Characterization of Rice Husk Ash and SiC Reinforced Aluminium Metal Matrix Hybrid Composite

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Abstract— *The properties of aluminium are improved remarkably by introducing hard inter metallic compound into the aluminium matrix. The present work has been undertaken with an objective to explore the use of rice husk ash and silicon carbide as a reinforcing material. In this work, the effect of rice husk ash and silicon carbide on mechanical properties of Aluminium metal matrix hybrid composites are studied. The reinforcing materials are generally* Al_2O_3*, TiO2 etc and are costly. Experiments have been conducted under laboratory condition to assess the mechanical characteristics of the Aluminium-Rice husk ash-Silicon carbide composite by fabricating the samples through Stir casting technique. Dispersion of reinforcement particles in aluminium matrix improves the hardness of the matrix material and compression behaviour of the hybrid metal matrix composite also evaluated.*

Keywords— Aluminium, rice husk ash, silicon carbide, hybrid metal matrix composite.

I. Introduction

The Aluminium Matrix Composites will continue to find new applications, but the large scale growth in the market place for these materials will require less costly processing methods and the prospect of recycling will have to be solved. Now a day's researchers all over the world are focusing mainly on aluminium because of its unique combination of good strength, light weight, wear and corrosion resistance, low density and excellent mechanical properties [1-7]. The unique thermal properties of aluminium composites such as metallic conductivity with coefficient of expansion that can be tailored down to zero, add to their prospects in aerospace and avionics. The deformation and fracture behaviour of the composite revealed the importance of particle size. A reduction in particle size is observed to increase the proportional limit, compressive strength, yield stress and the ultimate tensile stress. Rice husk is an agricultural residue which accounts for 20% of the 649.7 million tons of rice produced annually worldwide. This Rice Husk Ash is a great environment threat causing damage to the land and the surrounding area in which it is dumped. This ensures the researcher for effective utilization of this agricultural waste Rice Husk Ash has been found suitable for wide range of domestic as well as industrial applications. Rice Husk Ash can be used either as a value added material for manufacturing or as a low cost substitute for modifying the properties of existing products [8-17]. A systematic approach to this material can give birth to a new industrial sector of Rice Husk. By burning the husk under controlled temperature below 800°C ash is produced.

Rice Husk Ash with silica mainly in amorphous form, it can produce the composites with low density and having high temperature resistance and hardness [18-21]. Silicon Carbide (SiC) is used in abrasives, refractories, ceramics and high performance applications. The SiC can also be made as an electrical conductor and has applications in resistance heating flame igniters and electronic components.

II. Experimental Work

A. *Preparation of Rice Husk Ash*

During milling, 80% of paddy is rice and 20% is husk. The rice husk comes with some rice grains and sand mixed together both in particles and powdered form which has to be separated before use. It was first blown manually to separate the husk from rice grains and some sand particles and then washed with tap water three times by stirring in a container to allow the sand particles to settle at the bottom while the powdered grains and sand mixed with the water and became muddy. This muddy water was then poured away and the rice husk was manually removed from the container leaving behind the settled sand. The blown and washed rice husk was then dried under sun rays for three days on stainless steel trays. This rice husk was heated to 700^0C for 2 hours. The chemical composition of the rice husk ash (RHA) will be as shown in the Table 1. The rice husk ash was then burnt at 800^0C for one hour. The colour of the rice husk ash will be black.

Table 1: Chemical composition of Rice Husk Ash

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	Others
97.0	1.13	0.136	0.07	0.83	0.17	0.18	0.09	Balance

B. Sample Preparation-Stir Casting

It is a liquid state method of composite materials fabrication, in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring. The process layout of stir casting equipment, is shown in Fig. 1. Mechanical stirring in the furnace is a key element of this process. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement.

The stir casting equipment consists of conical shaped graphite crucible as shown in the Figure 2. It is used for fabrication of AMCs, as it withstands high temperature which is much more than required temperature [680°C].Along that graphite will not react with aluminium at this temperature. This crucible is placed in muffle which is made up of high ceramic alumina. Around which heating element (coil) is wound. The coil which acts as heating element is Kanthol-A1. This type of furnace is known as resistance heating furnace. It can work up to 900°C reach within 45 min. Aluminium, at liquid stage is very reactive with atmospheric oxygen. Oxide formation occurs when it comes in contact with the open air. Thus all the process of stirring is carried out in closed chamber made of sheet steel with nitrogen gas as inert gas in order to avoid oxidation. This reduces heat loss and gas transfer as compared open chamber. A K-type temperature thermocouple whose working range is -200°C to 1250°C is used to record the current temperature of the liquid. One end of shaft is connected to 0.5 hp PMDC motor with flange coupling. While at the other end blades are welded. 4 blades are welded to the shaft at 45°C. A constant feeding rate of reinforcement particles is required to avoid coagulation and segregation of the particles. This can be achieved by using hopper.

Fig 1: Stir Casting Equipment

Aluminium alloy matrix will be formed in the crucible by heating aluminium alloy ingots in furnace. A stirring action is started at slow rate of 30 rpm and increases slowly in between 300 to 600 rpm with a speed controller.

Fig 2: Crusible inside Furnace

Stir casting starts with placing of crucible in the furnace as shown in Fig. 2. Aluminium is used as the matrix material. Required quantity of aluminium alloy is cut from the raw material which is in the form of round bar. Aluminium alloy is cleaned to remove dust particles, weighed and then poured in the crucible for melting. At first, heater temperature is set to 500°C and then it is gradually increased up to 700^0C. High temperature electrical induction furnace helps to melt aluminium quickly, reduces oxidation level, enhance the wet ability of the reinforcement particles in the matrix metal. During melting argon gas is used as inert gas to create the inert atmosphere around the molten material. After the aluminium reaches molten state, silicon carbide powder, rice husk ash are added as reinforcements. Silicon carbide powder is preheated for 1 hour at 500^0C to remove the moisture content. Rice husk ash is not preheated as it is already heated at 700^0C. Reinforcements are weighed to required amount and are added with the help of hopper. Stirring is started after 2 minutes, Stirrer rpm is gradually increased from 0 to 300 RPM with the help of speed controller. Temperature of the heater is set to 630°C which is below the melting temperature of the matrix. A uniform semisolid state of the molten matrix was achieved by stirring it at 630°C.Pouring of preheated reinforcements at the semisolid stage of the matrix enhance the wet ability of the reinforcement, reduces the particle settling at the bottom of the crucible. Dispersion time was taken as 5 minutes. After stirring 5 minutes at semisolid stage slurry was reheated and hold at a temperature 700^0C to make sure slurry was fully liquid. Stirrer RPM was then gradually lowered to the zero.

The stir casting apparatus is manually kept side and then molten composite slurry is poured in the metallic mould. This makes sure that slurry is in molten condition. While pouring the slurry in the mould the flow of the slurry is kept uniform to avoid trapping of gas. This procedure is done for 2%, 4%, 6% addition of silicon carbide and constant 5% rice husk ash.

III.RESULTS AND DISCUSSIONS

A. Hardness Test

The Hardness test of all samples were conducted using Rockwell Hardness Testing Machine with a dwell time of 15 sec and applied load of 100kgf during test. For each and every composition three indentations were taken and average value is reported in Fig. 3.

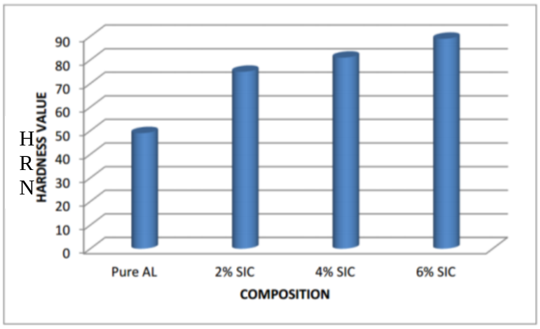

Fig 3: Hardness Value and % weight fraction of SiC with Al+5% RHA hybrid metal matrix composite

The hardness values of composites are increasing with the increase in Silicon Carbide composition due to intermetallic bonding between the aluminium and 5% RHA composite.

B. Compression Test

The compression test of all the samples were conducted on the compression testing machine and the corresponding compressive strength (in MPa) were noted for the two different percentages of deformation in length as shown in Fig. 4.

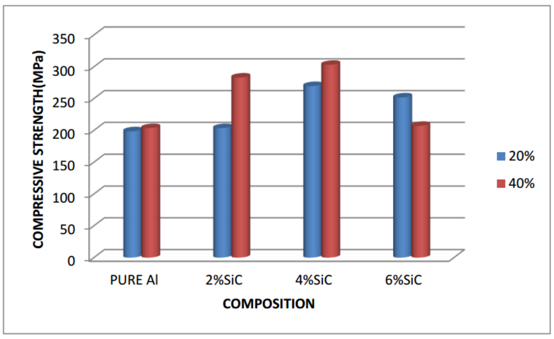

Fig 4: Compressive Strength and % weight fraction of SiC with Al+5% RHA hybrid metal matrix composite

It was observed that for a constant percentage of deformation, the compressive load increased with the increase in the Silicon Carbide Composition upto 4% constituent in the composite while Compressive strength decreases with increase in composition from 4% onwards.

C. Micro Structure Analysis

Micro Structure is the small scale structure of a material, defined as the structure of a prepared surface of material as revealed by a Microscope above 25x magnification. The Micro structure of materials can strongly influence the physical properties of materials such as strength, hardness, roughness, ductility, corrosion resistance and wear resistance.

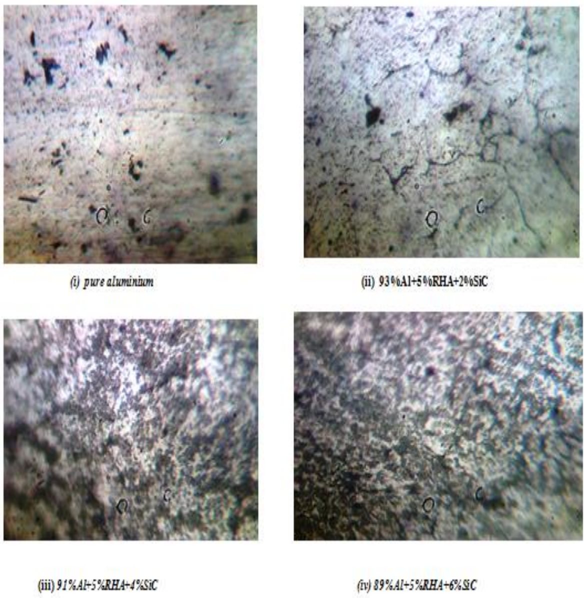

Fig 5:Microstructure Analysis of Pure Aluminium and % weight fraction of SiC with Al+5% RHA hybrid metal matrix composite

From the microscopic observation of Fig. 5, it is evident that grain size has increased significantly with increase in concentration of SiC in hybrid metal matrix composite. The increased grain size has shown difference in Physical properties. Usually increased grain size leads to increase in Strength and Hardness up to certain extent.

IV.CONCLUSIONS

Effect of Rice husk ash and silicon carbide as a reinforcement material in Aluminium matrix has been studied in this project. Concentration of silicon carbide is varied from 2%, 4% and 6% by Weight and percentage of rice husk ash is maintained at 5% of the total weight. The test specimens of different compositions of silicon carbide and rice husk ash with Aluminium are prepared by Stir Casting process followed by hardness, Compression test and micro structural observation. It is found that hardness of MMC increases with increase in SiC when compared to pure aluminium. The compressive strength of the hybrid metal matrix composite increases upto 4% addition of SiC and then decreases. From the microscopic observation it has been observed that the grain formation which led to the increase in strength.

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