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Characterization of Metal Matrix Composite Properties by Adding Bronze and Fly Ash for heat Exchanger Applications

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Abstract:

The present research work is on bronze alloy metal matrix composite reinforced with fly ash particulate in weight percentage of 3%, 6% and 9%. The specimens can be produced by Liquid metallurgy technique (Stir casting method) will be used to produce metal matrix composites using Aluminum Copper alloys as matrix material. The produced composites will be characterized with respect to mechanical properties and wear properties. Results obtained from the above investigation, it can be seen that the rate of wear is decreased with increasing bronze and will be helpful for the end of users in the foundry of automobile and aerospace industries.

Keywords — **Metal Matrix Composite, Mechanical Properties, bronze alloy.**

I. INTRODUCTION

Metal matrix composites (MMCs) reinforced with nano-particles, also called Metal Matrix nano-Composites (MMnCs), are being investigated worldwide in recent years, owing to their promising properties suitable for a large number of functional and structural applications. The reduced size of the reinforcement phase down to the nano-scale is such that interaction of particles with dislocations becomes of significant importance and, when added to other strengthening effects typically found in conventional MMCs, results in a remarkable improvement of mechanical properties.

The main issue to be faced in the production of MMnCs is the low wettability of ceramic nano-particles with the molten metal matrix, which do not allow the production of MMnCs by conventional casting processes. Small powder aggregates are in fact prone to form clusters, losing their capability to be homogeneously dispersed throughout the matrix for an optimal exploitation of the strengthening potential. For this reason, several alternative methods have been proposed in order to overcome this problem.

The production methods can be categorized into two major groups: *ex situ* and *in situ*. The first synthesis route consists of adding nano-reinforcements to the liquid or powdered metal, while *in situ* processes refer to those methods leading to the generation of ceramic nano-compounds by reaction during processing, for example by using reactive gases. Several methods have been developed for *ex situ* synthesis of MMnCs. In particular, different powder metallurgy techniques were successfully employed. Moreover, ultrasound-assisted casting plays a particularly promising role for its high potential productivity. Alternative methods are listed and discussed in a following section.

The methods used for the characterization of MMNCs are the same of those used for conventional MMCs and alloys. Of course, the downsizing of the reinforcement implies the use of higher resolution techniques for characterization of morphology and local chemistry of the constituents.

Strengthening Mechanisms:

The high mechanical resistance of MMnCs is the result of several strengthening mechanism contributions, namely: load transfer effect, Hall-Petch strengthening, Orowan strengthening, coefficient of thermal expansion (CTE) and elastic modulus (EM) mismatch .In the following sections, each strengthening methods will be discussed separately.

2.0 LITERATURE REVIEW:

Seah et al (2003) developed Al / quartz particulate composites cast in sand moulds containing metallic and non-metallic chills respectively. During testing, all other factors were kept constant and by the introduction of chills, the faster heat extraction from the molten MMC during casting led to an increase in the ultimate tensile strength and fracture toughness of the castings. In fracture analysis of the MMCs, cast using copper and steel chills showed ductile rupture with isolated micro-cracks and a bimodal distribution of dimples on the fracture surface. In contrast, fracture analysis of the MMCs cast without chills revealed brittle failure with separation of the quartz particles from the matrix.

Riccardo Casati and Maurizio Vedani(2013) Metal matrix composites reinforced by nano-particles are very promising materials, suitable for a large number of applications. These composites consist of a metal matrix filled with nano-particles featuring physical and mechanical properties very different from those of the matrix. The nano-particles can improve the base material in terms of wear resistance, damping properties and mechanical strength. Different kinds of metals, predominantly Al, Mg and Cu, have been employed for the production of composites reinforced by nano-ceramic particles such as carbides, nitrides, oxides as well as carbon nanotubes. The main issue of concern for the synthesis of these materials consists in the low wettability of the reinforcement phase by the molten metal, which does not allow the synthesis by conventional casting methods. Several alternative routes have been presented in literature for the production of nano-composites. This work is aimed at reviewing the most important manufacturing techniques used for the synthesis of bulk metal matrix Nano composites.

D.siva g. karthikeyan(2016) It was pragmatic that the hardness of the hybrid composite increased withincreasing reinforcementvolume fraction and density decreased with increasing particlecontent. It was also pragmatic that the tensile strength and yield strength increase with anincrease in the percent weight fraction of the reinforcement particles, the increase in strengthof the hybrid composites is probably due to the increase in dislocation density.Density of the composites decreased by increasing the content of the reinforcement.So these composites can be used in applications where to a great extent weigh reductions are desirable.The hardness of prepared composites are increased by increasing rice husk ashIt appears in this study that tensile strength increases with increases in weightpercentage of RHS. These composites can find application in automotive like piston,cylinder liners and connecting rods. These composites can alsofind application where li weight materials are required with good hardness and strength

Methodology:

EXPERIMENTAL WORK

The matrix material is used in the experiment investigation of commercially bronze. The fly ash was collected from the Lanco industries. The particle size of the fly as is sieved the range from (0.1-100 µm).

. Melting and Casting First of all, 150gm of commercially bronze was melted in a resistance heated furnace and casted in a mild steel die. The melt temperature was raised to 7200C. Then the bronze-fly ash (5%, 10%, 15% and 20%) composites were prepared by stir casting method. The 150gm of commercially bronze and then (5, 10, 15, 20) wt% of fly ash was added to the bronze melt for production of four different composites. The fly ash particles were preheated to 300oC for three hours to remove the moisture. Commercially bronze was melted by raising its temperature to 720oC. Then the melt was stirred using a mild steel stirrer blades. Fly ash particles were added to the melt at the time of formation of vortex in the melt due to stirring. The melt temperature was maintained at 6800C to 7200C during the addition of the fly ash particles. Then the melt was casted in a mild steel die. The hardness measurement testing was carried out Al (5, 10, 15 and 20) wt% fly ash composites. The hardness of the samples was determined by Rock well hardness testing machine with 65 kgf load and diamond cone. The detention time for the hardness measurement was 15sec. The tensile strength of the samples was determined by the universal testing machine.

Works Done Commercially bronze melted and casted϶ Bronze (5%, 10%, 15% and 20%) wt. % of fly ash composites was fabricated by stir casting method.϶ The hardness measurement was carried out for bronze fly ash composite samples.϶ The tensile strength was carried out for bronze fly ash composites samples.϶

FABRICATION OF BRONZE – FLYASH COMPOSITE:

The bronze - fly ash metal matrix material was stir casted in the form of desired shape and size by adding Fly Ash and Activated Carbon as reinforcements by various weight percentages. The casted specimen was rapidly cooled to room temperature by knocking them out from the mold after few minutes of casting. The test specimens were prepared by machining the casted materials under ASTM standards.

Experimental Testing of Mechanical Properties

A set of tests including tensile test, density test, hardness test, impact test were done for finding out the properties4. All the tests were carried out in room temperature with ASTM standards. Tensile test is carried out with ASTM E8/82 standard in UTM machine. The Percentage of Elongation, Percentage of Reduction in Area, Young's Modulus and Ultimate Tensile Strength were measured. Figure 1 shows the specimens used for tensile test and Figure 2 shows the decrease in percentage of elongation with increase in addition of Fly Ash. The Charpy impact test / CharpyVnotch test, is a standardized high strain-rate test which determines the amount of energy absorbed by material during fracture. Figure shows the specimen used for Charpy tests. Brinhell hardness test and Rockwell hardness test was conducted on each specimen. The hardness of the specimen id estimated using th standard equations.

$$\mathrm{BHN} = \frac{2P}{\pi D\left(D - \sqrt{D^2 - d^2}\right)}$$

P= Applied force kgf

D= Diameter of indenter mm

d= Diameter of indentation mm

Scanning Electron Microscope (SEM) was used to analyze the detail surface information of all compositions, orientation of particles, distribution of particles mixed, etc and the images are shown in Figure

Tensile Test: The sample for tensile test was prepared on lathe machine by turning operation as ASTM E8 standards. The tensile testing of the composite was done on UTM. Standard specimens with 100mm gauge length were used to evaluate ultimate tensile strength. The comparison of the properties of the composite materials was made with the commercially pure bronze.

Impact Test IZOD Test: The specimens for the IZOD test were prepared on shaper machine. The IZOD test specimen was 75mm long with 10×10 mm2 cross section, having a standard 45o notch 2mm deep.

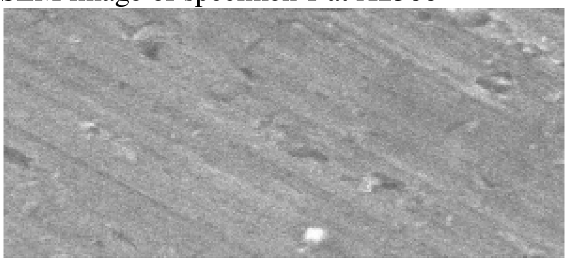
Hardness Test: The samples for the bending test were prepared on lathe machine. The samples were prepared according to ASTM E10. The dimensions for samples were 10mm diameter and 15mm length. After this, with the help of microscope, indent caused by the ball indenter is measured, a inbuilt micrometer scale is present in the microscope, which is adjustable according to the position of indent we can adjust it to measure the diameter of indent.

Micro structural Characterization

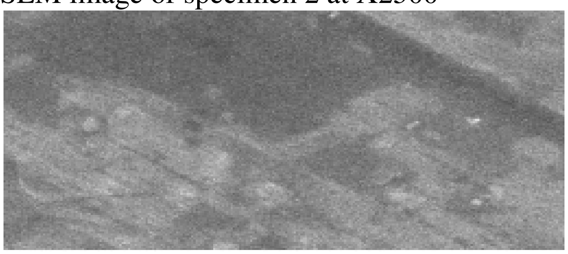
Scanning Electron Microscopy (SEM): Micro structural characterization studies were conducted to examine distribution of reinforcement throughout the matrix. This is accomplished by using scanning electron microscope. The composite samples were metallographically polished prior to examination. Characterization is done in etched conditions. Etching was accomplished using Keller's reagent. The SEM micrographs of composites were obtained using the scanning electron microscope. The images were taken in secondary electron (SE) mode. This analysis was done by a LEO scanning electron microscope (SEM) equipped with an energy dispersive X-ray (EDX) detector of Oxford data reference system. V

Figure shows specimens used for tensile test

SEM image of specimen 1 at X2500



SEM image of specimen 2 at X2500



SEM image of specimen 3 at X2500

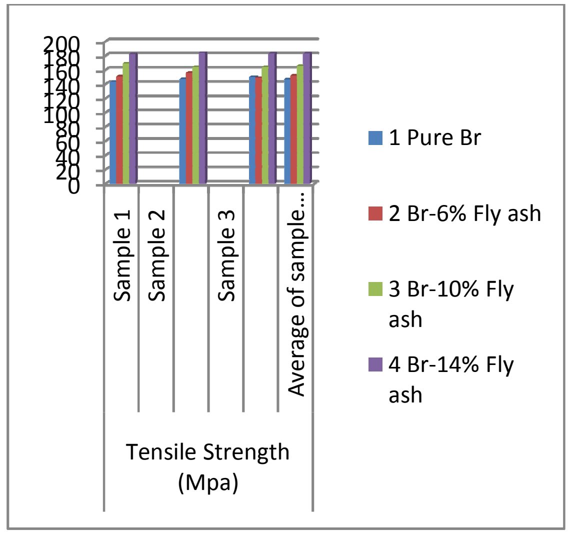
RESULT & DISCUSSION

TENSILE STRENGTH MEASUREMENT

Tensile test was performed on universal testing machine. The specimens were prepared according to ASTM E8 standard. The composites are prepared by adding the sugarcane bagasse fly ash. First specimen was prepared by adding 6% fly ash by weight, second was prepared by adding 10% fly ash by weight and the last was prepared by adding 14% fly ash by weight. The result of these three composites is compared with the result of pure bronze specimen.

Tables shows Tensile Strength of bronze and its Composites

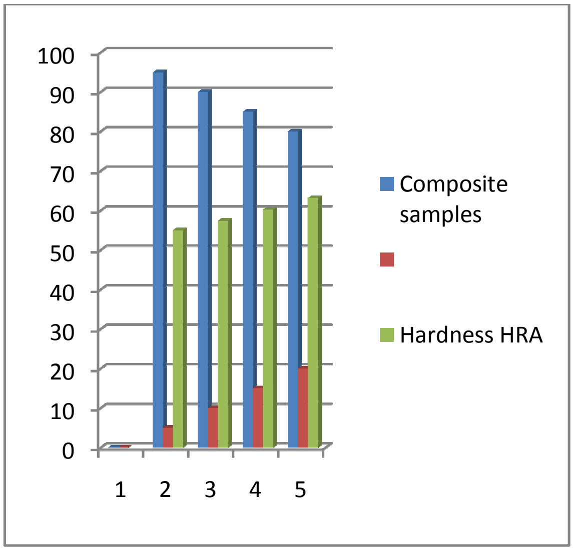
S No	Composite Samples	Tensile Strength (Mpa)			
		Sample 1	Sample 2	Sample 3	Average of sample 1,2,3
1	Pure Br	143	147	150	146.66
2	Br-6% Fly ash	151	156	149	152
3	Br-10% Fly ash	169	164	164	165.66
4	Br-14% Fly ash	182	184	183	183



Hardness Measurement:

Table shows Hardness measurement

Composite samples		Hardness HRA
Bronze (%)	Fly ash (%)	
95	**5**	**55**
90	**10**	**57.4**
85	**15**	**60.21**
80	**20**	**63.15**



Graph showing variations in composites vs. Hardness

II. CONCLUSIONS

From the study it's concluded that we can use fly ash for the production of composites and can turn industrial waste.

2. Fly ash up to 20% of weight can be successfully added to bronze by stir casting methods to produce composites.

3. The density of bronze-fly ash is decreased with increase in addition of fly ash and the density will be reduced.

4. The hardness of bronze-fly ash has increased with increase in addition of fly ash the hardness will be increased.

5. The tensile strength of bronze-fly ash is increased up to 15% of fly ash is added in the bronze

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