INTERNATIONAL RESEARCH JOURNAL OF ENGINEERING AND TECHNOLOGY (IRJET) E-ISSN: 2395-0056
VOLUME: 07, SPECIAL ISSUE | JUNE 2020 WWW.IRJET.NET P-ISSN: 2395-0072
International Conference on Recent Trends in Science & Technology-2020 (ICRTST - 2020)
Organised by: ATME College of Engineering, Mysuru, INDIA

PREPARATION AND INVESTIGATION OF ALUMINIUM-ALUMINA METAL MATRIX COMPOSITE

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Abstract— Composites materials are the most prominent materials for engineering applications. Metal matrix composites (MMCs) shows significantly improved properties compared to base alloys. Aluminium based MMC's have wide applications in automobiles, aerospace and marine sectors etc. The aluminium matrix composites mechanical properties are strongly dependents on microstructural parameters like shape, size and distribution of reinforcement particles. Therefore, the selection of variables is important to optimize the composites properties. Among various particulates used, alumina particle is one of the most economical and low density reinforcement available in bluk quantity in nature. In this study, aluminium alloy LM13 and 3%, 6%, 9% and 12% (by weight) alumina reinforcement of various micron size (106, 150, 250 and 355µm) composites were prepared by stir casting route. To study the structural characterization of the prepared composites optical microscope is used. It is observed that the alumina particles uniform distribution in the matrix material and also the bonding between reinforcement and matrix is good. The hardness of the prepared composites were increased with increasing the amount of alumina in aluminium alloy. Experimental results shown that there is icreased mechanical properties, when the addition of alumina weight 9% to the base aluminium alloy and also similar trend exists in all four arious micron size particle.

Keywords: *Al LM13 alloy , Alumina, Mechanical properties, Stir casting.*

I. INTRODUCTION

Technology related to industry is growing at a very rapid rate now days and consequently there is demand for modern materials. Particulate reinforced composites constitute a large portion of these modern advanced materials [1]. Metal matrix composite (MMC's) is a combination of the metal as matrix material and hard particle/ceramic as reinforcement to get good properties. MMC's are used for the space shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs, and a variety of other applications[2-3].

A good combination of high strength and ductility of the Aluminum based metal matrix composites (MMC's) have introduced the new material to a wide area of possible advanced applications. In general stir casting technology was used to preparation of MMC's in the processing time it melt of the selected matrix material, followed by reinforcement material is introducing into the melt, obtaining a suitable dispersion through stirring process. Its advantages is simplicity, flexibility and applicability to large quantity production. It is also attractive because, in principle this method suitable for engineering application in terms of production capacity and cost efficiency [4]. In metal matrix composites Aluminium is the most popular matrix material. Due to its lower density aluminium is quite attractive, their strengthened capability to be by precipitation, good resistance to corrosion, high thermal and high electrical conductivity and damping capacity. The demand for structural materials are to be cost effective and also to provide high performance has resulted in continuous attempts to composites develop as serious competitors to the traditional engineering alloys[5]. In the recent years, usage of particle ceramic as a reinforcement in metal matrix composites (MMC's) is steadily enhanching because of their advantages like good isotropic properties and the secondary processing possibility [6].

Composites based Al alloy have replace the other costlier material in many engineering applications significantly. The requirements concerning safety factor and reliability are always improving and therefore the properties like mechanical are more important [7].

II. METHODS AND MATERIALS

In this work aluminium LM13 alloy used as a matrix material and various micron size of alumina (106, 150, 250 and 355µm) as particulate reinforcement with different weight percentages (in wt.% 3, 6, 9 and 12) are used. The composites were preared by using stir casting method. Permanent mould made from cast iron is used for preparing composite

castings. ASTM standards are followed to prepare testing specimens of the prepared composites. The toughness and formability of 12% silicon aluminum alloy can be combined with the reinforcement particles. The matrix material LM13 aluminim alloy chemical compositions are shown in Table 1. Alumina provides excellent hardness properties on incorporation into the soft alloy, thereby using it better where hardness is desirable applications. Figure 1 shows the setup of stir casting method.

Table.1: Chemical Composition of Al alloy LM13 by Wt. %.

Elements	Zn	Mg	Si	Ni	Fe	Mn	Al
Wt. %	0.5	1.4	12	1.5	1.0	0.5	Balance

Figure.1: Stir Casting method setup.

III. PROCEDURE FOR PREPARED COMPOSITES TESTING

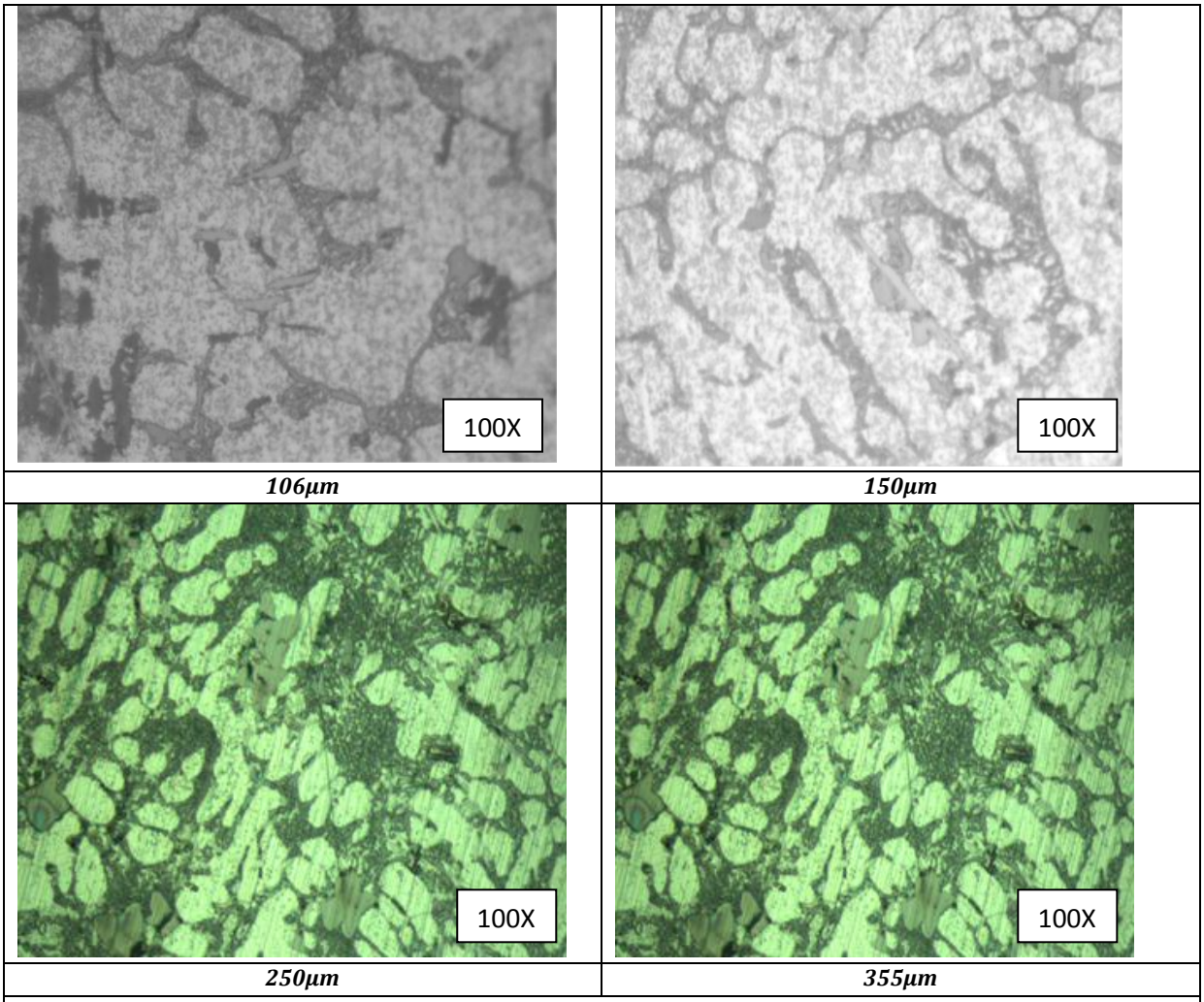
The ASTM standards are used to prepare specimens for hardness and tesile test to evaluate the properties. Zwick micro hardness testeing machine was used to measure hardness number. In BISS, Bengaluru, Karnataka the mechanical properties were evaluated. The specimens prepared for hardness as well as tensile test as shown in figure 2.

Figure.2: Hardness and tensile test specimens.

IV. RESULTS AND DISCUSSIONS

4.1 MICROSTRUCTURE EXAMINATION:

Microstructure is visualized with the help of optical microscope. The microstructure of the different specimens containing 3% weight of Alumina for the different microns size of 106µm, 150µm, 250µm and 355µm as shown in below figure 3. These are typical micrographs of the MMC's showing that the alumina particles are uniformly dispersed in the matrix aluminium alloy. The micrograph shows the increased reinforcement contents in the prepared composites.



106µm *150µm*

250µm *355µm*

Figure 3: Microstructure of Al LM13 alloy with 3% weight of alumina for four various micron size.

4.2 HARDNESS:

The prepared composites vicker hardness test results are tabulated in Table 2. To know the reinforcement effect in the matrix material, the hardness tests were condcted on Al alloy LM13-Al_2O_3 of various micron size composites. The specimens prepared were tested using Zwick Vickers microhardness testing machine. During test on specimens for 10 seconds a load of 50 gram was applied. The hardness was determined by recording the indentation mark prodced on specimen. The average value of the hardness number was taken after carried out test on specimen at three different locations. Figure 4 shows the microhardness test results of the prepared composites. The composite containing various micron size and wt.% of alumina reinforcement. From the Figure 4 clearly reveals the hardness number of the prepared composite material is much higher than that of its parent metal hardness number 130VHN. It is also shown that the prepared composite materials hardness numbers were increases with increased weight percentage of reinforcement content.

Table.2: VHN for different micron size of reinforcement alumina with weight percentage.

Weight percentage	Different micron size			
	106µm	150µm	250µm	355µm
3%	130	129	150	143

6%	177	141	172	162
9%	196	146	193	178
12%	188	143	195	183

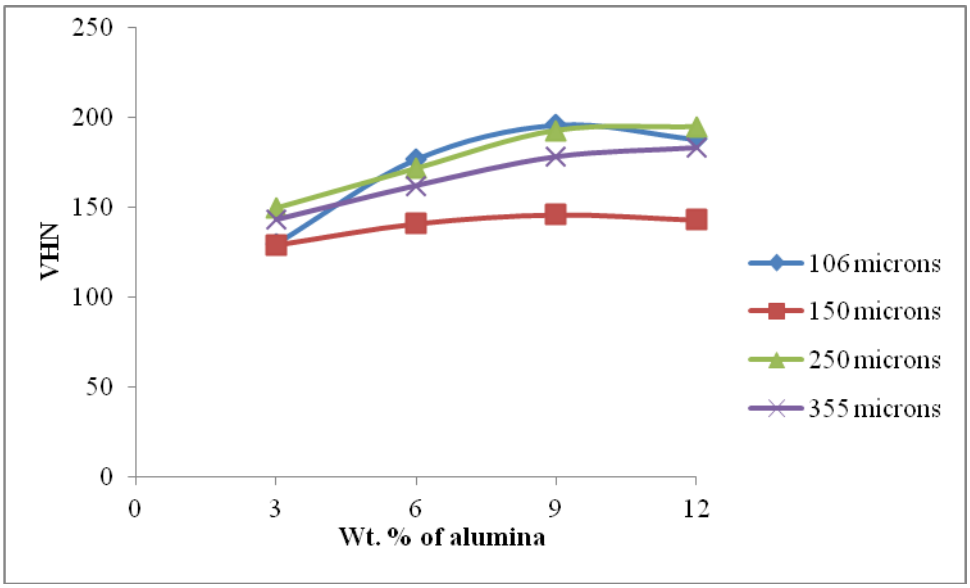


Figure.4: VHN v/s Wt.% of alumina for all for microns.

4.3 TENSILE TEST:

The tensile tests for prepared samples are performed according to ASTM E8 standard using UTM. The tensile test results of the prepared composite are tablated in Table 3. The values of tensile strength for four different micron size weight percentage of Al_2O_3 is shown in Figure 5. Addition of reinforcement Al_2O_3 in base alloy increases the tensile strength because the bonding strength between reinforcement and matrix material increases and also reinforcement material having good strength at different conditions. The figure 5 shows tensile strength increases with the addition of reinforcement for all four varios micron size particles. The addition of reinforcement makes the base alloy more ductile. Improved tensile strength makes use of prepared composites in many significant applications.

Table.3: Tabulation of results is as follows showing tensile properties of different specimens in Mpa.

Weight percentage	**Different micron size**			
	106µm	**150µm**	**250µm**	**355µm**
3%	166	144	128	147
6%	156	151	153	152
9%	145	162	173	160
12%	148	165	198	187

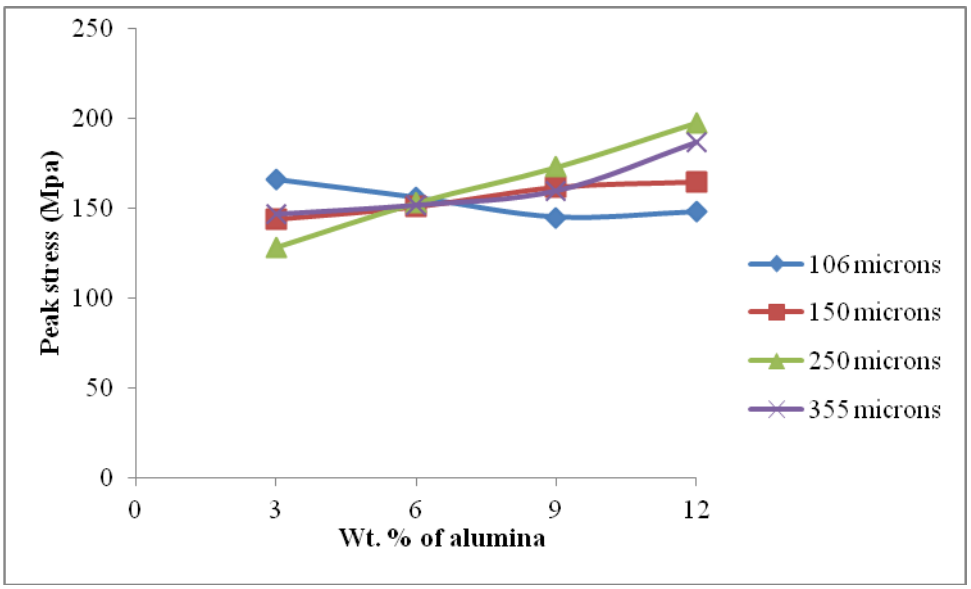


Figure.5: Peak stress v/s Wt.% of alumina for all four microns.

V. CONCLUSIONS

- Al alloy LM13-Alumina composites are prepared sucessfully by using stir casting method for reinforcement containing up to wt.percentage of 12.
- The microstructural obsevation shows the distribution of the alumina particles (reinforcement) in the aluminium base alloy (matrix material) is uniform.
- Hardness and tensile strength were increased with addition of reinforcement alumina for all various particle size of alumina.
- In overall, in this study the Al LM13 alloy - Alumina composites obtained excellent mechanical properties compare to base alloy ofaluminium.

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