

Investigation on Mechanical and Tribological Properties of A356 Reinforced with bottom ash MMC

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ABSTRACT: In the present investigation, the characteristics of A356 alloy including with Bottom ash as Particulate Reinforcement process is carried out by stir casting method, before heat treatment methods through which we can achieve required hardness, Microstructure Mechanical and Wear Properties and life extension of a automotive parts, A356 based metal matrix composite is responsible for room temperature strengthening effect and their high strength-to-weight ratio. This paper describes the Chemical Composition of A356 alloy & bottom ash and also an economic alternative to the use of traditional materials; the use of bottom ash shows a great influence input to waste minimization as well as resources Preservation.

KEYWORDS: Bottom ash, A356, Stir casting, economic choice.

I. INTRODUCTION

A356 based alloys have been developed with significant ductility, strength, elongation, hardness and toughness at room temperature in as-cast state. A356 alloys are ever more accepted in aircraft and automobile due to their lofty strength-to-weight relation and its thixotropic arrangement, its specific tensile strength and rigidity are superior to other Aluminum alloys. These qualities lead to less vehicle and aircraft weight and better fuel economy [5]. The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various discontinuous dispersoids used, bottom ash is one of the most inexpensive and low density reinforcement accessible in large quantities as solid waste by-product during combustion [2]. Composite material is one of the reliable solutions for such obligation. In composites, materials are united in such a way as to enable us to make better use of their parent material while minimizing to some extent the effects of their deficiencies Aluminium matrix composites (AMCs) are potential materials for various applications due to their good corporal and mechanical properties. The addition of reinforcements into the metallic matrix improve the stiffness, specific strength, wear, creep and fatigue properties compared to the conventional engineering materials. In recent decades, aluminum alloy based metal matrix composites are gaining important role in several engineering applications [1]. A356 alloy has been used as the matrix material because of its good formability, excellent mechanical properties and manufacturing properties. wide range of the applications in the industrial sectors. A356 based alloys have been developed with significant ductility, strength, elongation, hardness and toughness at room temperature in as-cast state[2]. Aluminium and its alloys outstretches its applications in the Automobile components, Aerospace and Marine industries on account of their durability, light weight, supreme surface finish, wear resistance and corrosion resistance and high strength to weight ratio. Complex geometries are produced with ease and are cost effective, they find enhanced utility in Aerospace sectors. Whereas in Automobile sector, due to its low density it can offer increased load capacity, superior mileage and concentrated pollution and higher profit to manufacturers. The low melting point, ease of formability, castability, handling and recycling has led to increased demand for aluminium composite components making more versatile for engineering and construction material.[9] Mechanical, technological and macrostructural properties of the casting prepared from this alloy depends on the properly performed process of melting and pouring, casting and mold with their structures, as well as their heat treatment procedure which plays a very important role in improving the properties. Current investigations in this work with the improvement of mechanical properties and

microstructure of aluminium alloy pertaining typically to the advancement in collection of alloys, synthesis of alloys, improvement of selection of modifiers, additives and reduction of impurities and slag and implementing a modern heat treatment technology has spurred their application by additional improvement in their properties[2]. A customary heat treatment consists in asset the castings in the furnace with constant temperature for predetermined period results thus improving the mechanical properties such as: Tensile strength and HB hardness; and in simultaneous deterioration of plasticity, and natural ageing. The decrease of the plasticity accomplished after heat treatment influences the growth of alloy's strength, thus the given application of the alloy should be selected depending on their optimal relation. Also in this work, the hardness of aluminium alloy A356-T6 was conducted by using precipitation hardening process. Enhancing the strength and hardness of metal Effect of Heat Treatment and Natural Ageing on Microstructure and Mechanical Properties of A3566 Reinforced with Bottom ash Composites alloys by the formation of extremely uniformly dispersed small particle of a second phase within the existing phase. Matrix is termed as Precipitation hardening. The diffusion of solute atoms into it from the matrix phase permits the precipitated particle to nucleate and grow [1]. Therefore, composites with bottom ash as reinforcement are probable to overcome the cost fence for wide spread applications in automotive and small engine applications. It is therefore expected that the integration of bottom ash particles in aluminium alloy will encourage yet another use of this low-cost waste by-product and, at the same time, has the prospective for conserving energy rigorous aluminium and thereby, reducing the cost of aluminium products.

II. LITERATURE SURVEY

K.P.Reddy et.al.(2016) In this report the author has studied about The effect of natural ageing on microstructure and mechanical properties of A356 reinforced with boron carbide, after and before heat treatment. In this investigation,

The permanent mold, gravity cast AGRM (A356 reinforced with B4C) alloys obtained from stir casting were heat treated for varied heat treatment parameters such as solution sing, and natural ageing, which spurred further improvement in the microstructure and the mechanical properties and concluded that Sound and dense castings were produced by Stir casting by means of pre-heated permanent mold. Heat treatment to a higher temperature resulted in Spherodisation of needle shaped Silicon particles leading to decreased aspect ratio, also natural ageing spurred further improvement in the microstructure and the mechanical properties. Heat treatment enhanced wear resistance and fine dispersion of second phases resulted in blocking dislocation slip leading to improved wear resistance and Improved Hardness, high strength to weight ratio, tensile and wear resistance was achieved in AGRM and reinforced B4C from heat treatment and natural ageing.

Anilkumar et.al. (2013) this paper studies about the mechanical and tribological behavior of reinforced AMC composite by varying Fly ash particle size. Three sets of composite with fly ash particle size 75-100 μ m, 45-50 μ m and 4-25 μ m was prepared and comparison study was made with Aluminum. The result showed significance decrease in mechanical behaviour such as compressive strength, tensile strength and hardness with increase in particle size of fly ash in AMCs composite with uniform distribution of fly ash.

Ramachandra et al. (2007) Investigated the wear and friction characteristics of Al (12% sic) matrix Composite reinforced with fly ash particles. The authors observed that wear resistance of the composite increased with increase in weight percent of fly ash while it decreased with increase in normal load and sliding velocity. With increase in fly ash content the slurry erosive wear resistance of the composite increased and the corrosion resistance decreased.

ShashiPrakash Dwivedi et.al. (2014) In this report the author has studied about Electromagnetic stirring process of A356/SiC composites. In this investigation, A356/SiC metal matrix composite with different weight percent of reinforcements (5%, 10% and 15%) were made-up by electromagnetic stir casting and showed significant increase in its mechanical properties such as microstructure homogeneity, fatigue etc.,

Dinaharan et.al. (2016)The paper reveals about the various characteristic of AMC reinforced fly ash produced by friction stir casting process such as optical microscopy, scanning electron microscopy and electron backscattered diagram. Homogeneous of FA is observed in the AMC produced by friction stir hardness. The result obtained from composite showed significant increase in micro hardness and wear resistance.

H. R.Ezatpour et.al.(2013) In this paper the research scientists studied about various mechanical properties like Hardness, Yield strength, Ultimate Tensile strength with mass fraction of Al₂O₃ in Aluminium. The Composite was manufactured by stir casting process. In this process the author also reviled about the various parameters like rpm, injection time, speed etc., considered for stir casting process.

Grigorios Itskoset et al (2011) In this report A356 Al-Fly ash composites were synthesized using pressure infiltration technique, by utilizing class C fly ash (FA) Metal Matrix Composites (MMCs) has excellent combination of physical, mechanical and tribological properties and their usage remains limited on account of their high production cost ,The fly ashes were separated into their different size fractions by manual screening, by using the respective sieves It was found that the finer the FA-particles, lower the friction coefficient. It was said finally that fine Fly Ash particles can strongly advantage the properties of composites and that grinding of fly ash facilitates MMCs-Manufacturing by pressure infiltration and it also advantages their wear properties.

III. MATERIALS & METHODOLOGY

3.1 A356 alloy

A356 alloy has been selected as the matrix material because of its good formability, outstanding mechanical properties and mechanized properties. Wide variety of the applications in the industrial sectors. A356 based alloys have been urbanized with substantial ductility, strength, elongation, hardness and toughness at room temperature in as-cast state. A356 alloys are ever more accepted in aircraft and automobile due to their high strength-to-weight ratio .In general, stiffer and lighter designs can be achieved with A356 alloys than is possible with steels. Aluminum alloy A356 was selected as matrix material. because, it is readily castable & widely studied and used. To select a suitable reinforcement and matrix for the aluminum nano composite, important factors such as density, wet ability and chemical reactivity at high temperatures should be considered. Silicon carbide is selected as reinforcement material because of its good wet ability, nearly identical density and the big difference of the thermal expansion coefficients with aluminum alloys. Metal matrix composites (MMCs) exhibit attractive physical and mechanical properties such as high tensile, creep and fatigue strengths, superior wear resistance, and improved thermal stability.

Table 3.1.1 Chemical composition of A356 Aluminium alloy, wt. Percentage

| Element | Cu | Mg | Si | Fe | Mn | Ni | Pb | Sn | Ti | Zn | Al |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----|
| Percentage | 0.051 | 0.730 | 7.761 | 0.500 | 0.116 | 0.030 | 0.024 | 0.015 | 0.027 | 0.042 | REM |

3.2 Bottom Ash

Bottom ash is one of the most inexpensive and low density reinforcement obtainable in large quantities as solid squander by-product during flaming of coal in thermal power plants. Hence, composites with bottom ash as reinforcement are likely to overcome the cost obstacle for wide spread applications in automotive & space craft, aircraft, military, marine Applications. Bottom ash is coarser than fly ash, with a sandy texture and particles ranging from about 0.1 mm to 50 mm in diameter. Bottom ash from dry-bottom boilers is generally dull black in appearance. It typically has the consistency of coarse sand to gravel and superior carbon content than fly ash. Bottom ash is the innate Particulate reinforcement.

Table 2: Chemical composition of Bottom ash, wt. Percentage.

| Element | SiO ₂ | Al ₂ O ₃ | Fe ₂ O ₃ | TiO ₂ | MgO | CaO | MnO | ZnO | CuO | P ₂ O ₅ | LOI |
|------------|------------------|--------------------------------|--------------------------------|------------------|------|------|------|-------|-------|-------------------------------|-----|
| Percentage | 65.50 | 16.21 | 4.90 | 1.20 | 0.75 | 2.80 | 0.12 | 0.020 | 0.040 | 0.080 | REM |

3.3 Mechanical Stir Casting Process Parameter

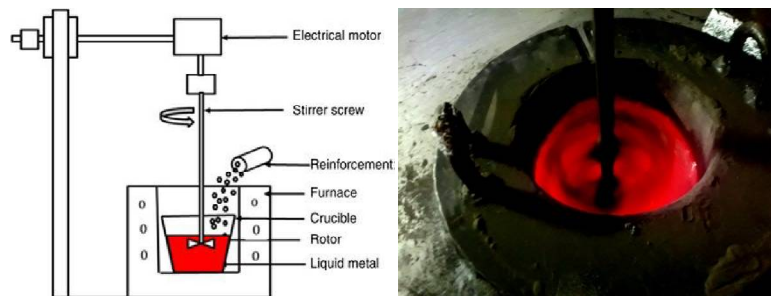


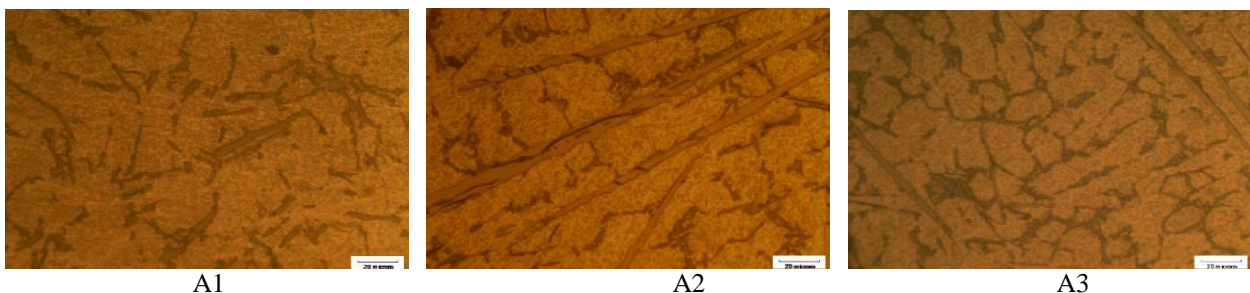
Figure 3.31: Schematic diagram of mechanical stir casting route

Clean the crucible which is made up of Graphite and Preheat the mould, Place the A356 metal pieces into the crucible, Maintain the furnace temperature around 750-800°C. Once A356 gains molten form add scum powder degassing tablet to it scum powder is used to remove slag, flux from the molten metal. degassing tablet [exo-chloro ethane] is used to remove unwanted gases from the molten metal, Preheat the reinforcements Pour this reinforcements into the molten metal with 2, 4, 6, 8, 10%wt each trail Using a Stirrer the reinforcements are stirred well in molten metal for about 10mins with approximate speed of 150-250rpm Then the molten mixture is poured into mould & left for cooling. Discontinuous reinforcement is stirred into molten metal, which is allowed to solidify. Stir casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of mechanical stirring. In stir casting, molten metal is stirred with the help of mechanical stirrer. This action disperses the reinforcing phase, which is added to the surface of the melt in the molten metal, and solidifies the composite. the crucial thing is to create good wetting between the particulate reinforcement and the liquid aluminium alloy melt. The preheated ceramic particles are introduced into the charge and it was stirred which leads to uniform dispersion of particles. The uniform distribution of reinforcement depends on material properties and process parameters such as the wetting condition of the particles with the melt, action on the particle surface. Hence, the breaking of the gas layer improves the wettability in fully liquid state. Stir casting process starts with placing empty crucible in the muffle

IV. EXPERIMENTAL RESULTS

4.1 Microstructure

The metallurgical microscope has been used for microstructure observation of matrix material. Some qualitative evidences of particulate distribution of combined Bottom excellence of bonding between two particulates and the matrix are obtained.



A1

A2

A3

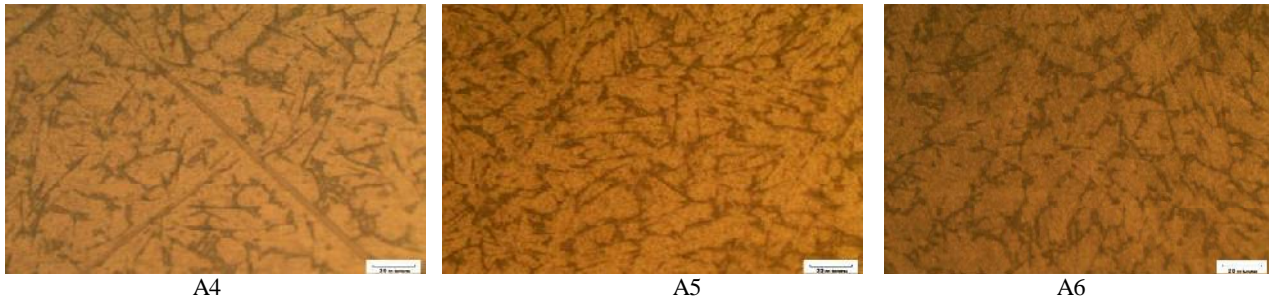
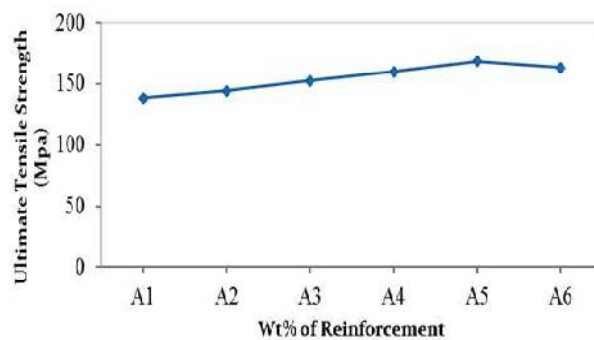


Figure 4.1.1: Microstructure of As-cast A356 composite (A1,A2,A3,A4,A5,A6)

The study of microstructure we can conclude that there is a homogeneous sharing of reinforcements in the alloy matrix. The bonding between particulates is satisfactory and finer grains of alloy matrix are found

4.2 Tensile test

The set of specimens were loaded in uni-axial tensile testing machine as per ASTM E8 standards and loaded until the failure of the sample occurs.

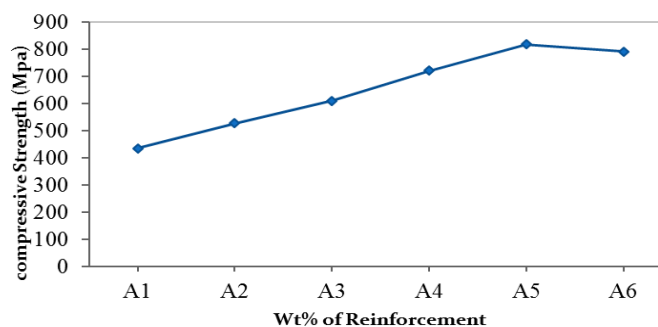


Graph 4.2.1: Evaluation of UTS for samples with various Bottom ash Compositions

It is noticeable from Graph the ultimate tensile strength (UTS) gradually increases with increase in weight % bottom ash reinforcement particles. reaches a maximum value of Bottom ash and then decreases.

4.3 Compression test

The set of specimens were loaded in uni-axial tensile testing machine as per ASTM E8 standards and loaded until the Crack formation occurs.



Graph 4.3.1: Evaluation of UTS for samples with various Bottom ash Compositions

It is noticeable from Graph the Compression strength gradually increases with increase in weight % bottom ash reinforcement particles. reaches a maximum value of Bottom ash and then decreases.

4.4 Effect of wear rate at varying load at room temperature

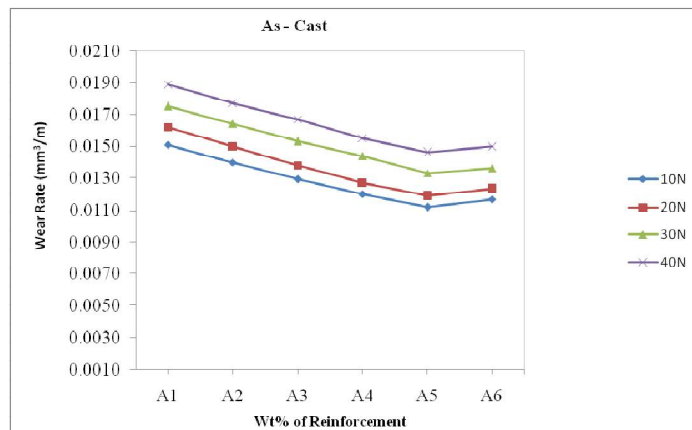


Fig. 4.4.1: Effect of wear rate at varying load

The variation of wear rate of A356 alloy and the composites with loads of 10,20,30and 40N where as other parameter are speed 400 rpm and sliding distance 1.6m/s kept constant was shown in figure 4.4.1. It clearly show that at all load condition the addition of bottom ash particles to A356 alloy result in less wear rate under different load condition& at a sliding speed 400rpm for room temp condition. In this case also wear rate is maximum for A356 and minimum for 8% of bottom ash particles. At higher applied loads, high wear rates are observed.

4.5 Effect of Bottom Ash Particle Addition on the Hardness

The Brinell hardness tester was used to carry out the hardness tests. The Binell hardness tester was used to carry out the hardness tests. The average value of the tests done at three different locations was considered as the hardness value of the composite specimens.

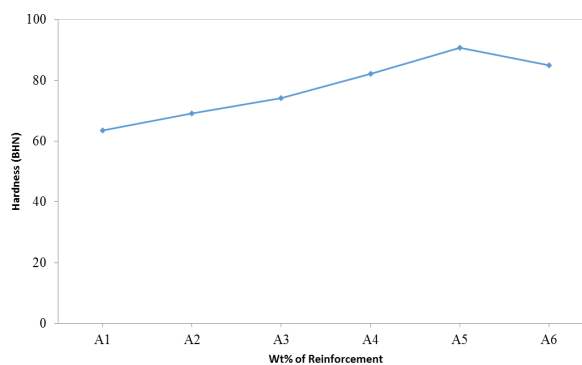


Fig. 4.5.1: Evaluation of Hardness for samples with various Wt % of bottom ash.

In this hardness test, the hardness of A356 alloy increases gradually with an increase in weight % of reinforcement. The graph increases up to A5 of reinforcement. Then the graph gradually decreases

V. CONCLUSION

Here we fruitfully fabricated the A356 bottom ash Composites by using Stir Casting method with proper sharing of bottom ash particles all over the specimen. We have drawn various conclusions from the various calculations based on the diff. experimental testes:

- [1] The microstructural studies revealed the uniform distribution of the particles in the matrix system.
 - [2] Reinforcing Aluminum & its alloys with bottom ash may show an appreciable increase in its mechanical properties.
 - [3] Hardness of the composites was determined by using brinell hardness testing machine as we found increased in the BHN at A5 wt%.
 - [4] Metal matrix composite of A356 reinforced with Bottom ash particulates is found to have improved wear resistance property.
- From results we uncover the optimal wear resistance value at A5 wt% of bottom ash having a good wear resistance compared A356 alloys without reinforcement.

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