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Evaluation of Mechanical Properties of Al6063 Alloy MMC Reinforced with SiC and Coconut Shell Ash

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Abstract: Aluminium is most commonly used material in engineering due to its good mechanical properities like weight to strength ratio, ductility and thermal conductivity etc. The conventional aluminium cannot meet the requirements of the modern industry. These requirements can be fulfilled by producing AMCs. In the present study, conventional and economic technique of stir casting was used to produce aluminium matrix composite which involves stirring the filler in the molten metal. In this study, aluminium Al6063 was used as a matrix and fine particles of Silicon carbide (Sic) and coconut shell ash (CSA) as reinforcement. The stir casting method was used for producing AMCs due to simplicity. Stirring was carried out with the help of machine for 15 mins at stirring rate of 250 rpm. The stirring speed was kept constant throughout the process. To analyze the effect of weight percentage of the reinforcements, tensile test, impact test, hardness test and optical microscopy were performed. Results show that the impact test, tensile strength and hardness of reinforced matrix increased as compared to unreinforced matrix. The optical microscopy shows the proper mixing of Al6063, CSA and SiC into the matrix. Present work is focused on the study of the effect of reinforcement on Al based MMC with addition of Sic and CSA with weight percentage of 4%, 8%, 12% respectively using stir casting technique. Various tests such as optical microscopy, tensile strength test, hardness as well as impact test were performed to investigate the mechanical behavior of composite alloy.

Keywords: MMCs, NFRCs, Stir Casting.

1. INTRODUCTION TO COMPOSITES

We live in a world that is both dependent upon and limited by materials. Human civilization started with Stone Age where people used only natural materials, like stone, clay, skin, and wood for the purposes like making weapons, instruments, shelter, etc. The increasing need for better quality tools led to Bronze Age, followed by Iron Age when people found copper and how to make it harder by alloying the use of iron and steel a stronger material that gave advantage in wars.The next big step in human civilization was the discovery of a cheap process to make steel which enabled the railroads and the building of the modern infrastructure of the industrial world. Thus there has been a need for human and material resources for centuries, which still going strong, **(Kailas, 2012).**

Composites are not just useful in making things fly. Cars of the future must be safer, more economical, and more environmentally friendly, and composites could help achieve all three. Although composites such as GRP have been used in the manufacture of automobile parts since the 1950s, most cars are still made from steel. High temperature matrix composites are also making possible cleaner-burning, more fuel-efficient engines for both cars and trucks. Composites are increasingly used in place of metals Sin machine tools. Therefore conventional engineering materials are unable to meet this requirement of special properties. Hence there is a great need for materials with special properties with emergence of new technologies. Thus, emerged new class of engineering materials i.e. composites. A composite material is composed of reinforcement embedded in a matrix. The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix.

Classification of Composites

On the basis of matrix material or matrix phase composites are classified as Metal Matrix Composites (MMC), Ceramic Matrix Composites (CMC), Polymer Matrix Composites (PMC). Metal matrix composites (MMCs), like all composites consist of at least two chemically and physically distinct phases, suitably distributed to provide properties not obtainable with either of the individual phases. A metal matrix composite (MMC) combines into a single material a metallic base with

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a reinforcing constituent, which is usually non-metallic and is commonly a ceramic. By definition, MMC‟s are produced by means of processes other than conventional metal alloying**, (Singh, 2012).**

Metal Matrix Composites

A composite material in which one constituent is a metal or alloy, the other constituent is embedded in this metal matrix and usually serves as reinforcement. Due to combination of metallic properties with ceramic properties, metal matrix composites show greater shear and compression strength with capabilities to perform at high temperature. Metal Matrix Composites (MMC's) are considered a group of advanced materials which represent low density, good tensile strength, high modulus of elasticity, low coefficient of thermal expansion, and good wear resistance, **(Baghchesar,2009).**

Natural fiber reinforced composites

The use of natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocelluloses fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. The natural fiber-containing composites are more environmentally friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling panelling, partition boards), packaging, consumer products, etc.

Coconut Shell Ash

Many researchers have made efforts for preparing carbon from agricultural by-products such as coconut shell apricot stones, sugarcane nutshells, forest residues and tobacco stems. Coconut shells have little or no economic value and their disposal is not only costly but may also cause environmental problems. Coconut shell is suitable for preparing carbon black due to its excellent natural structure and low ash content. Conversion of coconut shells into activated carbons which can be used as adsorbents in water purification or the treatment of industrial and municipal effluents would add value to these agricultural commodities, help reduce the cost of waste disposal, and provide a potentially cheap alternative to existing commercial carbons.

2. LITERATURE REVIEW

(Prasad, 2007). Produced aluminium - silicon carbide and boron carbide hybrid Metal Matrix Composites using stir casting method. Experimental results showed that at higher cutting speeds, good surface finish was obtained with faster tool wear. It was resulted that, tool wear and cutting force were directly proportional to the cutting speed, where as surface roughness was inversely proportional to the cutting speed.

(Chandrashekar et al., 2010).studied the effect of fly ash particles in Al-4, Si-Mg cast composite. The results showed that particle contents affected to the presence of porosities and hardness of the composites. It was observed that increasing the fly ash content increase the porosity in the composites; with the matrix alloy reinforced with high wt. % of fly ash particles have the highest porosity and lowest hardness.

J.Sarki et. al. Studied coconut shell filled composites which were prepared from epoxy polymer matrix containing up to 30 wt% coconut shell fillers. The effects of coconut shell particle content on the mechanical properties of the composites.

Kheder et. al (2011), employed liquid state mixing technique for preparing composite of pure aluminium reinforced with SiC, MgO & Al_2O_3, and in this technique degasser was added to the content of the composite while mixing to minimize gas bubbles at the final cast. It was found that the addition of SiC, MgO & Al_2O_3 particulates into the matrix increased the yield strength, the ultimate tensile strength & the hardness, & decreased elongation (ductility) of the composites in comparison with those of the matrix. Increasing wt% of SiC, MgO & Al_2O_3 increased their strengthening effect but SiC was the most effective strengthening particulates, for higher strength, hardness, & grain size reduction but it decreases ductility & toughness**.**

3. STIR CASTING PROCESS

Stir casting process is a liquid state process which is used to fabricate MMCs conveniently. The function of a stirrer is to agitate liquids for speeding up reactions. Stirrer was designed for homogenous mixing of liquid, solution, viscous

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material and solid liquid. It is the important parameter of stir casting process. It is mainly required for vortex formation of uniform distribution of particles. There are generally two types of stirrer used i.e. either stirrer is adjusted 90^o from the shaft or it is bent at 45^o from the shaft.

4. MMCS

For the preparation of AMC the matrix Aluminium alloy AL6063 is used as matrix for manufacturing of composites.
Reinforcements: Silicon carbide and Coconut Shell Ash was used as a reinforcement material.

5. SETUP

To heat the material at desired temperature pit furnanace is used. The pit furnace used for present work. Al6063 was melted in Graphite crucible by heating it at 750^{o}C for four hours in the furnace.

6. EXPERIMENTATION

Aluminium alloy AL6063 is used as matrix for manufacturing of composites. Aluminium alloy was cut from the ingot size into smaller pieces by a power hacksaw in order to feed them into crucible properly. Silicon carbide and CSA was used as a reinforcement material. The compositions used for making composites are described in the below table 3.1.
A sieve analysis is used to assess the particle size distribution of a granular material. A sieve analysis can be performed on any type of non-organic or organic granular materials including sands, crushed rock, clays, granite, feldspars, coal, and soil, a wide range of manufactured powders, grain and seeds, down to a minimum size depending on the exact method. In this experiment SiC and CSA particles in powdered form is used.Stirring was carried out with the help of machine for about 15 minutes at stirring rate of 250 RPM.


Fig.-Stirring Process

The silicon carbide particles and csa were preheated at 1100oC respectively for three hours to make their surfaces oxidized. The furnace temperature was first raised above the liquid us temperature of Aluminium up to 750oC to melt the Al alloy completely and then cooled down just below the liquid us to keep the slurry in Semi solid state.

Table 1: Samples with all parameters

SAMPLE No.	COMPOSITION
S1	Pure (AL6063)
S3	Aluminium (AL6063)+ 8% (SiC)
S6	Aluminium (AL6063) + 8% (CSA)
S9	Aluminium (AL6063) + 12% (SiC) +12% (CSA)

7. RESULTS

7.1 Charpy Impact test

The Charpy impact test was performed on the Impact testing machine provided by the institute. This result is shown in the figure in the form of bar chart with all process parameters.

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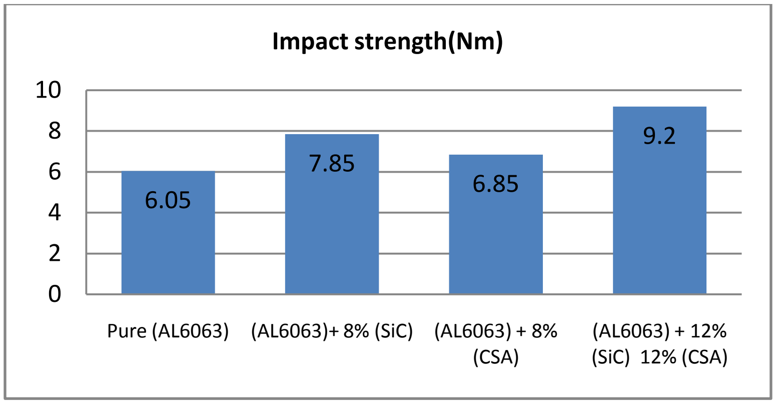
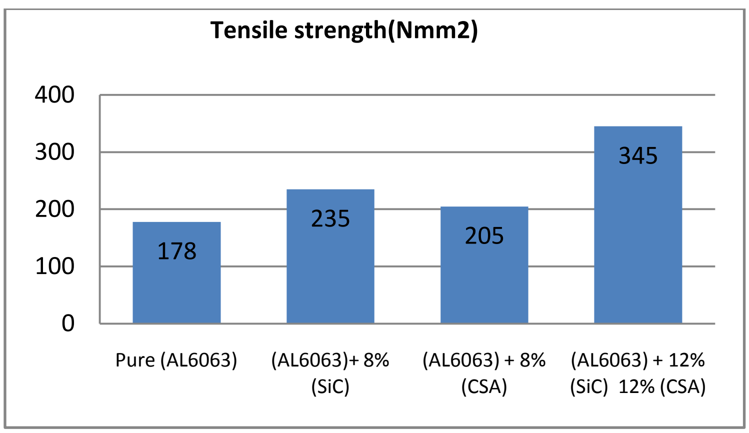


Graph shows that with the increase in SiC constituent Impact strength increases as compared to base metal. It is observed from figure that for a given percentage of SiC and CSA, higher value of impact strength is obtained with SiC. the increase is nominal which gives an indication that further increase in reinforcement may not have any considerable effect in impact strength. This increase and further saturation may be due to the complete dispersion of SiC and CSA into matrix and strong interfacial bonding between Aluminium alloy AL6063, SiC and CSA.

7.2 Ultimate Tensile Strength

Tensile test is used to assess the mechanical behavior of the composites and matrix alloy. Ultimate tensile strength (UTS), often shortened to tensile strength (TS) or ultimate strength, is the maximum stress that a material can withstand while being stretched or pulled before necking, which is when the specimen's cross-section starts to significantly contract. The samples for the tensile test were cut from the composite blanks with power hacksaw followed by the cutting on the shaper machine.



7.3 Vicker's Hardness Test

A Vicker's hardness tester was used for the hardness measurement. The specimens were prepared are metallographic finished with different grades of emery paper and subsequently rubbing with a keller solution. The hardness of composite samples was measured at 10 kgf load for 20 seconds for 25 to 30 times repeatedly on a sample. The result of Vicker's hardness test for AL6063 without reinforcement and the wt. % variation of different reinforcements SiC/CSA and AL6063 are shown in Table

In results Vicker's hardness test base metal had 114 VHN. But with the addition 8 % of silicon carbide in base metal it increases the tensile strength 127 VHN. But when added the 8 % of CSA in base metal it decreases the strength 125 VHN. The combined Vicker's hardness of 12% CSA and silicon carbide was 172 VHN increases the strength 172 VHN.

It is observed that hardness of SiC reinforced composite is more than that of CSA reinforced composite. Hardness of composite depends on the hardness of the reinforcement and the matrix. From the graphs it is clear that, as the reinforcement percentage increases the micro hardness also increases. The reason for this may be either the proper mixing due to high viscosity of molten composites or good interfacial bonding between the particle matrix interfaces.

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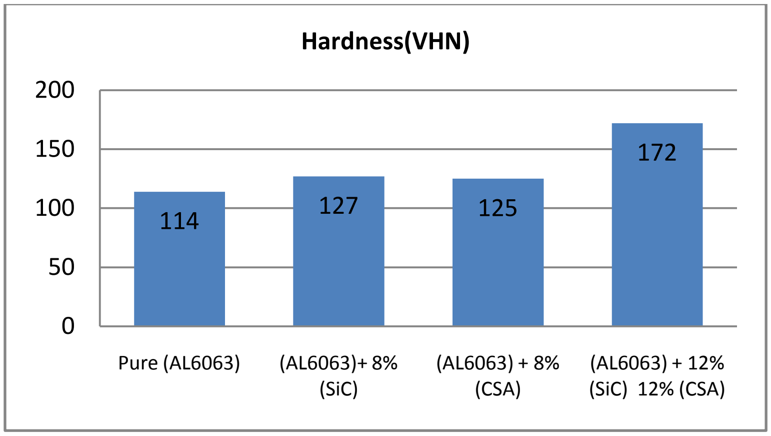

8. CONCLUSION & REMARKS

In this investigation, it is observed that with the use of different experimental techniques we were able to characterize some physical and mechanical properties of Stir casted Aluminium alloy AL6063 and its composites containing different weight fractions of SiC and CSA particles.

- Aluminium based composites with the addition of SiC and CSA was successfully achieved with stir casting process. It has been observed that stir formed Al alloy Al6063 with SiC/CSA reinforced composites is superior to base Al alloy Al6063 in terms of tensile strength, Impact strength and Hardness.
- Optical microstructures were analyzed to observe the presence and distribution of reinforcing particles in aluminium alloy. The investigations have revealed the presence SiC, CSA particles in alloy matrix in a uniformly distributed manner. The phases like CSA and SiC etc. have dispersed uniformly throughout in the MMC thus strengthening the resulting composite.

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