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CHARACTERIZATION OF ALUMINIUM METAL MATRIX COMPOSITES FABRICATED BY STIR CASTING

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ABSTRACT - *The heighten require for lighter materials with more withstand load Capacity in the field of automobile, aerospace and marine leads to the produce of new Aluminium metal matrix composites. The current work focuses on the preparation and characterization of composites. The AA7075 was selected as matrix metal and the graphite and iron powders (Gr,Fe) were selected as reinforcement to improve the mechanical properties of the composite. A hybrid Aluminium matrix composite was fabricated using stir casting technique, by adding 0, 1.5, 2.5 wt.% volume fraction of reinforcement particles such as graphite and iron powders. To study the effect of Gr and Fe particles in composite, tensile strength is measured using a universal testing machine as per the ASTM standards. Through the results, the tensile strength of the composites was gradually increased with the addition of reinforcements. The maximum tensile strength obtained on specimen at 2.5 wt.% when compared to 0 % of reinforcement composites.*

Keywords: AA 7075; graphite; stir casting; Hybrid composite;

1. Introduction:

Aluminium Metal matrix composites acquire several advantages among other base metal alloy materials which are low weight and high strength. Composites are mainly reinforced with mostly ceramic materials[1]. Silicon carbide (SiC), zirconium(Zr), tungsten carbide (WC), carbon nano tube (CNT), graphite (Gr), aluminium oxide (Al2O3), Silica(SiO2) and boron carbide (B4C) are a selection of the reinforcement particulate that has been considered.[1-8]. This technique offers some advantages such as: (a) fine and homogeneous distribution of the alloying elements and the reinforcing particles in the matrix, avoiding segregation of the reinforcement[1,].Usually all researches are focused on the wear properties of the aluminium alloy and amongst the various ceramic reinforcements, SiC, graphite are used with several materials and resulted in improved wear properties [1,2,6]. Al-7xxx series alloy also called aluminum–zinc alloy due to maximum zinc quantity ranging between 5.1 and 6.1 percent and chemical composition shown in Table 1. These series were invented first by Japanese company, in the year 1943 for production of airframe in the Navy[2]. Many researchers found that the inhomogeneous distribution of reinforcement particulates on the molten matrix, poor wettability, surface tension and high interfacial energy had reduced the mechanical properties [3]. The properties of the composites can be increased by preheating the reinforcement for removal of absorbed gas and moisture [3,4] The primary purpose of alloying 7075 Al alloy is to enhance toughness, corrosion resistance, machinability, and weldability.[5,9]. Mechanical Properties of 7075 Al-alloy are given in table 2.wear and mechanical characteristics of al 7075/graphite composites. Gr melting point is very high and also it is expensive .it is the very efficient reinforcement for 7xxx series of aluminium alloy. But the proper stirrering was required to mixing it with base metal, that the strength will be increased.[6,8,12]. In the field aluminium based hybrid composites, to explore the materials for automotive and aerospace applications. Stir casting is one of the novel methods to produce metal matrix composites with more uniform distribution of matrix and reinforcement constituents[11,14,15].It is evident that the minimum wear rate and coefficient of friction are possible mainly by the addition of the optimal level of graphite particulates to the base alloy, such as aluminum alloy. Hence, there exists a scope for future research work on the further identification and development of the potential of 7075 aluminum alloy–graphite composite[6,8,15].Therefore, the present work was planned to investigate the effect of aluminum matrix reinforced with “graphite and iron powder" particles using stir casting technique, for economical development of aluminum casting composite materials for engineering applications. The details of the research work are given in the subsequent sections.

2. Material Selection and Volume Fraction of Reinforcement:

2.1 Base metal: Aluminium alloy 7075

Aluminium 7075 is an aluminium alloy, with zinc as the primary alloying element. It is a strong material by strength comparable to many steels, and has good fatigue strength and average machinability. It has lower resistance to corrosion than other aluminium alloys, but has significantly better corrosion resistance than the 2000 alloys. It is relatively high cost material.

Table 2.1 Chemical Composition of AA7075 (weight %)

Elements	Zn	Mg	Ti	Si	Mn	Fe	Cu	Cr	Al
Wt. % composition	5.92	2.8	0.02	0.05	0.01	0.15	1.93	0.193	Bal

Table 2.2 properties of AA7075:

Density	2810 Kg/m^3
Melting Point	635˚C
Modulus of Elasticity	70-80 GPa
Poisons Ratio	0.35
Specific Heat Capacity	960 Kg-K
Tensile Strength	230 Mpa
Yield Strength	105 Mpa

2.2 Reinforcement Materials

2.2.1. Graphite powder:

Graphite is made up of only carbon atoms. Therefore, the chemical formula of graphite is C.

- Specific gravity - 1.9 – 2.3
- Density - 2.09–2.23 g/cm^3

2.2.2. Iron powder:

Iron is a chemical element with symbol Fe . It is by mass the most common element on Earth .The word is derived from the Latin word ferrum ("iron")

With additions of Fe reinforcement, the modulus increases, the role of the interfacial bond between Fe particulates and the aluminum matrix may further detract from the mechanical properties when the composite is subjected to high temperatures.

Table 2.3 Properties of (Fe) iron:

Thermal expansion	11.8 µm/(m·K) (at 25 °C)
Thermal conductivity	80.4 W/(m·K)
Electrical resistivity	96.1 nΩ·m (at 20 °C)
Curie point	1043 K
Young's modulus	211 GPa
Shear modulus	82 GPa
Poisson ratio	0.29
Bulk modulus	170 GPa

2.3 Volume fraction of reinforcements:

A hybrid aluminium matrix composite with AA7075 aluminium alloy as matrix material was fabricated using stir casting technique, by adding 5 wt.% volume fraction of reinforcement particles such as graphite and iron powders. To study the effect of Gr and Fe particles, composites were created with individual reinforcements also, for 5 wt.% volume fraction. volume fraction of reinforcements is shown on table 2.4.

Table 2.4 Volume Fraction of Reinforcements

MATERIALS	AA7075 (wt.%)	Graphite (wt.%)	Iron – Fe (wt.%)
AA7075/Gr/Fe	95	2.5	2.5
AA7075	100	0	0
AA7075/Gr/Fe	97	1.5	1.5
AA7075/Fe	95	0	5
AA7075/Gr	95	5	0

3. Experimental Work

Stir Casting is a liquid state method for the fabrication of composite materials, in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring.The stir casting technique was used to fabricate the composite specimen as it ensures a more uniform distribution of the reinforcing particles. This method is most economical to fabricate composites with discontinuous fibers or particulates.

In this process, matrix alloy (AA 7075) was first superheated above its melting temperature around 800 degree Celsius and then temperature is lowered gradually below the liquidus temperature to keep the matrix alloy in the semisolid state. At this temperature, the preheated reinforcement particles around 200 degree Celsius were introduced into the slurry and mixed using a stirrer.

The composite slurry temperature was increased to fully liquid state and automatic stirring was continued to about five minutes at an average stirring speed of 300-350 rpm under protected organ gas. The particles distributing uniformly throughout the matrix alloy. The melt was then superheated above liquidus temperature and finally poured into the die mould for testing specimen. The specification of the fabricated composite is 280 mm height and 28 mm diameter. The process parameters of stir casting are shown below.

3.1 Process Parameters:

- Furnace Temperature - 800 °C
- Furnace capacity - 1000 - 1200 Grams
- Stirrer Speed - 350 RPM
- Stirring Temperature - 750 °C
- Stirring Time - 8 minutes
- Preheat Temperature of Reinforcement - 250 °C

3.2 Fabricated Composite Component With 5 Different Volume Fraction:

The fabricate composite component is shown in figure 1.

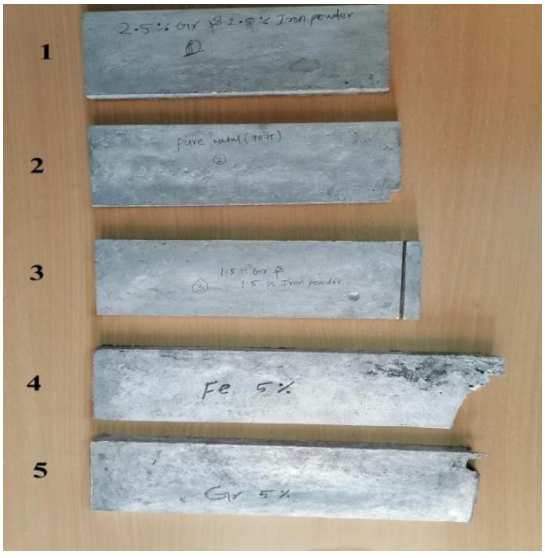

Figure 1- fabricated composite plates

(1) - component 95% AA7075 / 2.5% of each Gr & Fe

(2) - component 100% AA7075

(3) - component 97% AA7075 / 1.5% of each Gr &Fe

(4) - component 95% AA7075/Fe 5%

(5) - component 95% AA7075/Gr 5%

4. Mechanical Testing:

Tensile Test:

The Tensile test was done as per the ASTM E8 standard. The tensile specimen shown on figure 2.and the tensile results was shown on table 4.1.

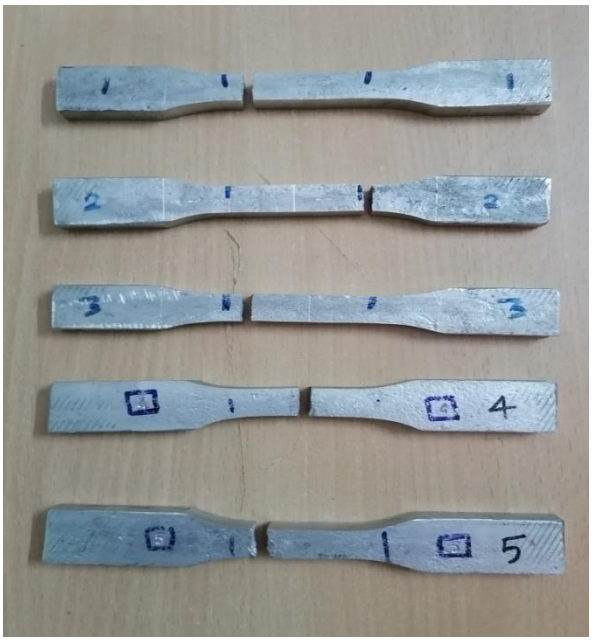

Figure 2- tensile specimen as per E8 standard.

Table 4.1: tensile test results

Specimen	MATERIALS	Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Percentage of Elongation (%)
1	AA7075/Gr 2.5% /Fe 2.5 %	40.86	87.02	1.04
2	AA7075	22.58	50.91	3.82
3	AA7075/Gr 1.5% /Fe 1.5%	37.88	84.00	2.94
4	AA7075/Fe 5%	72.63	107.28	2.90
5	AA7075/Gr 5%	83.24	140.16	3.38

4.2 Result and Discussions:

- AA7075 – iron powder and Graphite powder composites were developed by using stir-casting method.
- The investigation results are tabulated and shows increase in mechanical properties when both graphite and iron powder reinforcements are increased.
- The max tensile strength obtained at 5% of Gr is 140.16 N/mm^2. And also at 5% of fe is 107.28 N/mm^2.
- In the hybrid composite 2.5 % of Gr and 2.5% of Fe the max tensile strength was obtained is 87.02 N/mm^2. From the following results the tensile strength was gradually increased when reinforcement weight percentage increased.

5. Conclusion:

In the current research work, various percentages of reinforcements of graphite and iron powders were added to Al7075 were fabricated by stir casting technique. The tensile properties were studied. The following conclusions were reported.

- In the hybrid composite the max tensile strength was obtained is 87.02 N/mm^2. From the following results the tensile strength was gradually increased when reinforcement weight percentage increased.
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