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Production of Particle Reinforced Aluminum Matrix Composites Using Random Rotation of Mold

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Abstract: **Production of particle reinforced composites is still in the development stage and investigations are in progress to devise techniques to uniformly distribute the reinforcing particles in the matrix so as to get the best properties. The cause of non-uniform distribution is the density difference and non-wetting behavior of the liquid metal and the particles. Random rotation of the mold is used in the present study to distribute redmud particles in an aluminum matrix. Red mud is a waste produced in the production of alumina and unless disposed properly cause environmental problems. A laboratory ball mill used for mineral processing was modified to suit the requirement. The castings were made in the ball mill with the molds rotating randomly. The microstructure of the samples showed uniform distribution of particles in the matrix. Variants in the mold designs tried and microstructures obtained are reported in the paper. It is observed that upto 25% of redmud can be added to aluminium successfully and obtain uniform distribution of the particles.**

Keywords: **Random rotation, Aluminium matrix composite, redmud**

I. Introduction

Particle reinforced metal matrix are highly sought after material for their excellent combination of properties. Aluminum is the common matrix material because it is cheap and easy to cast. (1)Among the several routes through which MMCs are produced casting is the most common and widely accepted. The properties of mmcs are influenced by the nature matrix, type and amount of reinforcement and the distribution of the reinforcement. For most applications a uniform distribution of the reinforcement is aimed at. However because of the density difference and non wetting behavior between the particle be and the liquid metal the distribution is not uniform varying widely along the height and breadth of the casting. (2)Stir casting helps in distributing the particles added to the vortex formed by the stirring action. However the particles may get redistributed when the metal slurry is poured into the mold. There is a limit to the maximum amount of particles that can be added by this method. A higher amount of metal causes difficulty in continuing stirring operation.(3) In devised method the stirring of the melt is continued even during solidification by rotating the mold in random directions. A higher amount of particles can be added by this technique.

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II. Experiment

Commercially pure aluminum obtained from NALCO, Angul, Odisha, was used as the matrix. The composition of aluminum used is given in table1. Aluminum had a density of 2.78g/cc , and tensile strength of 6.5 Kgf / mm2. Red-mud used as reinforcement particles was obtained from alumina plant at Damonjodi. Odisha. It was dried and sieved before addition. The size of dust was measured by sieve analysis. Average size of the powder was 150 micro mm dia. Red-Mud dust was subjected to X-ray diffraction, DTA analysis. Loss of ignition was 16%. The composition of red mud is given in table2. It has a number of chemical constituents with different shape and size. Shape of the Red mud particles were observed on a low magnification microscope 50X , 150X, and 250X. It was observed that some of them are like fibres, some of them are of irregular shapes. But the average size is 150µ. The analysis is based on X-ray analysis.(4)

III. Experimental Setup

A laboratory ball mill was modified to impart random rotation to the mold. Molds were fabricated using corrosion resistant steel sheets of 3mm thickness and had a cross section 30 x 30mm and 100rnm height. The molds were filled with the required quantity of red-mud and aluminum to obtain varying reinforcement percentage in the composites. Then the perforated box was welded to 6mm diameter rings for obtaining a sphere. The box along with the molds containing the

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red-mud aluminum mixture was heated for a period of 5 hours at a temperature of 8000 C to make sure that aluminum is completely molten. Then the box was dropped into the ball mill quickly and ball mill started. The rotation of the mill continued for 30 minutes. This did not ensure mixing. In the next attempt the mould was made using 64mm diameter galvanized iron pipes of 100mm height. The pipe was filled by different % of red mud and aluminum by weight. The pipe was sealed by gas welding. Each pipe mold was welded to number of rings to give them a spherical shape. The mold designs tried are shown in fig1. The mould was then heated in a pit furnace maintained at 800°C for 5 hours. The hot mould then transferred to the ball mill immediately. The ball mill was rotated at 40 rpm for a period of 30 minutes ensuring complete solidification. The casings thus obtained were tested for microstructure. Red-mud was dried properly before use. Red-mud addition was made in quantities of 10%, 15%, 20%, 25%, 30% by weight. Details of experimental setup are shown in fig1. Samples for microstructure were collected from various locations of the casting. The microstructure was examined optically after etching with kellers reagent. (5)

IV. Results and Discussion

Physical examination showed no porosity in the samples. However a central shrinkage cavity was observed in all the castings at more or less in the centre region. Red mud upto 20% could be fully incorporated in the casting. 25% and 30% a part of the red mud remained and did not enter in to the casting. Figure 2 shows the microstructures obtained for 10%, 15% and 20% red-mud. The microstructure shows uniform distribution of particles. The particles are of various constituents as shown in the analysis in t-2. No preferential segregation of the particle is noticed from the microstructure. The different constituents have a wide range of density and chemical composition. This shows that the method of random rotation can be used successfully to distribute reinforcement particles in a melt uniformly.

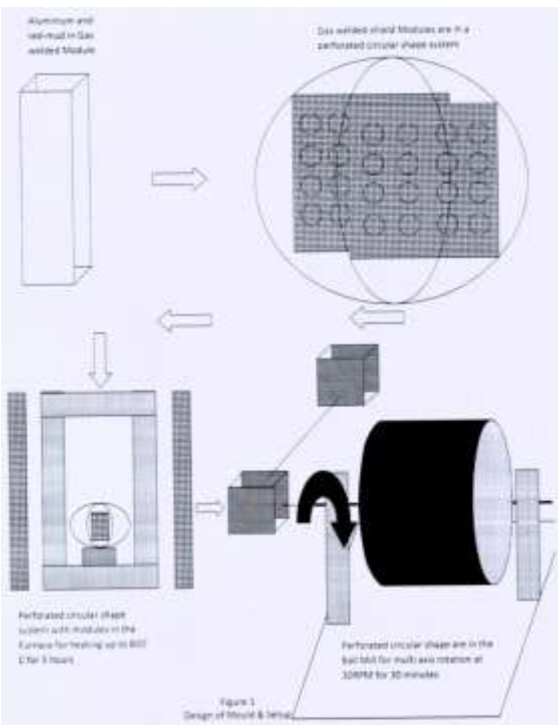

Figure 1. Experimental Setup

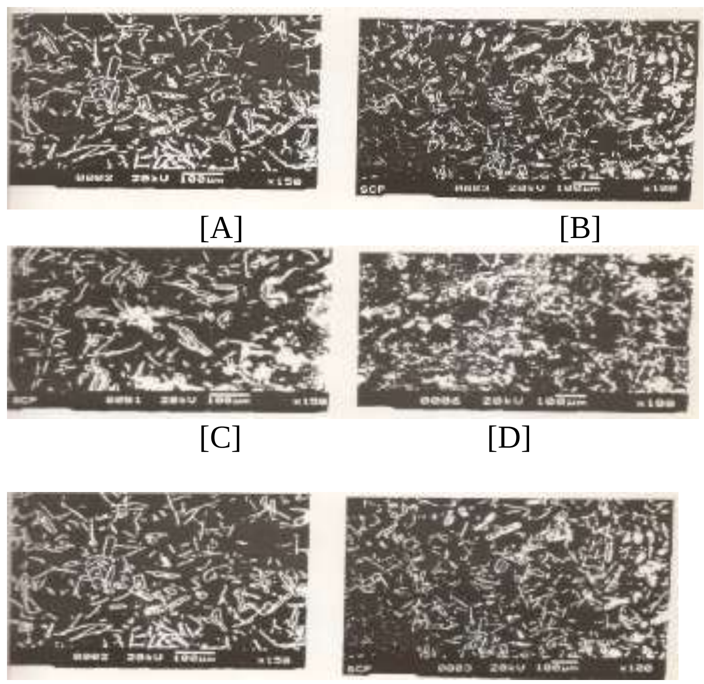

Figure 2. Microstructure of Samples

a	10 % Redmud side	b	10% Redmud centre
c	15% Redmud side	d	15% Redmud centre
e	20% Redmud side	f	20% Redmud centre

TABLE -1 COMPOSITION OF ALUMINUM

Element	Wt Mt	Si	Fe	Pi	V	Cu	Mn	Al
%	0.941	0.08	0.15	0.001	0.007	0.001	0.003	99.7691

TABLE2. RED MUD ANALYSIS

COMPONENT	%age	COMPONENT	%age
Al_2O_3	15.00	Fe_2O_3	62.78
TiO_2	3.77	SiO_2	0.0097
Na_2O	4.88	CaO	0.23
P_2O_5	0.67	V_2O_5	0.379
Zn	0.018	Ga_2O_3	0.0097
Mn	1.1	Mg	0.056
Organic C	0.88	Fe_2O_3	Balance

V. Conclusion

Random rotation of molds during solidification can be successfully utilized to obtain metal matrix particulate reinforced composites with a uniform distribution of reinforcement. Aluminum matrix composites with 20% of red mud particles can be successfully produced by this method.

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