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Research Article

Evaluation of Mechanical Properties and Characterization of LM13 Reinforced with Fused Sio_2

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Abstract

This research work aims at developing and mechanical characterization of aluminium (LM13) based metal matrix composite reinforced with varying percentage of fused SiO_2 (3%,6%,9%,12%).The mechanical properties are completely dependent on the microstructural parameters of the system. Also the microstructure further depends on the cooling rates during solidification process. Various Chills like Silicon carbide, Mild steel, Copper were used during the casting process to increase the rate of solidification, which enhances the mechanical properties of the composite. The chill casted specimens were subjected to hardness tests followed by microstructure studies. Finer microstructure and better hardness value were seen for specimen's casted using copper chills, whereas silicon carbide and mild steel chills gave rise to very coarse structure with reduced hardness values compared to copper chills.

Keywords: *LM13, Fused SiO_2, chills, Microstructure, Hardness*

1. Introduction

Al based Composite are known for their surface finish, texture and processing choices due to which they are widely used in aviation and automobile sectors [Kainer, K.U *et al*,2003].With the expansion in the interest for quality composites, it has very crucial to deliver aluminum composites free from unsoundness. Aluminium based composite casting is subjected to microshrinkage.

The remarkable capacity of the composite materials for the particular necessities makes these materials more prominent in an assortment of uses, for example, aviation, automobile (cylinders, chamber liners), and auxiliary segments, bringing about saving in material and energy [Jacob, S, *et al*,1970; Kutumbarao, G.V, *et al*,1972].

As of late there has been a lot of enthusiasm for creating metal matrix composites (MMC) in view of their special mechanical properties, for example, light weight and high versatile modulus. Spray deposition, fluid metallurgy technique and powder metallurgy are used to develop particulate reinforced MMCs. Since costly equipments are required and the processing is difficult and laborious, the expense to deliver MMCs by these techniques is high, which has restricted the utilizations of MMC materials. The hot and cold rolling procedure are used to manufacture specific strengthened MMCs of high complexities. A few different procedures used to deliver discontinuous MMCs likewise incorporate rheocasting, compocasting and squeeze casting [Daniel B. *et al*, Wang, Y.-Q., *et al*, 2011, Composite with Different Fraction of Alumina,1995]. The characterizations of mechanical properties of discontinuous MMCs are available from various reports with reference to these, the mechanical properties, for example, Young's modulus and quality have been enhanced by 20% - 40% by due to addition of reinforcements. Notwithstanding, pliability has disintegrated amazingly with expanding substance of reinforcements. There are numerous smaller scale basic variables, for example, base material and reinforcement used, the volume fraction and the size of the particulates, and each of these may impact mechanical properties of the composite [H. C. Yuen, *et al,* 1993; B. Ralph *et al*,1997].

Aluminium reinforced with particulates exhibits awesome physical & mechanical properties. On a weight-balanced premise, numerous Al-based metal network composites (MMCs) can outrage cast steel, Al, Mg and for all intents and purposes some other strengthened metal or compound in a wide assortment of utilizations. Thus, it appears to be plausible that such MMCs will replace customary materials in numerous business and modern applications soon. Apart from having sound mechanical properties, they also have improved fracture crack propagation resistance, show high abrasion resistance, and good micro creep performance. Since these materials are being utilized where they are subjected to cyclic

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loading, it is essential to consider the crack mode and comprehend their harm level utilizing a ruinous assessment strategy. Most imperative stage in a casting procedure is hardening of metal in the mold. Since Al combinations solidify over an extensive variety of temperature, they are subjected to different defects like porosity, breaks, blow openings and so forth. Aluminum based composite castings cast utilizing sand molds face porosity issue as smaller scale shrinkage The miniaturized scale shrinkage can be minimized by using chills (which go about as warmth sinks) situated at predetermined spots in the mold [Z. G. Wei, *et al*, 1997; Y. P. Rao, *et al*,1995; K. Yeow, *et al* 1980; B. D. Agarwal *et al*,1974.].

Chilling lessens grain of the composites down to an interface controlled structure, to get a material with new utilitarian properties. Hardness and fracture strength of aluminum composites fundamentally reliant on processing methods, dispersoid content, chill conditions, microstructure, and interfacial bonding attributes. Wise positioning of chills will subjugate microshrinkage or dispersed porosity in composites. Chills are used by foundry engineers for generation of value castings. Chilled cast iron has a place with a gathering of metals having excellent hardness, good sturdiness, and high quality. They are broadly utilized as a part of the production of wear shoes, wear liners, rollers, brake shoes, cam surfaces, wearing plates and other machine segments and supplies requiring such material qualities. There is lot of information available on the mechanical properties of ductile iron and austempered flexible iron that can be used by design engineer [Hemanth J *et al*, 1996].

Effect of particulate reinforcement & chilling on wear, hardness & strength of aluminum based metal matrix cast composites with kaolinite (Al_2SiO_5) and carbon (C) particulates was studied. It is found that chilled HMMCs with Al_2SiO_5-9%/C-3% dispersoid content ended up being the best in upgrading the mechanical and wear properties.The development and mechanical characterization of chilled aluminum-quartz composite that can be casted utilizing metallic and nonmetallic chill pieces were studied. The composite created appeared to give critical weight savings and enhanced mechanical properties. Studies on microstructure and microhardness of chill cast Al-B_4C composites reveals that the utilization of end chills favors directional hardening as well as quickens solidification process. Mechanical properties of composite materials depend on micro structure parameters. Advancement of microstructure relies on cooling rate amid stage change. In spite of the fact that the microstructure advancement relies on upon numerous procedure parameters, the end structure is chosen by the cooling conditions amid solidification [Hemanth J *et al*, 1995; K H W Seah, *et al*, 1995].

2. Experimental Studies

Composite Preparation

The composite preparation includes thorough mixing of the matrix material LM13 with Fused SiO_2 in a graphite crucible with constant stirring. Initially the mold was prepared by keeping chills in proper position Fig 1.After melting the matrix material in crucible Fig 2 at around 700^0C , coated fused SiO_2 particles preheated to 400^0C were introduced evenly into the molten metal alloy by means of special feeding attachments. Meanwhile the dispersoid treated molten nickel was well agitated by means of a mechanical impeller rotating at 450 rpm to create a vortex Fig 3.

The moulds of the plate type of castings (American foundrymen society standard) were prepared using silica sand with 5% bentonite as binder and 5% moisture and finally they were dried in air furnace. The dispersoid treated Al-alloys was be finally poured in to the dried mold which was cooled from one end by varieties of chills set in the mould. After solidification these test blocks will be subjected to heat treatment (aging) and later test specimens were taken out from the chill end to obtain the final casted specimens Fig 4.

Figure1 Mold preparation with Chills

Figure 2 Aluminium ingots being melted

Figure 3 Melted Stir casting

Figure 4 Final Casted Specimens

Mechanical Characterization and Testing

Microstructure

The specimens for optical microscopy were prepared according to ASTM E3 standards. The samples were first subjected to grinding and polishing followed by etching. Microscopic examination was conducted on all the specimens using VG 9000 scanner as well as Neophot-21 metallurgical microscope. Various etchants were tried but dilute Kellers etchant proved to be the best and was therefore used. Photomicrographs of all the specimens were taken to study their micro-constituents and the distribution of Fused SiO_2 particulates.

Figure 5 Metallurgical Microscope

Hardness Tests

Hardness tests were conducted on each of the specimens as indicated in Fig 6 . As specified in the AFS standards, a Micro Vickers Hardness Tester with 5 mm ball indenter and 300 kg load was used on the polished specimens. Each hardness result was obtained from an average of at least three repetitions on the same sample.

Figure 6 Hardness test specimen

3. Results and Discussion

Microstructure

The microstructures of the specimens with varying % of reinforcement (3, 6, 9, and 12) and various chills like cu, graphite, MS& SiC were taken. It is observed from the microstructural studies that dispersoid is evenly distributed because of uniform stirring and density difference. Bonding is very much intact between the base material and reinforcement, due to preheating of the reinforcement. There is no micro porosity in the microstructure. Due to chilling very good grain structure is observed. The best microstructure was seen at 6% and 9% reinforcement Fig 7a & b.

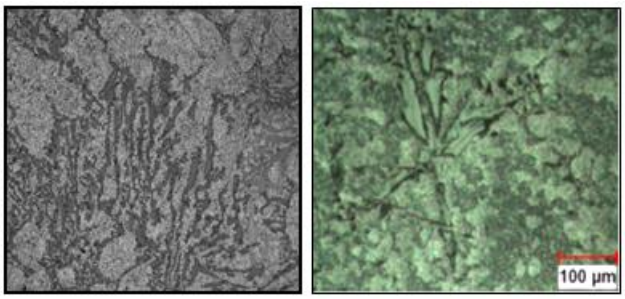

Figure 7a Microstructure of 6% (Cu, graphite, MS & SiC Chills)

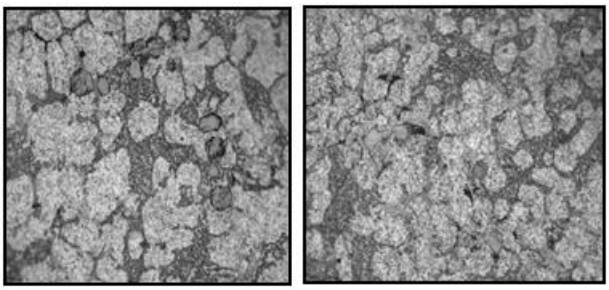

Figure 7b Microstructure of 9 %(Cu, graphite, MS & SiC Chills)

Hardness

The experimental results of the hardness tests done on castings chilled using different chills and cast without any chills are tabulated in Table2.It is a fact that for metallic materials, hardness increase as tensile strength increases. Changing of different chill does have a significant effect on the hardness of the casting. The graph showing the comparison results of hardness tests with Copper, mild steel, graphite, Si-Carbide chill and cast without any chills (as shown in figure 8)

Table 2 Comparison Results of Hardness Test (VHN)

Type of Chill	Reinforcement wt %			
	3	6	9	12
Cu	102.7	102.7	110.3	101
MS	99.7	101	114.7	104
SiC	102	102	105	75
Graphite	74	83	100	91

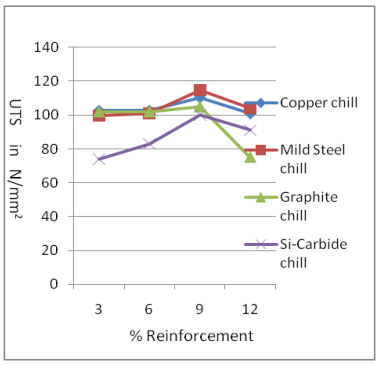

Figure 8 Comparison Results of Hardness

Conclusions

LM13 based MMC can be produced successfully from a conventional electric induction furnace. Fine grain structure, uniform distribution of dispersoid and good bonding between the matrix and the dispersoid is obtained with the use of copper chill, whereas, the grain size successively increases with the use of steel, iron, silicon carbide and composite without chills. Different chill material and the dispersoid content plays an important role in the variation of mechanical properties.The results clearly reveals that hardness of the developed metal matrix composite increases due to presence of hard Fused SiO_2 ceramic particulates in the matrix. The mechanical properties of chilled LM13 composite are also significantly affected by bainite content (chilling rate) of the material. Therefore the vast areas of applications of LM13 chilled composites are in the manufacture of components where the periphery of the part needs very good surface properties.

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