© 2019 IJSRSET | Volume 6 | Issue 3 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology
DOI : https://doi.org/10.32628/IJSRSET196351

Investigations on Mechanical Properties of Heat-treated Aluminum 7075/Graphite Powder/Bagasse ash Hybrid Metal Matrix Composites

***Madhu M G[1], H K Shivanand[2], Maibusab[3], Kiran R[3]**

[1]Lecturer, Department of Mechanical Engineering, Government polytechnic Udupi-576104, Karnataka, India.

[2]Professor (Department of Mechanical Engineering), University Visveswarayya College of Engineering, Bengaluru, Karnataka, India

[3]P.G Scholar, Department of Mechanical Engineering, University Visveswarayya College of Engineering, Bengaluru, Karnataka, India

*Contact Author e-mail: madhulinghayath@gmail.com

ABSTRACT

Metal Matrix Composites (MMC's) consist of either pure metal or an alloy as the matrix material, while the reinforcement generally a ceramic material. Aluminium composites are considered as one of the advanced engineering materials which have attracted more and more benefits. Now a days these materials are widely used in space shuttle, commercial airlines, electronic substrates, bicycles, automobiles, etc., Among the MMC's aluminium composites are predominant in use due to their low weight and high strength. The key features of MMC's are specific strength and stiffness, excellent wear resistance, high electrical and thermal conductivity. Hence, it is proposed to form a new class of composite. Al 7075 alloy reinforced with Graphite Powder and Bagasse ash to form MMC using Stir casting. The MMC is obtained for different composition of Graphite powder and Bagasse ash particulates (varying Graphite powder with constant Bagasse ash and varying Bagasse ash with constant Graphite powder percentage). The test specimens are prepared as per ASTM standard size by turning and facing operations to conduct tensile tests, compression tests and hardness tests. The specimens are tested for tensile strength and compression strength as per ASTM standard E8 by using universal testing machine and hardness as per ASTM standard E10 at different loads by using Brinell hardness testing machine. Through the results, it is concluded that the MMC obtained has got better tensile strength, compression strength and hardness properties when compared to non-heat-treated Al 7075 alone.

Keywords : T6 Heat Treatment, Al7075, Graphite, Bagasse Ash, Ultimate Tensile Strength, Compression strength, hardness.

I. INTRODUCTION

This research is a compilation of the overview of the research work and characteristic aspects of the evaluation of the composite materials fabricated utilizing Aluminium as the matrix phase and Graphite powder and Bagasse ash as the reinforcement phases.

Traditional materials do not always provide the necessary properties under all service conditions. Metal matrix composites (MMC's) are advanced materials resulting from a combination of two or more materials (one of which is metal and the other a non-metal) in which tailored properties are realized. In recent years there has been a considerable interest in the use of metal matrix composites (MMC's) due to their superior properties. Though many desirable mechanical properties are generally obtained with the fibre reinforcement, these composites exhibit an isotropic behaviour and are not easily producible by conventional techniques. MMCs reinforced with Graphite powder and Bagasse ash particulates tend to offer modest enhancement of properties. Among the MMCs the most metal used is aluminium reinforced with Graphite powder and Bagasse ash. Generally, aluminium is light weight, which is fore most requirement application and is less expensive than other light metals such as titanium and magnesium. Moreover, when a reinforcement material is added to Aluminium matrix, the properties will further enhance, thereby making it a prospective material for many light weight applications. Metal-matrix composites are either in use or prototyping for the space shuttle, commercial airliners, electronic substrates, bicycles, automobiles and a variety of other applications. Aluminium matrix composites, a growing number of applications require the matrix properties of super alloys, titanium, copper, magnesium, or iron. Like all composites, aluminium-matrix composites are not a single material but a family of materials whose stiffness, strength, density, thermal and electrical properties can be tailored to the suitable requirement. The matrix alloy, reinforcement material, volume, shape of the reinforcement, the location of the reinforcement, and the fabrication method can all be varied to achieve required properties. Regardless of variations, however, aluminium composites offer the advantage of low cost over most other MMCs. In addition, they offer an excellent thermal conductivity, high shear strength, abrasion resistance, and high-temperature operation, no flammability, minimal attack by fuels and solvents, and the ability to be formed and treated on conventional equipment. In the present investigation, an Al 7075 alloy was used as the matrix material and Graphite powder, Bagasse ash as additives. The composite was produced using conventional foundry techniques.

II. MATERIALS PROCUREMENT

ALUMINIUM 7075 ALLOY

Aluminum alloy 7075 is an aluminum alloy, with zinc as the primary alloying element. It is strong with strength and has good fatigue strength and average machinability. Alloy7075 is heavily utilized by the aircraft and ordnance industries because of its superior strength.

Figure-1 shows Al-7075 Ingots used in the experiments to prepare samples.

Fig-1: Aluminum 7075 Ingots

BAGASSE-ASH

Sugarcane bagasse ash is a byproduct of sugar factories found after burning sugarcane bagasse which itself is found after the extraction of all economical sugar from sugarcane. It is an industrial waste which is used worldwide as fuel in the same sugarcane industry. These sugarcane bagasse ashes (SCBA) have been chemically, physically and miner logically characterized in order to evaluate the possibility of their use as a cement replacing material in concrete industry.

Fig-2: Fine Bagasse Ash

GRAPHITE POWDER

Graphite is a form of elemental carbon. Graphite is used in several fields due to its electrical conductivity and chemical properties. Synthetic graphite is a manmade essence contrived by the heavy temperature processing of amorphous carbon materials. The types of amorphous carbon used as precursors to graphite are many and can be consequent from coal, petroleum, or natural and synthetic organic materials. In a few cases graphite can constant be manufactured by the direct precipitation of graphitic carbon (CO) from pyrolysis of a carbonaceous gas such as pyrolytic graphite (acetylene). One important commonality between all graphite precursors is that they must contain carbon.

Fig.3: Graphite powder

III. EXPERIMENTAL DETAILS

Composite is picked as matrix material inferable from its wide application in numerous designing divisions including car and aviation areas. Further, this composite displays great quality and formability. Graphite exhibits the properties such as high rigidity, low thickness, low rubbing and wear resistance and high thermal conductivity. The mixture structure of composites utilized as a part of the present study is accounted for in the Table 1. Both Graphite and Al7075 combinations were acquired from M/s Fen expense Metallurgical, Bangalore, India. What's more, bagasse fiery debris is found in mandya sugar stick industrial facility.

The composites are manufactured by following steps:

1. Casting.
2. Machining.
3. Testing.

Casting

The microstructure of any material is a complex function of the casting process, subsequent cooling rates. Therefore, composites fabrication is one the most challenging and difficult task. Stir casting technique of liquid metallurgy was used to prepare Al 7075 and Al 7075 Hybrid composites.

Ingots of AL-7075 amalgam are set in heater and heater is warmed up to 800^{0}C. Refer Fig 4 Ascertained amounts in weight rate are filled in the liquid AL-7075 and mixed utilizing zirconium covered spoon. All around mixture composites are filled in the die, which is as demonstrated in the fig 4.

The melting range of Al 7075 alloy is of 700 – 800^{0}C. A known quantity of Al 7075 ingots were loaded into the Graphite crucible of the furnace for melting. The melt was super-heated to a temperature of 800^{0}C and maintained at that temperature. The molten metal was then degassed using Hexo chloro ethane tablets for about 8min.

Fig 4: A stir casting setup as shown in Figure, consist of a Coke fired Furnace and a stirrer assembly, which was used to synthesize the composite.

Machining

Tensile test specimens are arranged according to the ASTM E8 principles utilizing a profoundly refined machine, which is indicated in the Fig 5. Test specimens are of 20mm grasp width, 30mm hold length, 62.5mm gage length and 75 mm length of diminished cross area, inward measurement of 12.5mm and aggregate length 155mm and is indicated in the Fig 6.

Fig 5: Casted composites

Fig 6: Tensile specimen

Compression and Hardness test specimens are prepared according to the ASTM E9 benchmark. The test specimens used are of 20mm breadth and 20mm length as indicated in Fig 7 & 8.

Fig 7: Compression Specimen

Fig 8: Hardness specimen

Testing

The test specimens are prepared as per ASTM standard size by turning and facing operations to conduct tensile tests, compression tests and hardness tests. The specimens are tested for tensile strength and compression strength as per ASTM standard E8 by using universal testing machine and hardness as per ASTM standard E10 at different loads by using Brinell hardness testing machine. Through the results, it is concluded that the MMC obtained has got better tensile strength, compression strength and hardness properties when compared to Al 7075 alone.

Heat Treatment:

T6 Heat Treat Process

Our T6 heat treatment of cast specimens offers increase in hardness and other mechanical properties, which is often required for many applications. The T6 heat treat is a two-step process. The castings are first allowed to cool naturally and are then heated at an elevated temperature in one of our high temperature ovens. After a set period of time the castings are quickly quenched. The castings are then moved to one of our low temperature ovens for the second step of the process.

In order to develop the correct balance of mechanical properties, it was thought essential to subject the test casting to an optimized thermal treatment (viz. solution heat treatment and quenching). Test samples of suitable length were solutionized in a heat treatment furnace for a temperature of 525^0C ±5^0C for duration of 5 hours. After solutionising the samples were immediately quenched in water kept at room temperature, stored in the tanks below the furnace. The quenching was done strictly within 15 seconds of opening the furnace door.

The specimen (as cast condition) were subjected to the following heat treatment conditions.

- The castings are first allowed to cool naturally and are then heated at an elevated temperature of 525^{0}C for 5 hrs.
- Quenching in water at a temperature of 60^{0}C

Table 1: Percentage of Reinforcements.

Models	Reinforcements		
	AL 7075 in %	Graphite Powder in %	Bagasse Ash in %
A1G2B	97	1	2
A1G4B	95	1	4
A1G6B	93	1	6
A3G2B	95	3	2
A3G4B	93	3	4
A3G6B	91	3	6
A5G2B	93	5	2
A5G4B	91	5	4
A5G6B	89	5	6

IV. EXPERIMENTAL PROCEDURE

TENSION TEST

The ASTM E8 method covers the tension testing of metallic materials in any form at room temperature, specifically, the methods of determination of yield strength, yield point, tensile strength, elongation, and reduction of area.

Testing Procedure

1. Measure and record the tensile specimen dimensions of diameter 12.5mm and gauge length 62.5mm were machined from the cast specimens with gauge length of the specimens parallel to the longitudinal axis of the casing necessary to determine the cross-sectional area at its smallest point.
2. Use ink and a scribe or punch to place gage marks on the test specimen gage length of 62.5mm. The distance between the gage marks after the specimen is broken is used to determine the percent elongation at break. To accurately compare elongation values between tests, the gage lengths must be the same.
3. Zero the testing machine without the specimen inserted in the grips. Then install the specimen in the grips and start loading the sample. The speed of testing is generally specified in the rate of straining of the specimen. In addition, the test rate is to remain constant through yield but can then be increased when determining ultimate tensile strength and elongation at break.
4. Run the test until specimen failure or fracture. Remove the broken sample from the machine and the results will be recorded in computerized UTM.

Compression Test

Specimens are machined according to ASTM(E9) standards viz, diameter 20mm ±0.1mm and length 20mm ±1mm and test was conducted on computerized Universal testing machine. Ductility of the specimen is evacuated in term of percentage of elongation, UCS and young's modulus in terms of MPa. The nine specimens of each compositions of cast and heat-treated composites were tested and average results are noted down. The fig 9 & 10 are the photos of compression specimen before the test and after the test respectively.

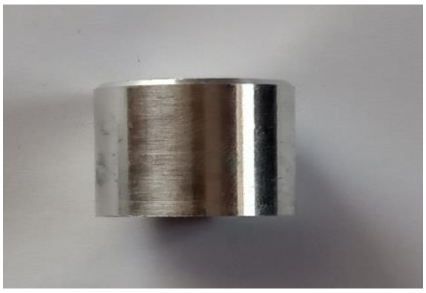

Fig 9: Compression Specimen before test

Fig 10: Compression Specimen after the test.

Hardness Test

The specimen is placed on the top of the table and raised it with the elevating screw, till the test sample just touched the ball

A load of 250kg is applied on the specimen for a period of 30seconds, during which indenter presses onto the specimen. The steel ball during this period moved to the position of the sample and made indentation.

The diameter of the indentation made in the specimen is recorded by the use of the micrometer microscope. The diameter of indentations is taken and the BHN is calculated.

The fig 11 & 12 are the photos of Hardness specimen before the test and after the test respectively.

Fig 11: Hardness Specimen before test

Fig 12: Hardness Specimen after the test.

V. RESULTS AND DISCUSSION

Mechanical properties like Ultimate Tensile strength, Yield strength, Ultimate Compression Strength (UCS) and Hardness are found for the developed composites of different weight % of Graphite powder and Bagasse ash in Al alloy 7075. The present work attempts to understand the influence of reinforcements on the matrix alloy and artificial ageing process on the Al alloy-based Hybrid composites compared to as cast composites.

Figs. 13-15 and Tables 2 shows the effect of Graphite powder and Bagasse ash on the various mechanical properties of all alloy composites viz. Ultimate Tensile strength, Yield strength, Ultimate Compression Strength (UCS) and Hardness respectively. Each value represented is an average of nine measurements. Each value is repeatable in the sense that the individual values did not vary by more than from the mean value.

Ultimate Tensile Strength

The tensile specimens prepared in accordance with ASTM E8 were subjected to homogeneous and uniaxial tensile stresses in a Universal Testing machine.

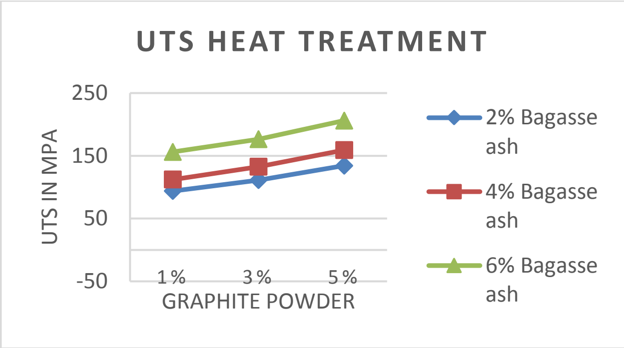

Fig. 13; The effect of Graphite powder and Bagasse ash on the UTS of the Heat-treated Hybrid composites at the non-heat treatment condition.

Effect of Graphite powder and Bagasse ash on UTS

The factors influencing the UTS are complex and inter-related. Several variables, such as distribution of the particles/ fiber in the matrix, the mechanical properties of the matrix and the reinforcing particles/fibers and the bonding between the matrix and the reinforcement, are reported to influence the strength of discontinuously reinforced composites strongly. Also, various strengthening mechanism have been proposed to explain the improvement in strength in the case of discontinuously reinforced MMCs. They include the classical composite strengthening through the load transfer between the ductile alloy matrix and the hard and brittle particle reinforcement.

Effect of heat treatment on Ultimate tensile strength

Heat treatment seems to increase the UTS monotonically by significant amounts for the composites of various Graphite powder and bagasse ash contents. The maximum percentages increase in UTS of the composites is 18%. Heat treatment causes the matrix to be hardened and it removes internal locked residual stresses, allowing easier movement of the dislocations. This homogenization also allows the diffusion of segregated components to produce a more uniform composition. The heat treatment is there has influenced the increase in the UTS of the composites.

Compression Strength

Compression strength of the hybrid composites specimens and of the base alloy, plotted against the Graphite powder and Bagasse ash.

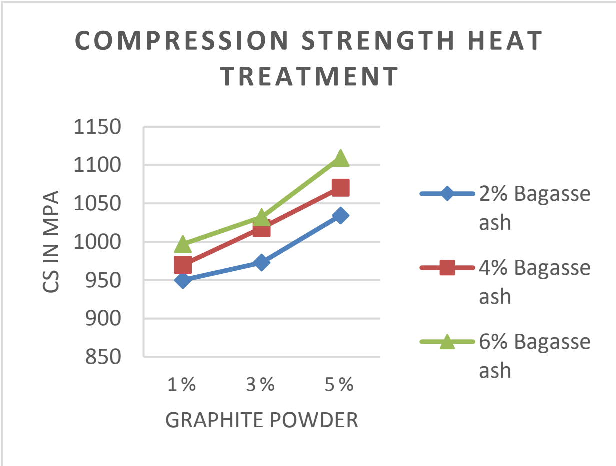

Fig. 14; The effect of Graphite powder and Bagasse ash on the Compression strength of the Heat-treated Hybrid composites at as cast condition.

Effect of heat treatment on Compression strength

Fig. 14 revealed that the heat treatment of composites has increased their compressive strength this may be due to reinforcement of microstructure that acted as barrier to dislocation of grains.

In the present investigation heat treatment and addition of Graphite powder and Bagasse ash reinforcements were found to increase compression strength. As more graphite powder and Bagasse ash particulate were added, decrease in the inter-fibre distance between hard Graphite powder caused an increase in dislocation pile-up. Moreover, improvement in compression may be due to the matrix strengthening that might have occurred following a reduction in composites grain size and the generation of a high dislocation density in the matrix as a result of difference in coefficient of thermal expansion between matrix and reinforcements. The heat treatment has increased the compressive strength by significant amounts.

Hardness

Hardness measurements were made on different sections of the as cast and heat-treated material as per ASTM E10 standards and the results are plotted in Fig.8.41 & 8.42 Brinell hardness tests were carried out on samples of both cast alloy and heat treatment composites, by applying 250 kg for a period of 15 seconds.

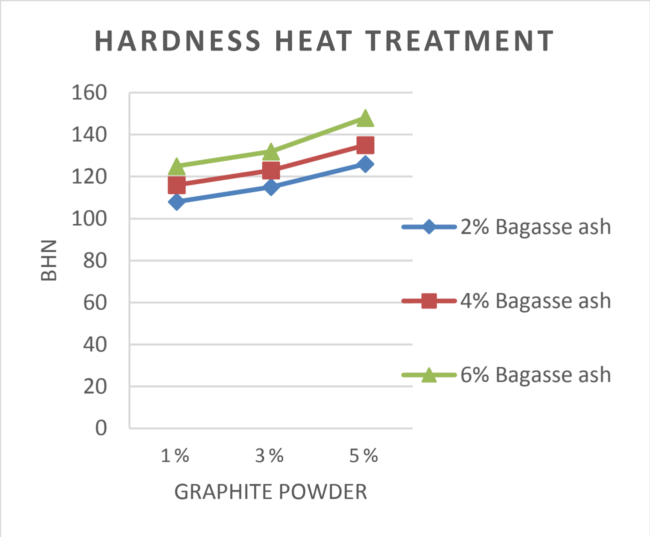

Fig. 15; The effect of Graphite powder and Bagasse ash on the Brinell Hardness of the Heat-treated Hybrid composites at as cast condition.

Effect of heat treatment on Hardness

The hardness of the aluminum alloys is increased with the addition of Bagasse ash and Graphite powder reinforcements. Table 2 show the increase in the hardness is due to the addition of graphite powder particles and Bagasse ash, which can be attributed to the fact that the Graphite powder and Bagasse ash possess higher hardness and its presence in the matrix improves the hardness of the composite.

Table 2: Tensile strength, Compression strength and Hardness of Heat-treated hybrid composites

Composition no	Tensile strength in N/mm2	Compression Strength in N/mm2	Brinell Hardness
A1G2B	93.89	950.13	108
A1G4B	112.09	970.04	116
A1G6B	156.52	996.97	125
A3G2B	111.08	973.14	115
A3G4B	132.85	1018.19	123
A3G6B	176.25	1032.16	132
A5G2B	134.45	1034.35	126
A5G4B	159.25	1070.5	135
A5G6B	206.26	1109.39	148

VI. CONCLUSION

The recently developed hybrid composites have been considered as candidate materials for applications in severe environments confronting modern technologies. Among various composites, MMCs are great practical interest. MMCs feature compositional variations from ceramic at one surface to metal at the other leads to the unique advantages of a smooth transition in thermal stress across the thickness and minimized stress concentration at the interface of dissimilar materials. As a result, such composites are rapidly finding applications in aggressive environments with steep temperature gradients such as turbine components and rockets nozzles.

The summary of the effect of particulates and fibres on the Mechanical properties of Aluminum 7075 hybrid composites like Ultimate Tensile Strength, Yield strength, Young 's modulus, ductility, Compression strength etc. are as follows.

- New MMCs can be synthesized both by liquid metallurgy technique successfully with enhanced properties using low cost Graphite Powder and Bagasse ash particulate reinforcement. Stir and permanent mold castings can be obtained with microscopically uniform distribution of particles.

- There have been notable improvements in the essential material properties with the increase in the reinforcement compositions, the properties like Ultimate Tensile strength, Yield strength, Young's modulus and Compression strength have increased significantly with the addition of Graphite powder and Bagasse ash particulate content up to 1%, beyond that we observe that there is not much change in the properties.
- The addition of the reinforcements has resulted in a steady increase in the hardness. The addition of graphite powder and Bagasse ash, could have caused the increase as composites are generally hard.

The heat treatment on the hybrid composites has got very good effect on all the mechanical properties, because it has further improved the properties with appreciable amount.

VII. REFERENCES

[1]. Zhao, M.. "Friction and wear properties of TiB"2"P/Al composite", Composites Part A, 200611

[2]. Srivatsan, T.S, Meslet Al-Hajri, M Petraroli, B Hotton, and P.C Lam. "Influence of silicon carbide particulate reinforcement on quasi static and cyclic fatigue fracture behavior of 6061 aluminum alloy composites", Materials Science and Engineering A, 2002. Publication.

[3]. Baradeswaran, A. and A. Elaya Perumal (2014). "Wear and Mechanical Characteristics of Al 7075/Graphite Composites." Composites Part B: Engineering, Vol.56, pp.472-476.

[4]. Baradeswaran, A. and A. Elaya Perumal (2014). "Study on Mechanical and Wear Properties of Al 7075/Al2O3/Graphite Hybrid Composites." Composites Part B: Engineering, Vol.56, pp.464471.

[5]. Ravinder Kumar and Suresh Dhiman (2013). "A Study of Sliding Wear Behaviors of Al-7075 Alloy and Al-7075 Hybrid Composite by Response Surface Methodology Analysis." Materials & Design, Vol.50, pp.351-359.

[6]. Ramesh, C.S., R. Keshavamurthy, and J. Madhusudhan. "Fatigue Behavior of Ni-P Coated Si3N4 Reinforced Al6061 Composites", Procedia Materials Science, 2014.

[7]. C. S. Ramesh. "Sand Abrasive Wear Behavior of Hot Forged Al 6061-TiO2 Composites", Journal of Materials Engineering and Performance, 12/23/2010 Publication

[8]. Chinnakurli Suryanarayana, Ramesh, Ummar Khan Attaullah, Kumar Saheb, Apoorva Kumar, and Manoj Kumar Rajput. "Slurry Erosive Wear

[9]. Behavior of Forged Al6061-CeO2-TiO2 Hybrid Composites", Volume 2A Advanced Manufacturing, 2013. Publication

[10]. Wear behaviour of hot extruded Al6061-SiC"p (Ni-P coated) composites", Wear, 20110729 Publication

[11]. Bhagat, R.B.. "Elevated-temperature mechanical properties of silicon-carbide whisker-reinforced aluminum matrix composites", Materials Science & Engineering Publication

[12]. N. Altinkok. "Use of Artificial Neural Network for Prediction of Mechanical Properties of - Al2O3 Particulate-reinforced Al-Si10Mg Alloy Composites Prepared by using Stir Casting Process", Journal of Composite Materials, 07/12/2005

[13]. Chen, Fei, Zongning Chen, Feng Mao, Tongmin Wang, and Zhiqiang Cao. "TiB2 reinforced aluminum based in situ composites fabricated by stir casting", Materials Science and Engineering A, 2015. Publication

[14]. Sukumaran, K.. "Studies on squeeze casting of Al 2124 alloy and 2124-10% SiCp metal matrix composite", Materials Science & Engineering A, 20080825 Publication

Cite this article as : Madhu M G, H K Shivanand, Maibusab, Kiran R, "Investigations on Mechanical Properties of Heat-treated Aluminum 7075/Graphite Powder/Bagasse ash Hybrid Metal Matrix Composites", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 6 Issue 3, pp. 258-566, May-June 2019. Available at doi : https://doi.org/10.32628/IJSRSET196351
Journal URL : http://ijsrset.com/IJSRSET196351