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Comparative Studies on Mechanical Properties of Granulated Blast Furnace Slag, AA7075 and Pure Al Reinforced With Al-Sic Composite

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Abstract – In the present industrial scenario , Al-Sic composite`s containing different weight percentages such as AA7075 2%,GBF Slag4%, ,Pure Al 2%GBF slag 2 % mixed with Al-Sic And Pure Al 3% GBF Slag 1% and AA7075 2 % mixed with Al-Sic his are giving very high strength and low weight ratio. These metal matrix composites are produced by stir casting method. This method is less expensive and very effective four samples of composite materials have been prepared according to the ASTM standard of Tensile, Density and Compression tests are carried out by using experimental procedure. Mostly MMCS are used in Aeronautical and Automobile. The best results are obtained at And Al 3% GBF Slag 1% and AA7075 2 % of standard size Al-Sic Particles.

Key Words: Al-Sic Composite, Stir Casting, MMCS, GBF Slag, Pure Al, AA7075.

1. Introduction

Metal Matrix Composition (MMCs) are advanced materials Resulting from a combination of two or more materials in which tailored properties are realized. Al MMCs are most promising materials of recent interest, these poses high specific strength, higher wear resistance and lower thermal expansion coefficient in comparison to their base alloy matrices due to the incorporation of suitable particles or fibers into matrix metal.[1][2] Present scenario manufacturing of MMCs is improved. Widely due to the high strength because when particles like TiB2, Tic, Al2o3, BF4 etc. are reinforced with al-alloys and finding out stir casting process is simple and this process mostly improved because MMCs are, mostly used in Aerospace and Automotive Applications and cost still remains a major barrier in designing and then Is particles reinforced Al- Composite Component for wider applications[3]. Blast furnace slag is the one major byproductof pig iron production, regularly generated each year in significant volumes as thousands of Tons Granulated blast furnace slag (GBF slag) is obtained by Quenching molten iron slag (a byproduct of iron making) from a Blast furnace in water or steam, to produce a glassy, Granulated Product. National Slag Association (NSA) USA was established in the year 1918. It is in the process of instituting a university educational program as a means to introduce blast slag as a Beneficial material to the engineering environmental department of the major universities in USA[4].10 Million tons of blast furnace slag Produced in India annually as a byproduct of iron and steel industry. chemical analyses of blast furnace slag is usually show that four major oxides (Lime ,Magnesia, Silica, Alumina) make up about a 95% of thetotalminorelementsincludeSulfur,iron,Mangenese,Alkalis,and trace amounts of several others this by product as the potential for increased value diversity of suitable end product could be produced from this materials.it has been observed that the GBF slag that is produced in the steel plants in huge quantities is dumped in the dump-yard and then later used for Road construction mostly in the plant itself; however this uses in practical purpose is only limited in overall consumption of slag[5].Hence, in the present research work an attempt was made to see the possibility of adding these solid wastes as Reinforcing particles in Aluminum matrix to produce the low cost, light weight and high specific strength Aluminum Metal Matrix Composites (AMMCs)[6].In the present investigation Al-Sic alloy was chosen as matrix material because of its wider applications in the family of aluminum-copper alloys. This alloy has a higher tensile and yield strength with lower elongation Typical uses of this alloy are aircraft structures, rivets, hardware, truck wheels and screw machine products. At present very limited information is available on the GBF slag reinforced Al-Sic alloy composites [7]. Therefore the present investigation makes an attempt to synthesize the fly ash and GBF slag reinforced Al-Sic alloy composites by stir casting route; later these composites were characterized in terms of tensile, density, hardness and mechanical properties under compression[8].

2. Experimental Setup

2.1 Materials:

Al-Sic was used as matrix material and AA7075, Pure Al and Pure Al particles were added as reinforcements to prepare composites in this study. The chemical composition of Al –sic used as matrix material is given in Table 1. To increase the wettability of Composite in the molten Al-Sic, 1 Vol. % of magnesium (Mg) was added to molten Al-Sic during casting.

Table 1. Composition of Al-Sic used as matrix material (Vol. %)

Elements	Al	Sic
Vol%	75	25

The reinforcement materials were Pure Al, AA7075and granulated blast furnace slag particulates which were procured from Thermal power plant and Iron making plant (Blast Furnace area) respectively of RashtriyaIspat Nigam Limited (RINL), Visakhapatnam Steel Plant, and Visakhapatnam, India. The chemical composition of the as received Pure Al, AA7075 and granulated blast furnace slag was given in Table 2, Table 3 and Table 4

Table 2. Composition of Pure Al used as matrix material (Wt. %)

Elet's	Fe	Si	Cu&Na	Mg&Ti	V&Zn	Mn	Al
wt.%	0.09	0.05	0.005	0.004	0.008	0.001	Remains

Table3.Composition of AA7075 used as matrix material (Wt. %)

Elements	Al	Cr	Cu	Fe	Mg	Mn	Si	Ti	Zn	Other each
Wt%	91.4	0.28	2	0.5	2.9	0.3	0.4	0.2	6.1	0.20

Table 4.Composition of GBF Slag used as matrix material (Wt. %)

Elements	Cao	Sio2	Al2O3	Mgo	Feo	Mno
Wt%	38	40	222	11	0.49	2

Figure2. 1.1 shows the Al-Sic,AA7075 ,Pure Al, and As received blast furnace slag was observed coarse in nature; hence it underwent crushing and grinding operation. As received and processed blast furnace slag powders were shown in Figure 2.1.2

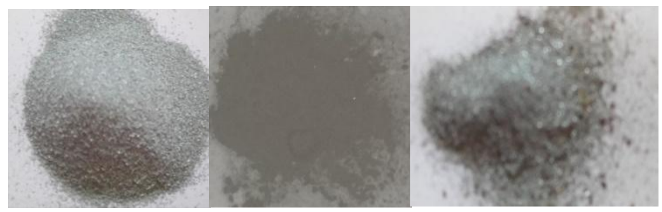


Fig.2.1.1 shows the Al-Sic, AA7075 and Pure Al

A B

Fig2.2.2.Shows GBF Slag A). Original GBF slag B). Crushed GBF Slag

2.2 Stir Casting:

Figure 2.2 and stir casting furnace. Stir casting method is used to melt the Al-Sic ingots.

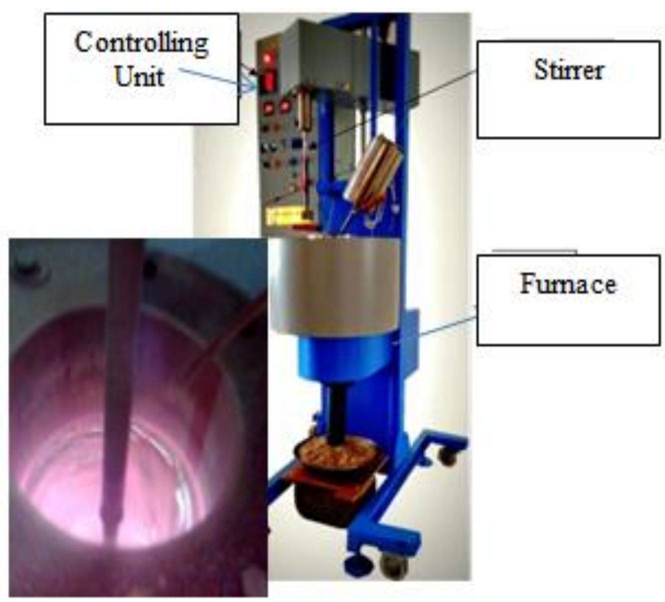


Figure 2.21: Experimental set up with bottom casting facility for synthesis of Al-Sic composites.

In a stir casting process, the reinforcing phases are distributed into molten matrix by mechanical stirring. The melting capacity of the stir casting furnace is 2 kg at a Temperature of 613 °C. A stirrer positioned at the top of the furnace is used to mixing the reinforcement in the molten metal. An electric motor is used to rotate the stirrer through belt drive, at 1800 rpm. As Stirrer has to rotate at 500 rpm, the shaft and the stirrer have large pulley which reduce the rpm. In this process, the matrix material is heated to above its liquids temperature so that the metal is totally melted. The melt is then cooled down to a temperature between the liquids and solidus points and kept in a semi-solid state. At this stage and particles are added and mixed.

2.3 Fabrication:

Al-Sic particle is charged into the crucible. Switch on the furnace and temperature is gradually raised up to 613°C molten metal in main Stirrer with 5minutes. From the stirring action of 5 minutes the reinforced material is evenly distributed entire liquid metal. Clean the die before pouring the liquid metal, so that it reduces the solidification rate. Magnesium is added to the liquid metal which increases the welt ability of the matrix and assisted particle incorporation. The liquid stage metal matrix composite is taken out and poured in to the die then cooled.

3. TESTING

3.1 Tensile Strength:

The tensile test is the most widely used test to determine the mechanical properties of materials. In this test, a piece of material is pulled until it fractures. Test is carried out by using electronic Tensometer shown in fig 3.1and load is obtained when specimen is goes to break point and displacement point are also obtained. This test is carried out with respect to different compositions. Fig 3.2 ASTM: E8/E8M-11 standards Tensile Specimens.

Fig 3.1.1 ASTM: E8/E8M-11 standards Tested Tensile Specimens and setup.

3.2 Density Test &Porosity:

Density is measure of mass per unit volume .it is measured by using Archimedes principle, the object is prepared by using ASTM ISO2811 Standards. When object is immersed in liquid, difference between two masses (in grams) will equal (Almost Exactly)the volume(in ml)of weighted, knowing the mass and object allows us to calculate the density test carried out with a setup and specimen fig.3.2.1

A B

Fig 3.2.1Density Test A) Experimental Setup B) Sample Specimens

Formulae used for Density test is

Density= (Mass/Volume) g/cc

Porosity: PMMC= (m)/ ((m-m1) × (ρH_2o).

m :Mass of composite in Air in grams

m1=Mass of same composite in distilled water and density of distilled water 0.998g/cm3

According to rule of mixture theoretical calculations can be done by using formulae

$\rho c = vr\rho r + (1-vr)\,\rho m$

Where

ρc=Density of composite

vr=Weight ratio of reinforcement

ρr=Density of reinforcement

ρm=Density of Unreinforced Al-Sic

Porosity= (1-(measured/calculated)) × 100

3.3. Compressive Test:

Compressive test carried out by using UTM (Universal Testing Machine) and sample is prepared as shown in fig.3.3.1, when a sample is placed in between two plates and compression done up to 11mm then load is applied in upward direction then sample is shorten in the direction of applied forces and expands in the direction perpendicular to the force. Compression test is essentially the opposite of the more common tension test. Compressed samples shown in fig.3.3.2

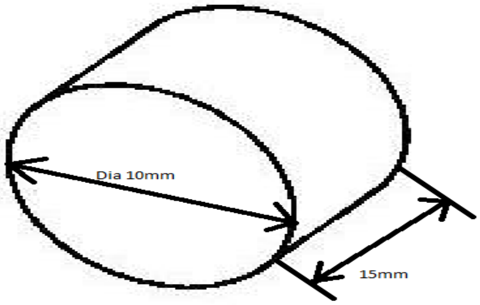


Fig.3.3.1: Schematic Representation of Compressive Test Sample

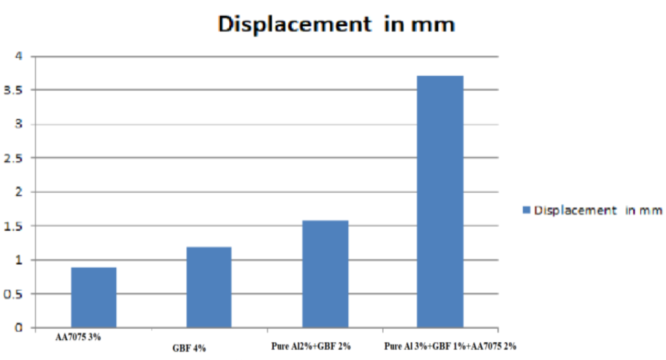
Fig 3.3.2 Compressed Specimens and setup on UTM

4. Results & Discussions:

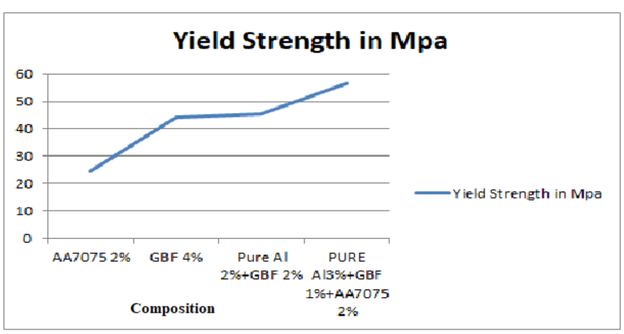
4.1.1 Tensile Test Results:

1. For testing we carried out Electronic Tensometer and results shown in graphical way.

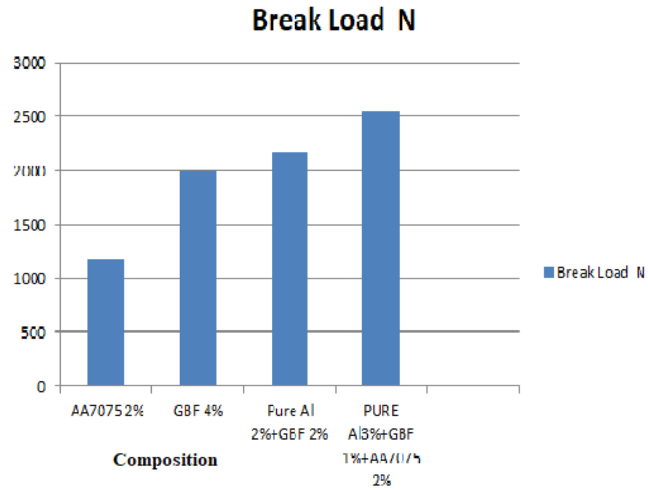
2.Displacement and Yield Strength Graphs Drawn by using Formulae's.



Graph4.1. 1: A)CompositionVs Displacement in mm



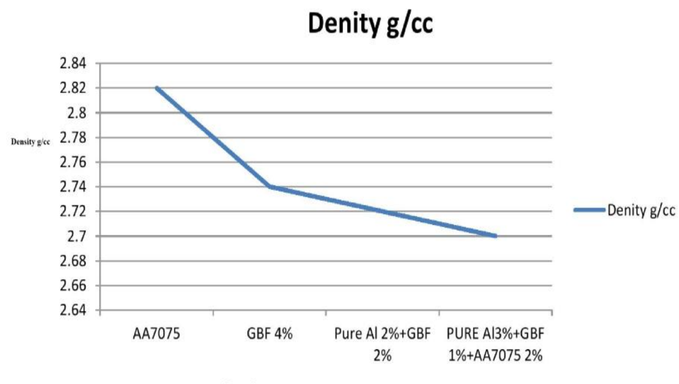
Graph 4.1.1 B) Composition Vs Yield Strength in Mpa



Graph 4.1.1 C) Composition Vs Break Load in N

4.1.2 Density Test Results:

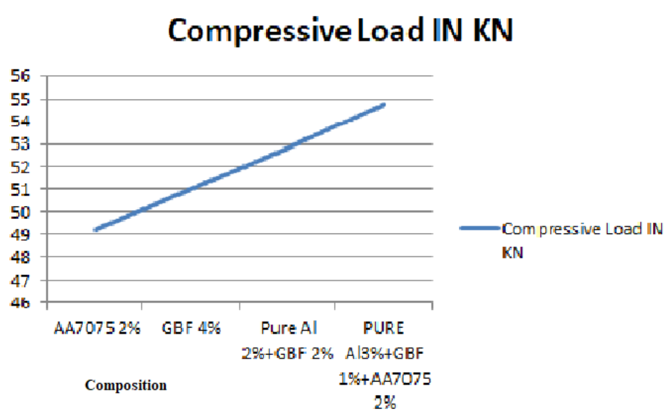
Test done by using Archimedes Principle and results shown in graphical way.



Graph 4.1.2 Composition Vs Density in g/cc.

4.1.3 Compressive Test Results:

By using UTM we have done compression test and results are drawn graphically.



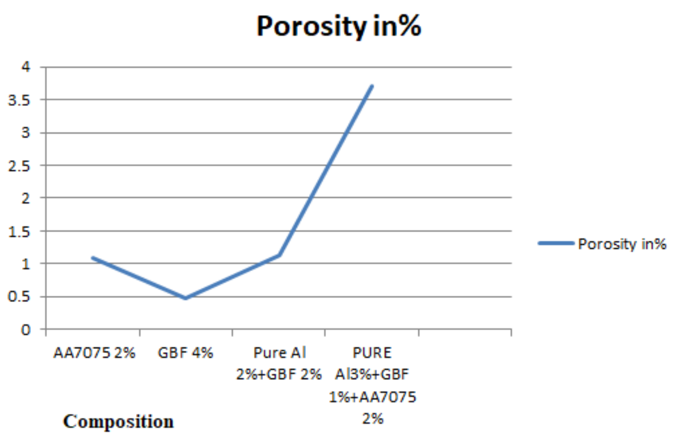
Graph 4.1.3 Composition Vs Compressive Load in KN

4.1.4. Porosity:

Porosity is Calculated By using Formulae's is mentioned in 3.2 Density & porosity

Table5. Theoretical and measured densities of Al-Sic Composites by varying Different wt.% and % porosity in respective alloy and compositess.

Specimen	Density(g/cc)		%porosity
	Theoretical	Measured	
AA7075 2%	2.82	2.7892	1.09
GBF 4%	2.74	2.727	0.47
Pure Al2%+GBF 2%	2.72	2.689	1.13
Pure Al3%+GBF 1% +AA70752%	2.7	2.6766	3.70



Graph4.1.4: Represents Composition Vs %Porosity

5. Conclusion:

Industrial wastes like GBF slag were utilized successfully for the production of Al-Sic based MMCs. Al-Sic-GBF slag composites were produced by stir casting route successfully. There was a uniform distribution of reinforcement particles in the matrix phase and also existing a good bonding between matrix and reinforcements. The Tensile strength and compression Strength of the composites increased whereas the density of the composites decreases with presence of reinforcement than the base alloy. Enhanced mechanical properties were observed for Different composites than alloy under compression.

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