

The Influence of Electroless Copper Coatings on A356 Alloy Reinforced With Bottom Ash Partials.

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ABSTRACT: The purpose of this work is to investigate copper's influence on the cast aluminum alloys. A356 alloy reinforced with both Cu coated bottom ash particles and Cu coated bottom ash powder are prepared by stir casting technique. Bottom ash particles are used to increase the hardness of composite. Bottom ash is coated with a copper layer through electroless deposition method. The analysis indicated the presence of copper on both the surfaces of bottom ash. It was found that density, hardness and tensile strength of the hybrid composites. Copper coating on the reinforcements improved the ductility due to improved wettability. Copper which increased porosity or not; and in that case explore this relationship between the amount of copper and the mechanical behavior. The possibility of formation of a uniform electroless deposition (ED) of copper on micron-sized bottom ash particles was investigated in this study.

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

I. INTRODUCTION

Cast aluminum-silicon alloys, especially hypoeutectic alloys are widely used in the aerospace and automotive industries due to the high mechanical properties and excellent foundry characteristics. New demands on effectiveness of energy while using products put focus on an optimal material. High goals have been put up for the car manufacturer regarding fuel consumption in vehicles. Casting is an economical, environmentally friendly and effective method of production that allows shaping in one step. Casting in light alloys approximation to have a big unused potential in lightweight constructions. Aluminum castings are used rarely in critical applications due the concerns about the variability in properties. This variability is a consequence of structural defects in the casting for example pores and oxide bi films which degrade mechanical properties [1]. The use of aluminum alloys increases for every year. The properties of alloying elements are an important factor to have knowledge about. The focus of this work is to get an optimal amount of copper in the aluminum cast material. To realize this it is important to have knowledge about alloying elements, casting processes and how the microstructure affects the cast materials properties [4]. Copper as an alloying element increase the strength, hardness, fatigue, creep resistance and machinability in an aluminum-silicon alloy. Strength and ductility are depending on how copper is distributed in the alloy. Copper is found dissolved in the dendrite matrix or as aluminum-copper rich phases. Alloys with dissolved copper in the matrix shows the most increase of strength and retains ductility. Continues network of copper at the grain boundaries increases the strength to appreciable levels but the ductility decreases [1]

To increase the content of copper in the alloy a higher hardness is achieved and porosity formation increases [2] The copper and its alloys are used in a wide variety of systems and applications such as: industrial equipments, heat exchangers, bearings, connectors, transport, etc. [6] applications based on the beneficial effect of highly thermal and electrical conductivity, corrosion resistance, mechanical resistance and the wear [5]. In the construction industry; plumbing, wires, heating, air conditioning systems, in covers and facades of buildings. The scaling in sulfuric and hydrochloric acid is the method more habitual to eliminate the formed oxides over the copper-based materials during the grinding process and fabrication operations. The organic acids such as the citric acid, presents advantages over the mineral acids of be less aggressive, easier to handle and do not present hazard for the health and the environment. This kind of scaling is adequate to eliminate the copper oxides and the spots (fogging) originated during the exposition of

the copper to the atmosphere without attacking the copper substrate. In this work is shown the results about the study, applying the electrode position technique of produce a copper coating from the industrial residues in the scaling process of the same material. Substrates of low carbon steel were coated for grounding connection and it was evaluated the electrochemical response.

II. LITERATURE SURVEY

Electroless copper plating is widely used for the fabrication of printed circuit boards and other electronic devices. Electroless copper can provide a seed layer on a dielectric material for subsequent acid copper electroplating.[5] There is renewed interest in copper deposition for ultra-large scale integrated circuits (ULSI) because of the higher conductivity of copper versus aluminum. Electroless copper plating is well suited for uniform copper deposition on a variety of substrates.⁷ However, when compared to the electrodeposition of copper, electroless plating has a lower deposition rate (1 to 3 $\mu\text{m/hr}$; ~ 40 to 120 $\mu\text{-in. /hr}$) and the resultant deposit has less desirable metallurgical properties.¹⁰ Furthermore, electroless plating requires more rigorous control because of transient bath changes, and the deposit mechanical properties are highly processdependent. Thus, further improvements are necessary for the electroless copper plating process to meet the specific needs of ULSI circuitry. The deposition rate and deposit properties of electroless copper plating depend on the copper complexing agent, reducing agent, bath temperature and pH.¹¹ In addition, additives such as stabilizers, accelerators and brighteners are used. The copper coated ceramic particles can be fabricated by solid, liquid or vapour state methods.⁹ Electroless deposition (ED) represents one of the liquid preparation routes which is widely used for preparing metallic coatings onto various surfaces. ED provides a means for metallic coating of ceramic reinforcement without the requirement for costly electrolytic bath or other electroplating equipment and associated electrical running costs. The ED technique has been shown to controllably provide coatings of homogenous thickness on complex shaped components.

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.

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. Sand to gravel and superior carbon content than fly ash. Bottom ash is the innate Particulate reinforcement.

3.3 Electroless Copper Coating

One litre of above mentioned electrolyte bath was taken in a beaker and mixed thoroughly. The pH value of the solution was maintained at 13 by addition of NaOH, while temperature of the bath was maintained at 600 C. Under these operating conditions, the bath was stirred by use of magnetic stirrer. The above procedure is repeated for coating bottom ash particulates (5g) at each time. The concentration of the dispersoids to be coated was 15g/L for bottom ash

while for graphite it was 5g/ltr .However the total time adopted for coating was 30 min. The coated powders were then filtered and dried in an oven.

3.4 Casting processes

Casting processes are divided into two major categories, expendable mould and permanent moulds. Expendable moulds are sand casting, lost wax method, vacuum moulding and shell moulding. Permanent moulds are high pressure die casting, gravity die casting, and centrifugal casting and squeeze casting.

3.4.1 Sand casting

A new mould has to be created by a pattern each casting but the sand in the mould could be cast-off. The sand has poor heat transfer and the surfaces of the metal will solidify and shrink and a gap will be formed which decrease the heat transport. The design of the gating system is important for a good delivery of the metal into the cavity of the moulds.

3.4.2 Gravity die casting

Usually alloys with a low melting point are used like aluminum and magnesium. This kind of casting method is used especially in large series developed with an even thickness of the material. The dies are preheated or pre cooled to about 200 – 300 degrees Celsius. The metal is poured into the die and force to fill the hold mould is the gravity. Compared to sand casting gravity die castings provide higher strength and finer structure because of the faster cooling rate. The faster cooling rate depends on the good heat transfer in the metal die.

3.4.3 High pressures die casting

The metal is forced in to the die with high pressure up to 150 MPa. The casting is held under pressure until it is solidifies. The casting product has a range of weight between 90 gram and 25 kg. It is a very automatic casting process for high production rates with good strength, parts with complex shapes and good dimension accuracy which can make thousands of castings every hour.



After production, the specimens were remelted and solidified using the gradient solidification technique, figure 5, which enables production of samples with a low content of porosity and oxide films defects, and providing a well-fed and homogenous microstructure; thereby revealing the inherent potential of the alloy's mechanical properties that are to a large extent determined by the microstructure constituents and not by the defects. The gradient solidification furnace operates by holding the rod in a heated environment until it is fully remelted, while protected from oxidation by the use of an argon gas shield. The temperature in the furnace was set to 713°C and the samples were left at that temperature for 32 minutes. The heating element is then raised at a prescribed speed while the metal sample remains in a stationary position. At the base of the rising heating element, there are jets of water which cool the metal specimen as it passes.

IV. RESULTS AND DISCUSSION

4.1 Hardness test

Composite	BHN (Uncoated)	BHN(Cu Coated)
A356 A1wt%	80	86
A356 A5 wt %	88	90

Table: 4.1 Hardness of various composites (under coated and non coated conditions)

Hardness testing of the prepared composites is carried out using Brinell hardness testing Machine. It is clear that, improvement in hardness is seen with the adding up of Bottom ash reinforcements to A356 alloy. It can be also noted that Hardness improves with increasing addition levels of bottom ash from A1 wt % - A5 wt %. Further, the composite containing Cu coated bottom ash particles have improved hardness compared to the composite with uncoated bottom ash partials particles. It may be attributed to homogeneous dispersion of bottom ash reinforcements due to optimum stirring speed and time and also due to better bonding of the bottom ash partials with the A356 matrix due to copper coating; this is confirmed by optical photo micrographs and SEM study.

4.2 Microstructure

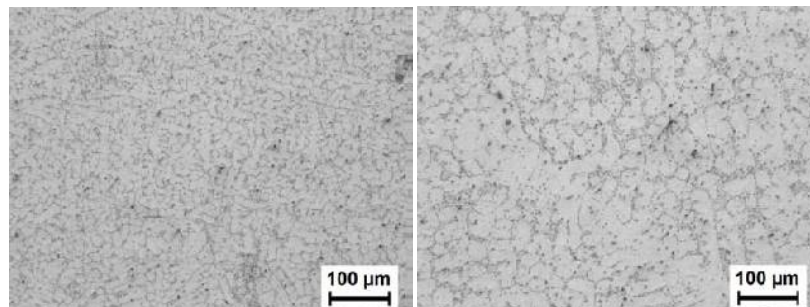


Fig.4.2 Optical photographs of cu coated A356 –SiC composites

Higher solidifications rate consequences in a better microstructure. When the solidification rate is low the growth of bottom ash, aluminum-copper rich and intermetallic particles is larger. The strontium alters the bottom ash morphology and size making the particle edges slightly rounder. As for the high pressure casting, the bottom ash size is 100 µm and the bottom ash particles are very small because of the high solidification rate. A small amount of aluminum copper rich phases is observed in the material.

V. CONCLUSION

The present work deals with the preparation of characterization of waste bottom ash reinforced with A356. The metallic coating of bottom ash particles is a useful technique in order to promote reinforcement bonding with the matrix alloy. The possibility of formation of a uniform electroless deposition (ED) of copper on micron-sized bottom ash particles was investigated in this study.

A356 MMC's reinforced with bottom ash obviously show improvement in mechanical properties due to reinforcing of a harder bottom ash into A356 metal matrix. Perfection in mechanical properties enhances with increase in bottom ash reinforcements from A1-A5 wt % in A356 matrix. Copper coating of bottom ash reinforcements at 100 microns has a profound effect on increased density and wettability and adhesion due to which further improvements in mechanical properties observed. Further with adaption of most favourable stirring speed and time better homogeneous dispersion of bottom ash reinforcements in A356 matrix can be made which in turn helps in achieving improved mechanical and wear properties.

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