in the table5.3. The variation of BHN with different compositions is shown in the fig 5.4 below.

Sl. No	% of Al7075	% of TiB_2	Gr	Brinell Hardness numbers (BHN)	
				nano	micro
A	100	0	0	110.5	110.5
B	95.5	2.5	2	122.9	112.9
C	93.5	2.5	4	126.5	121.5
D	93	5	2	144.5	138.7
E	91	5	4	130.9	126.5

Table 5.3 Brinell Hardness Numbers

From the tests it is observed that, the hardness of the nano composites has increased more than the micro composites when 2..5 % TiB2 and 2 % Gr is added. By further increasing the amount of Gr to 4 % and also the TiB2 to 5 % the hardness has increased in both Nano and Micro composites. But when the 5% of tiB2 and 4% of Gr

were taken then the hardness has decreased than the previous case.

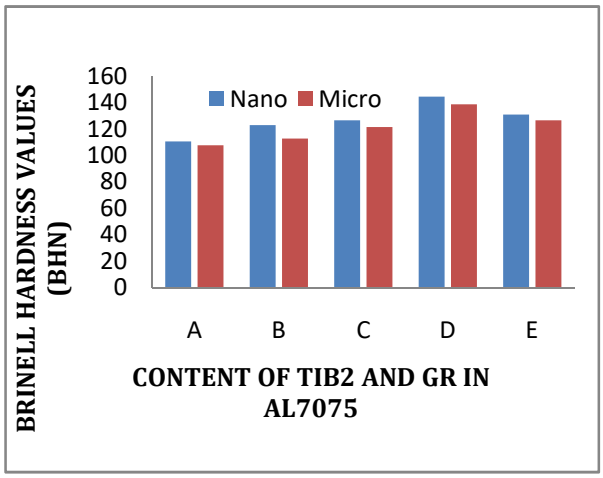

Fig 5.4 Variation of Brinell Hardness Numbers

4. Impact Test:

The table 5.4 shows the Impact energy values in joules and also figure 5.5 depicts the variation of Impact energy for different compositions.

Sl.No.	% of Al7075	% of TiB_2	% of Gr	Impact Energy (Joules)	
				Nano	Micro
1.	100	0	0	2	2
2.	95.5	2.5	2	2	2
3.	93.5	2.5	4	2	2
4.	97	5	2	6	4
5.	91	5	4	4	2

Table 5.4 Imapct Energy Values

It is observed that by adding small amounts of TiB_2(2.5%) and Gr(2%, 4%) has significantly not improved the impact energy values of the both micro and nano composites. But further increasing the amount of TiB_2 to 5% keeping the Gr at 2% has shown significant improvement in the impact energy. Still increasing the amount of Gr to 4% keeping TiB2 at 5% has shown decrease in the impact energy values.

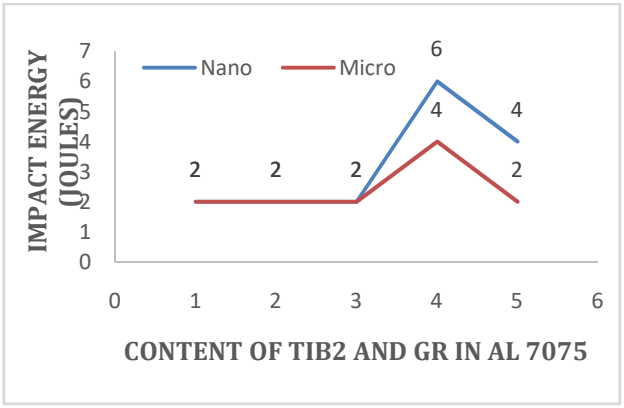

Fig 5.5 Variation of Impact Energy

6.CONCLUSIONS

By conducting different tests like tensile, compression, hardness, impact test, the following conclusions were made

By adding the TiB2 to the AL7075 the strength and % elongation has improved significantly. The amount of the TiB2 directly reflects in the strength of the both the micro and nano composite.

Addition of Graphite to the composite, resulted in the decrease of tensile strength and % elongation of the composite. But it has improved the hardness of the composite. Composite with 4% of graphite has shown good hardness values to the composite.

The impact strength of the composites has improved significantly by adding TiB2. Both nano and micro composite have shown good impact strength when 5% of TiB2 and 2% Gr are added. But the impact strength has dropped when the Gr % has Increased to 4%.

Both Micro and Nano composites have shown positive trend in the tensile strength, % elongation, Impact strength when amount of TiB2 has increased, but negative trend is observed with increasing Graphite %

The Nano composites are more sensitive to TiB2 compared to the Micro composites.

The amount of Gr significantly reflects in the hardness of the composite both in micro and nano composites.

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