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Effect Of Heat Treatment on Tensile and Hardness Properties of Aluminium-7075 Alloy Reinforced With Graphite and Bagasse-Ash Composites

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Abstract: In this present investigation efforts are made to study the tensile strength and hardness properties of as cast and heat treated AA7075 alloy reinforced with graphite and bagasse-ash composites. The vortex method of stir casting was employed, in which the reinforcements were introduced into the vortex created by the molten metal by means of mechanical stirrer. Brinell hardness and tensile strength of both the samples have been prepared as per the ASTM E8 standards. Results give out that there will be greater effect of reinforcing different bagasse-ash and heat treatment condition in aluminium alloy matrix composites. An improved mechanical properties occurs on reinforced compared to Unreinforced MMCs alloys.

Keywords: Al matrix composites; Bagasse-ash; Graphite; tensile strength and hardness properties; Heat treatment

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I. INTRODUCTION

Aluminum alloys such as 7075 Al reinforced with ceramic particles have found wide range of applications in automotive parts such as pushrods, cylinder, piston and brake disc etc,sports, aerospace, marine and in many other fields owing to their low coefficient of thermal expansion, low density, high thermal conductivity, high wear resistance, better corrosion resistance and high strength to weight ratio. The strength of the composite can be further improved by thermal treatments[2]. Heat treatment is an operation in the fabrication of an engineering materials system. The main objective of heat treatment is to make the material system structurally and physically fit for engineering application[1] These thermal treatments are similar to those ordinarily used for hardening aluminum alloys .Widely used treatments like T4 and T6 treatments involve solution heat treatment ,quenching and subsequent natural and artificial aging respectively and is the common method to increase the strength of the composite[2].Monolithic metals are not suitable many advanced engineering applications due to their poor properties in service conditions and at elevated temperatures. For advanced application, materials system must have tailor made properties like better mechanical, superior wear resistance and physical properties like low CTE, high thermal conductivity etc.[3-5] In this regard, a new class of material known as composites have been developed which can be defined as multiphase material made up of two or more physically and/chemically distinct phases known as matrix phase and reinforcement phase and possesses the characteristics of both the matrix and reinforcement phase [6-7]. The properties of composites can be designed and modified according to required applications by choosing appropriate matrix and reinforcement material that exhibit superior mechanical properties, excellent tribological property, good thermal and electrical conductivity coupled with low coefficient of thermal expansion when compared to monolithic metals and alloys [8-9]. Compared to polymer and ceramic matrix composites, metal matrix composites (MMCs) have been the subject of significant research and development over the past three decades. They are gaining widespread popularity over the conventional metals / alloys in various high tech applications. This is because of its attractive and superior mechanical properties. Nowadays all fields of engineering utilize the metal matrix composite which are extremely efficient in terms of design and weight applications [10-11].

II. OBJECTIVES OF PRESENT WORK

The main objective of this project is to develop Al (7075)/ graphite and bagasse-ash particulate metal matrix composites. Where the graphite and bagasse-ash are used as reinforcement material & Al 7075 is used as matrix material. Different weight percentages of Specimens are prepared by using liquid route metallurgy technique. Test specimens are prepared to evaluate tensile and hardness characteristics.

III. EXPERIMENTAL DETAILS

Following steps are carried out in our experimental work:
1. Material selection
2. Composite preparation
3. Testing

3.1 Material selection

The Al 7075 alloy (matrix material), graphite and bagasse-ash 30-40 μm size particles (reinforcement) were used for fabrication of MMCs. The chemical composition of Al7075 is given in the Table 1.the reinforcement percentages is given in Table 2.

Table 1: Chemical Composition of Al 7075

Composition	Al	Zn	Fe	Mg	Mn	Cu	Si	Cr	Ti
% Composition	**88.6**	**5.6**	**0.5**	**2.5**	**0.3**	**1.6**	**0.4**	**0.23**	**0.2**

Table 2: Percentages of reinforcements

Models	Reinforcements	
	Bagasse ash	**Graphite**
1	1%	2%
2	3%	2%
3	5%	2%
4	1%	4%
5	3%	4%
6	5%	4%
7	1%	6%
8	3%	6%
9	5%	6%

3.2 Composite preparation

The graphite of 30-40 μm size and bagasse-ash were used as the reinforcement and the graphite content in the composites was varied from 2% to 6% in steps of 2% by weight and bagasse-ash are varied from 1% to 5% in steps of 2% by weight. Liquid metallurgy technique was used to prepare the composite materials in which the graphite and bagasse-ash particles were introduced into the molten metal pool through a vortex created in the melt by the use of an alumina-coated stainless steel stirrer. Zirconium coated stirrer used to stir the molten metal. The stirrer was rotated at 200–300 rpm for duration of 15 minutes and the depth of immersion of the stirrer was about two-thirds the depth of the molten metal. The resulting mixture was tilt poured into preheated permanent moulds.

3.3 Heat Treatment

The composite melt was cast in a permanent mould. Cast Al7075 alloy and all synthesized composites are subjected to heat treatment process. The sequence of heat treatment process involved were solutionizing, quenching, aging and furnace cooling. Solutionizing was done at a temperature of 520˚C over a time period of one hour and then quenched in a water bath. Immediately after that artificial aging was carried out in a muffle furnace at a temperature of 175˚C for different time period of 1, 3, 5 and 7 hours. Both solutionizing and aging temperatures were maintained accurate to within ±2 ˚C and quench delays in all cases were within 10 sec. Hardness and tensile strength were carried out on both unheat treated and heat treated samples

3.4. Brinell hardness test

As per ASTM E10 standard test method Brinell hardness tests were carried out by forcing a hard steel or carbide sphere of a specified diameter under a specified load into the surface of a material and measuring the

diameter of the indentation left after the test. The Brinell hardness number, or simply the Brinell number, is obtained by dividing the load used, in kilograms, by the actual surface area of the indentation, in square millimeters. The result is a pressure measurement, but the units are rarely stated.
The BHN is calculated according to the following formula:

$$BHN = \frac{F}{\frac{\pi}{2} D * (D - \sqrt{D^2 - Di^2})}$$

Where
BHN = the Brinell hardness number
F = the imposed load in kg
D = the diameter of the spherical indenter in mm
Di = diameter of the resulting indenter impression in mm

3.5. Tensile test

Tensile tests were conducted at room temperature using universal testing machine (UTM) in accordance with ASTM E8-82. The tensile specimens of diameter 8.9 mm and gauge length 76 mm were machined from the cast composites with the gauge length of the specimen parallel to the longitudinal axis of the castings.

IV. RESULTS AND DISCUSSION

4.1 ***Tensile and hardness properties***

The results of the *Tensile and hardness* tests such as ultimate tensile strength and hardness of as cast and heat treated Al7075 MMCs are given in the Figure 4.1, Figure 4.2 and Figure 4.3 respectively.

4.1 Effect of reinforcements and heat treatment on UTS of Al 7075 alloy

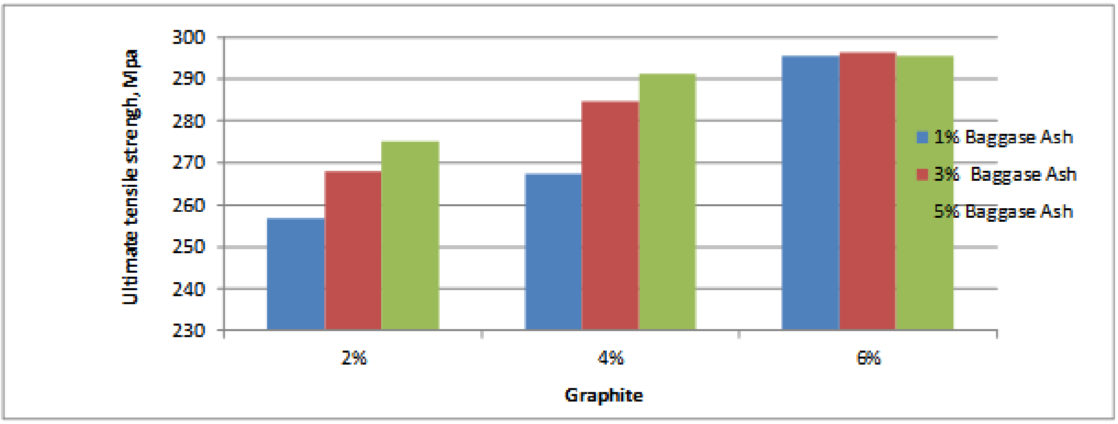

Fig 4.1 Variation of UTS with respect to graphite and bagasse-ash variation in as cast

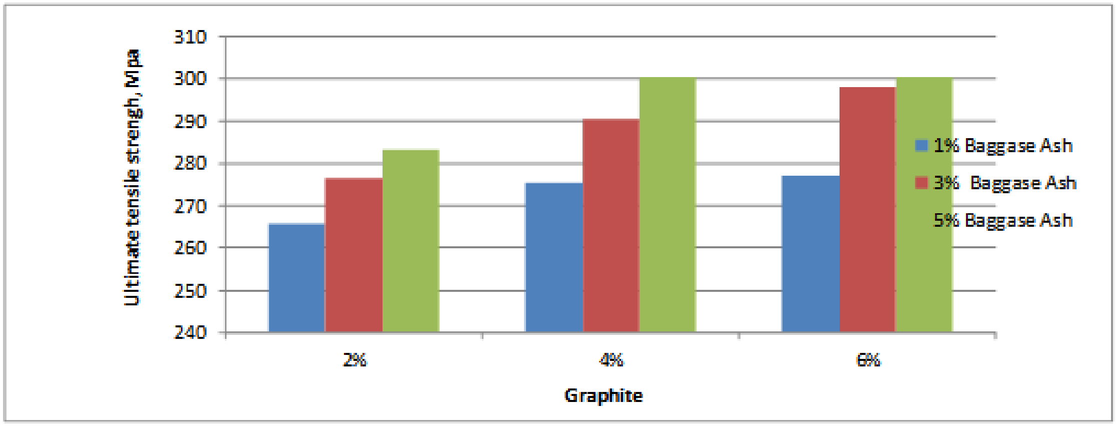

Fig 4.2 Variation of UTS with respect to graphite and bagasse-ash variation in 5hour HT

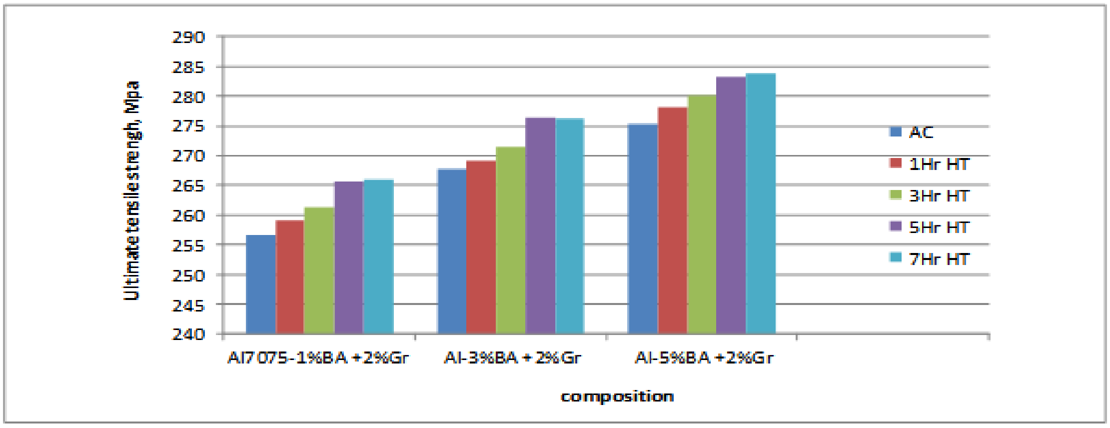

Fig 4.3 Variation of UTS with respect to heat treatment

Figure.4.1 to 4.3 shows effect reinforcements and heat treatment on Al7075 alloy MMCs, during the heat treatment, intermetallic particles are precipitated which resist the movement of dislocations in a crystal lattice (12-13). BA and graphite particles and precipitation of intermetallic increase tensile strength. As the amount of BA and graphite particles and intermetallics put together increase, the tensile strength increase less proportionately. The aluminium based particulate reinforced composite, the dislocations are generated during solutionizing due to thermal mismatch between the matrix and the ceramic reinforcement particles. Most of the matrix during aging favour nucleation of semi-coherent precipitates (14).Therefore, need arises for a longer solutionizing time and accelerated aging at elevated temperature for aluminium based particulate reinforced composite, when compared to unreinforced alloys. This marked improvement in tensile strength of both Al7075 alloy and its composites studied on heat treatment can be attributed to larger extent of formation of fine intermetallic precipitates after age hardening

4.2 Effect of reinforcements and heat treatment on Hardness of Al 7075 alloy

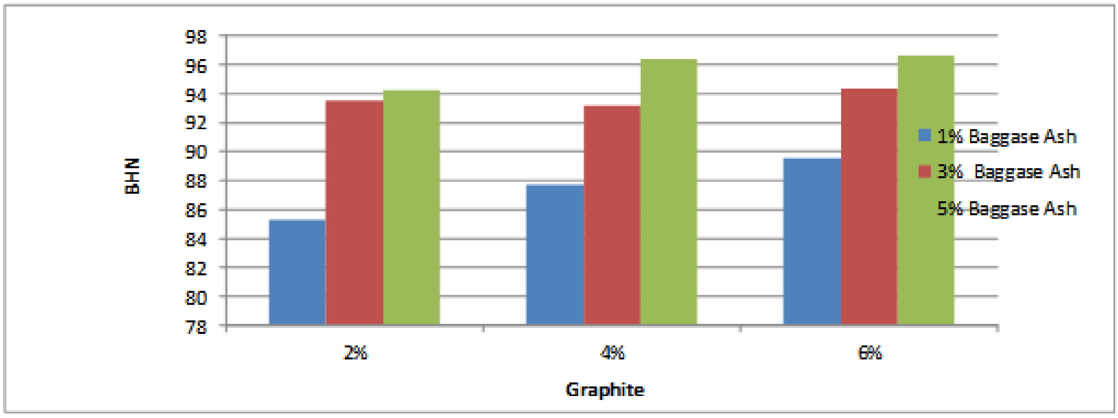

Fig 4.4 Variation of BHN with respect to graphite and bagasse-ash variation in as cast

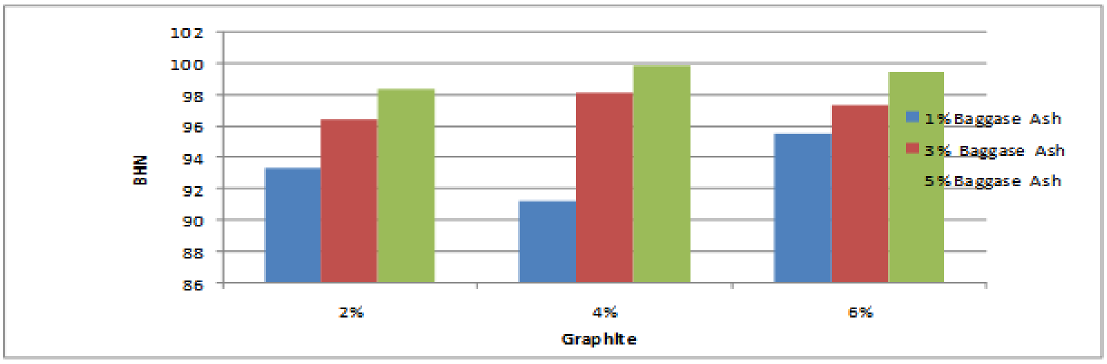

Fig 4.5 Variation of UTS with respect to **graphite and bagasse-ash** variation in 5hour HT

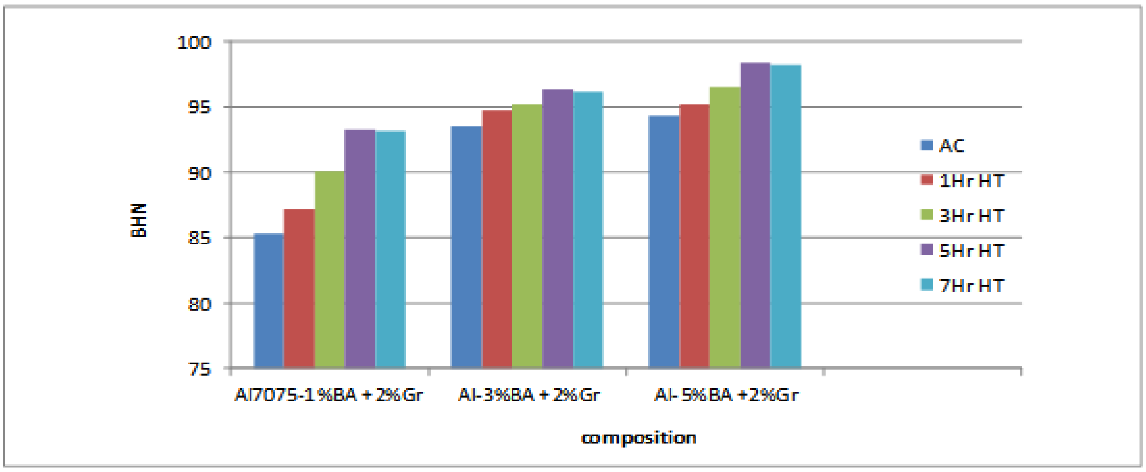

Fig 4.6 Variation of UTS with respect to heat treatment

The variation of hardness with increased content of graphite and bagasse-ash in the matrix Al7075 in as cast condition is shown in figure 4.4. It is observed that with increased content of graphite and bagasse-ash in the matrix alloy, there is a significant improvement in the hardness of the composites. This trend is similar to the result of other researchers [15]. The variation of micro hardness under heat treatment conditions are shown in figure 4.6 Heat treatment has a profound influence on the hardness of the matrix alloy as well as its composites. For a solutionizing temperature of 520°C, solutionizing duration of 2 hour, ageing temperature of 175°C, quenching media and ageing duration significantly alters the microhardness of both the matrix alloy and its composites. The maximum hardness was observed for the studied composites for ageing duration of 5 hours. In all the quenching media, and under all ageing times studied, composites exhibited higher hardness when compared with the matrix alloy. Ageing of matrix alloy and its composites for a duration of 5 hours results in obtaining maximum hardness of the matrix alloy and its composites.

V. CONCLUSIONS

1. The hardness increases with increasing wt. % of reinforcement for the MMCs.
2. Important micro-structural changes occur during initial addition of reinforcement.
3. The mechanical properties such as UTS, yield strength and hardness increase with increasing wt. % of reinforcement for the MMCs.
4. Heat treatment has a significant effect on UTS and BHN of matrix alloy and its composites

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