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Research Paper

EFFECT OF FLY ASH, E-GLASS ON TENSILE STRENGTH AND HARDNESS IN AL 7075 BASED HYBRID COMPOSITE

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Metal Matrix Composites (MMC's) consists of either pure metal or an alloy as the matrix material, while the reinforcement generally a ceramic material. MMCs are widely used in space shuttle, commercial airliners, Electronic substrates, bicycles, automobiles, Golf clubs, and a variety of other applications. While the vast majorities are Aluminum matrix composites. The key features of MMCs are high specific strength and stiffness, improved wear resistance, high electrical and thermal conductivity. Hence, it is proposed to form a new class of composite, Al (7075) alloy reinforced with E-glass and Fly ash particulates to form MMC using graphite die casting. The MMC is obtained for the different compositions of E-glass and Fly ash particulates

The test specimens are prepared to the standard size by turning and facing operations to conduct tensile, hardness tests and subjected to heat treatment. The specimens were tested for tensile test at different loads by using Universal Test Machine, test for hardness, by using Brinell hardness testing machines. The results are plotted and it is concluded that the MMC obtained has got better tensile strength and hardness, compared to Aluminum alloy (7075) alone.

Keywords: MMC, Fly ash, E-glass, A1 (7075)

INTRODUCTION

A composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications. Modern composite materials are usually optimized to achieve balance of properties for a given range of materials that may be considered as composites and the broad range of uses for which composite materials may be designed. Composites are commonly classified at two distinct levels. The first level of classification is usually made with respect to the matrix constituent. The major composite classes include metal matrix (MMC's), ceramic matrix composites (CMC's). The term "organic matrix composite" is generally assumed to include

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two classes of composites: polymer matrix composites (PMC's) and carbon matrix composites (commonly referred as carbon – carbon matrix) carbon matrix composites are typically formed from PMC's by including the extra steps of carbonizing and densifying the original polymer matrix. The second level of classification refers to the reinforcement form – particulate reinforcements, whisker reinforcement, continuous fiber laminated composites, and woven composites in order to provide useful increase in properties**.**

METAL MATRIX COMPOSITES (MMC's)

The term Metal Matrix Composite (MMC) covers a wide range of material combinations. It can include materials such as glass fibers contained in a lead matrix or something altogether different such as carbon fibers in a titanium matrix. The combinations are endless. Knowing the microstructure of these composites can provide important information about their physical and mechanical properties. Metal-matrix composites are either in use or prototyping for the Space Shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs, and a variety of other applications. The properties of the composite depend to a great extent on the combination of the properties of the matrix and the fibers

Aluminum is the third most abundant element in the earth's crust, which contains 8% Aluminum. It is a constituent of most rocks and in the form of Aluminum silicate it is an important source of clays commercially, the most important source of the metal is bauxite which contains 52% Al203, 27.5% Fe203 and 20.5% H20, Bauxite is treated with caustic soda and calcites at 1200° produce high purity alumina. The alumina is then smelted electrolytic cell to produce pure Aluminum.

ALUMINIUM 7075 ALLOY (MATRIX)

7075 is an aluminum alloy, with zinc as the alloying element. It is strong, with good fatigue strength and average machinability, but is not weldable and has less resistance to corrosion than many other alloys.

Table 1: Chemical Composition of Al 7075

Composition Details	% Composition
Zinc	5.1 - 6.1
Magnesium	2.1 – 2.9
Copper	1.1 – 2.0
Chromium	0.18 - 0.28
Fe	<=0.50
Si	<=0.40
Mn	<=0.30
Ti	<=0.20
Zr+Ti	<=0.25
Total Other	<=0.15
Aluminium	Remainder

Table 2: Physical Properties Al 7075

Physical properties	Range
Density	2.8 (gm/cc)
Melting point	475^0C- 635^0 C
Thermal conductivity	155 (Wm-1 K –1)

FLY ASH (Reinforcement)

Fly ash closely resembles volcanic ashes used in production of the earliest known hydraulic cements many years ago. Those cements were made near the small Italian town of Pozzuoli - which later gave its name to the term "pozzolan."

Table 3: Mechanical Properties Al 7075

Mechanical and elastic properties	Range
UTS	225-570 (MPa)
Shear stress	150-350(MPa)
Brinell hardness	65-70
Modulus of Elasticity	72000 (MPa)
Modulus of Rigidity	27100 (MPa)
Poisson's Ratio	0.33

Figure 1: Ingots of Al-7075

Figure 2: Fly Ash

Instead of volcanoes, today's fly ash comes primarily from coal-fired electricity generating power plants. These power plants grind coal to powder fineness before it is burnt. Fly ash - the mineral residue produced by burning coal - is captured from the power plant's exhaust gases and collected for use. Fly ash is a fine, glass powder recovered from the gases of burning coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron.

PHYSICAL PROPERTIES

Fly ash consists of fine, powdery particles that are predominantly spherical in shape, either solid or hollow, and mostly glassy (amorphous) in nature. The particle size distribution of most bituminous coal fly ashes is generally similar to that of silt (less than a 0.075 mm or No. 200 sieve). Although sub bituminous coal fly ashes are also silt-sized, they are generally slightly coarser than bituminous coal fly ashes. The specific gravity of fly ash usually ranges from 2.1 to 3.0, while its specific surface area (measured by the Blaine air permeability method) may range from 170 to 1000 m^2/kg. The color of fly ash can vary from tan to gray to black, depending on the amount of unburned carbon in the ash. The lighter the color, the lower the carbon content. Lignite or sub bituminous fly ashes are usually light tan to buff in color, indicating relatively low amounts of carbon as well as the presence of some lime or calcium. Bituminous fly ashes are usually some shade of gray, with the lighter shades of gray generally indicating a higher quality of ash.

E-GLASS

E-Glass or electrical grade glass was originally developed for standoff insulators for electrical wiring. It was later found to have excellent fiber forming capabilities and is now used almost exclusively as the reinforcing phase in the material commonly known as fiberglass. Glass fibers are generally produced using melt spinning techniques. These involve melting the glass composition into a platinum crown which has small holes for the molten glass to flow.

Composition of E-glass

E-Glass is a low alkali glass with a typical nominal composition of SiO_2 54wt%, Al_2O_3 14wt%, CaO+MgO 22wt%, B_2O_3 10wt% and Na_2O+K_2O less than 2wt%. Some other materials may also be present at impurity levels.

Properties of E-Glass

a) Low cost
b) High production rates
c) High strength
d) High stiffness
e) Relatively low density
f) Non-flammable
g) Resistant to heat
h) Good chemical resistance
i) Relatively insensitive to moisture
j) Good electrical insulation

Figure 3: E Glass

FORMATION OF COMPOSITE

Furnace: In foundry practice, melting is the second important operation next to mould making. Usually the molten metals from the blast furnace, steel making furnaces and other nonferrous metal smelting furnaces are not cast directly. This is because, the metal may not be in a refined state and it is difficult to pour large quantity of molten metal directly. The product from smelting furnaces is cast into some regular shapes, like pigs in the case of pig iron from blast furnace, and these are re-melted in different furnaces with addition of alloying elements, scrap, flux, etc., to obtain the required composition. Furnaces for melting selected based on many factors.

Figure 4: Induction Furnace

Casting: In this process, the required quantity of aluminum 7075 is pre-decided and as per requirement the quantity of E-Glass and Fly ash is calculated. After calculation, the ingots of aluminum 7075 is cut into small pieces and added into the crucible which is preheated and then it is kept for melting. After getting molten stage we are going to add degassifier such as hexachloroethane to remove hydrogen from molten metal in order to avoid void formation during solidification. After adding the degassifier to molten metal the preheated E-Glass and Fly ash is added to the crucible and by making use of mechanical stirrer it is thoroughly mixed. After reaching nearly 700^{0}C the molten metal poured into the pre-heated moulds or dies. And it is left for solidification.

Figure 5: Test Specimens After Machining

Tensile Strength

Tensile test was carried out as per ASTM 8 standards for as cast and heat treated specimen and the values are tabulated as given below.

Figure 6: Specifications of Test Specimens for Tensile

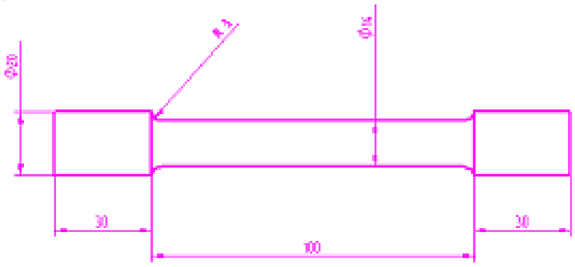
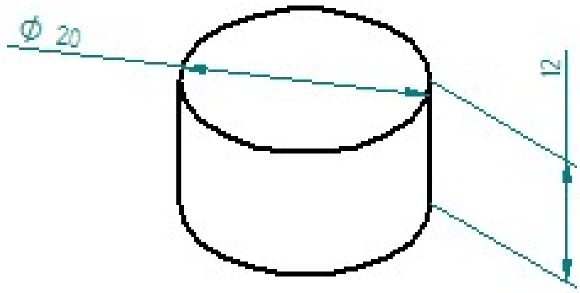


Figure 7: Specifications of Test Specimens for Hardness Tests



Hardness

Hardness measurements were made on different sections of the as cast and heat treated specimen as per ASTM E10 standards and the values are tabulated as given below.

Table 4: Tabular Coloumn for as Cast Specimen

Sl.No.	% of Al (7075)	% of Fly -ash	% of E Glass	Tensile Strength(Mpa)	% of Elongation
1	97	1	2	230	7
2	95	1	4	250	6
3	93	1	6	260	5
4	95	3	2	232	7.2
5	93	3	4	255	6.1
6	91	3	6	261	5.7
7	93	5	2	233	7.5
8	91	5	4	253	6.4
9	89	5	6	261	5.9

Table 5: Tabular Coloumn for Heat Treatment Specimen

Sl.No.	% of Al (7075)	% of Fly -ash	% of E Glass	Tensile Strength(Mpa)	% of Elongation
1	97	1	2	228	7.1
2	95	1	4	253	6
3	93	1	6	255	5
4	95	3	2	232	7.3
5	93	3	4	255	6.2
6	91	3	6	261	5.8
7	93	5	2	233	7.8
8	91	5	4	254	6.5
9	89	5	6	261	6

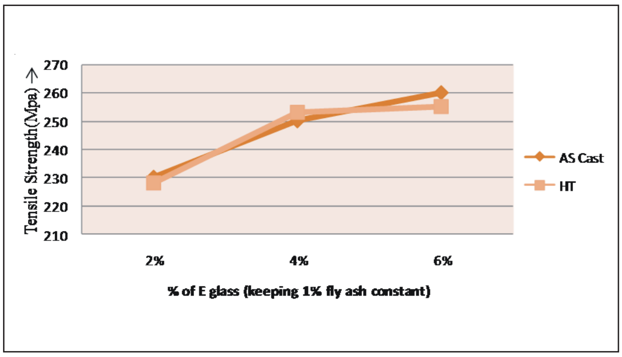
Table 6: Tabular Coloumn for Brinell Hardness Test for as Cast Specimen

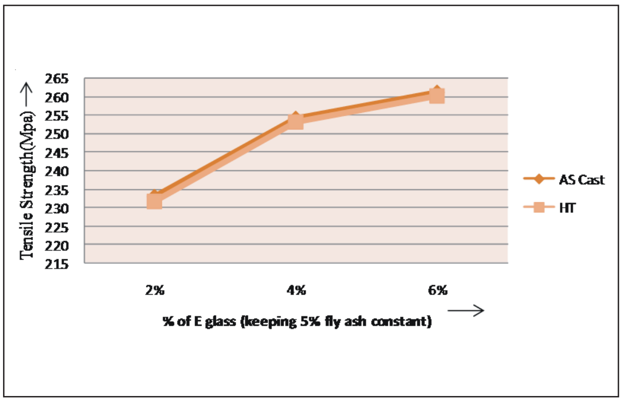
Sl.No.	% of Al (7075)	% of Fly -ash	% of E Glass	Indenter (mm) (Mpa)	Load in kgf F	Dia of indentati on (mm)	Brinell Hardness Number (BHN)
1	97	1	2	2.5	60	0.9	91.15
2	95	1	4	2.5	60	0.833	106.86
3	93	1	6	2.5	60	0.833	106.85
4	95	3	2	2.5	60	0.9	91.85
5	93	3	4	2.5	60	0.833	106.86
6	91	3	6	2.5	60	0.833	106.86
7	93	5	2	2.5	60	0.833	106.86
8	91	5	4	2.5	60	0.833	106.86
9	89	5	6	2.5	60	0.8	116.2

Table 7: Tabular Coloumn for Brinell Hardness Test for Heat Treatment Specimen							
Sl.No.	% of Al (7075)	% of Fly -ash	% of E Glass	Indenter (mm) (Mpa)	Load in kgf F	Dia of indentati on (mm)	Brinell Hardness Number (BHN)
1	97	1	2	2.5	60	0.833	96
2	95	1	4	2.5	60	0.933	104
3	93	1	6	2.5	60	1	110
4	95	3	2	2.5	60	0.833	98
5	93	3	4	2.5	60	1	108
6	91	3	6	2.5	60	1	108
7	93	5	2	2.5	60	0.833	104
8	91	5	4	2.5	60	0.9	108
9	89	5	6	2.5	60	1.03	118

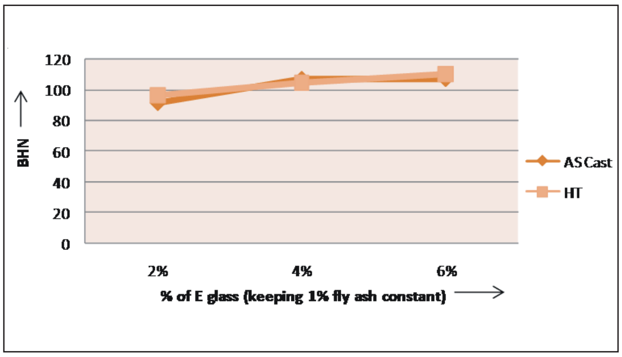
Results and Discussion

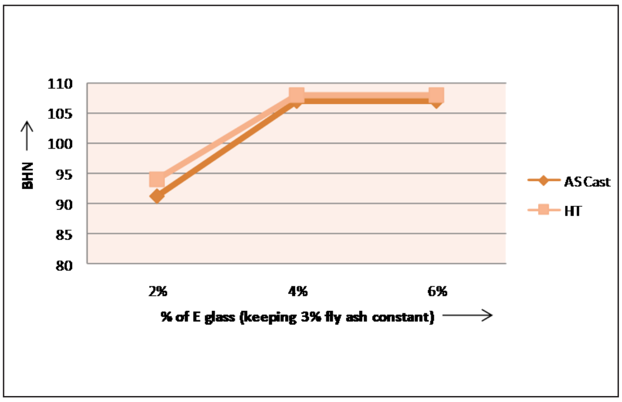
Variation of Tensile Strength is plotted for the as cast and heat treated specimen.

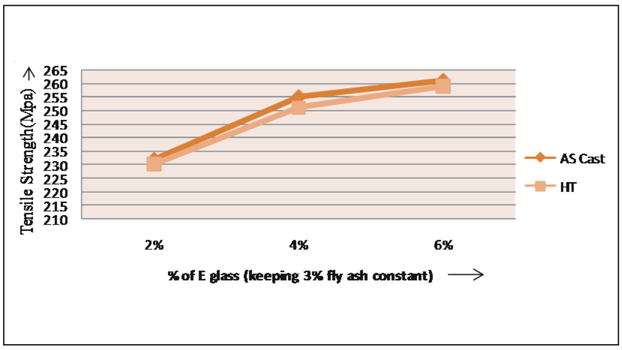


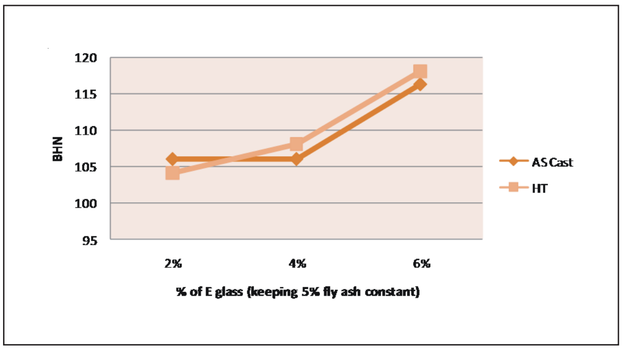


Variation of Hardness is plotted for the as cast and heat treated specimen.



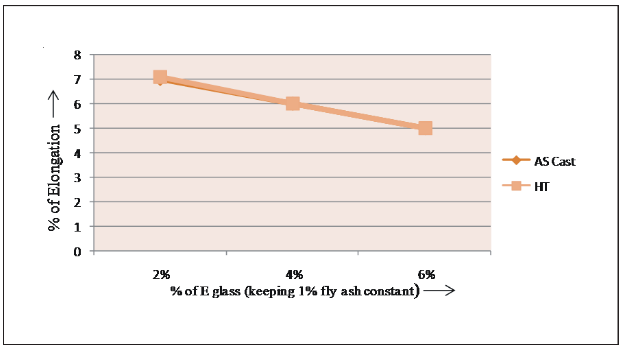


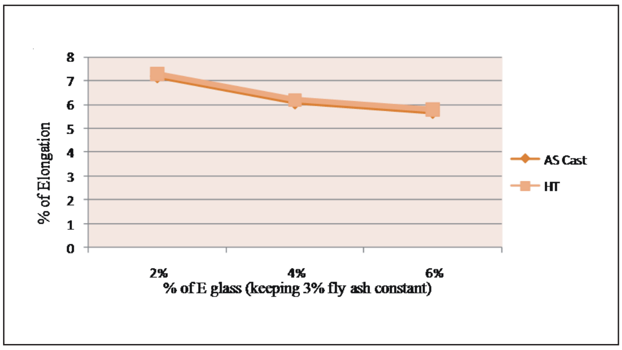


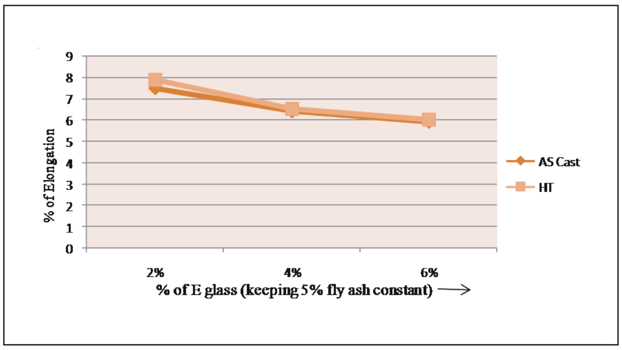


It can be observed that tensile strength and hardness increases with increased percentages of E-glass percentage and fly ash.

Variation of % of Elongation is plotted for the as cast and heat treated specimen.







Slight reduction of % elongation is observed with increases in fly ash and E-Glass composition.

CONCLUSION

MMC of Al (7075) reinforced with E-glass and fly ash particulates is found to have the improved tensile strength and hardness Compared to Al (7075) alloy. It is also found that hardness increases as the % of E-glass and fly ash particulate increases.

It is found that percentage of Elongation decreases with increase in tensile strength. Hence the MMC formed is superior to Al (7075), with almost same density as that of the individual. Further, tensile strength and hardness slightly increased with heat treatment.

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