[ICAMS: March 2017]
ISSN 2348 – 8034
Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

DEVELOPMENT AND CHARACTRIZATION OF SILICA PARTICULATE REINFORCED ALUMINIUM METAL MATRIX COMPOSITE

Mallikarjuna G B[*1] & Dr. E Basavaraj[2]
[*1]Assistant professor, Deparment of Mechanical Engg., KIT, Tiptur, Karnataka
[2]Professor, Deparment of Mechanical Engg., JNNCE, Shivamogga, Karnataka

ABSTRACT

Composites materials are the most prominent materials for engineering applications. Metal matrix composites (MMCs) possess significantly improved properties compared to unreinforced alloys. Aluminium based MMC's find wide applications in aerospace, automobiles and marine sectors etc. The mechanical properties of aluminium matrix composites are strongly dependent on microstructural parameters like shape, size, volume fraction and distribution of reinforcement particles. Therefore, judicious selection of the variables is important to optimize the properties of the composites. Among various particulates used, silica is one of the most inexpensive and low density reinforcement available in large quantity in nature. In this study, aluminium alloy LM13 and 3%, 6%, 9% and 12% (by weight) silica of different micron size (106, 150, 250 and 355µm) composites were prepared by stir casting route. Optical microscope is used to identify the structural characterization of the prepared composites. It is observed that the uniform distribution of silica particles in the matrix and also exists in a good bonding between matrix and reinforcement. The hardness of the composites were increased with increasing the amount of silica in aluminium. Experimental result shown that there is enhanced mechanical properties, when silica weighing 9% was added to base aluminium alloy and also similar trend exist in all four different micron size of silica.

KeyWords: Al alloy LM13 , Silica, Mechanical properties, Stir casting.

I. INTRODUCTION

Industrial technology is growing at a very rapid rate and consequently there is an increasing demand and need for new materials. Particulate reinforced composites constitute a large portion of these new advanced materials [1]. Metal matrix composite (MMC's) is engineered combination of the metal (Matrix) and hard particle/ceramic (Reinforcement) to get tailored properties. MMC's are either in use or prototyping 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 material to a wide area of possible advanced applications. In general stir casting of MMC's involves producing a melt of the selected matrix material, followed by introducing reinforcement material into the melt, obtaining a suitable dispersion through stirring. Its advantages lie in its 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]. Aluminium is the most popular matrix for the metal matrix composites. Aluminium is quite attractive due to its low density, their capability to be strengthened by precipitation, good corrosion resistance, high thermal and high electrical conductivity and damping capacity. The demand for structural materials to be cost effective and also to provide high performance has resulted in continuous attempts to develop composites as serious competitors to the traditional engineering alloys[5]. In the recent years, usage of ceramic particle - reinforced metal matrix composites (MMC's) is steadily increasing because of their advantages like isotropic properties and the possibility of secondary processing facilitating fabrication of secondary components.[6].

Al alloy composites have the potential to replace other costlier material in many significant engineering applications. The requirements concerning safety and reliability are always increasing and therefore the mechanical properties are ever more crucial [7].

II. METHOD & MATERIALS

ISSN 2348 – 8034
Impact Factor- 4.022

In this work aluminium alloy LM13 used as a matrix material and different micron size of silica (106, 150, 250 and 355µm) as particulate reinforcement with different percentages (in wt.% 3, 6, 9 and 12) based on the variation in weight. The composites were preared by using stir casting method. Cast iron permanent mould is used for processing composite castings.The test specimens of the composites are prepared according to ASTM standards. The toughness and formability of Aluminum –12% silicon alloy can be combined with the strength of quartz particles. The chemcal composition of matrix material LM13 alloy is shown in Table 1. Quartz is a hard mineral and provides excellent hardness on incorporation into the soft lead-alloy, thereby making it better suited for applications where hardness is desirable. The table 2 shows different properties of reinforcenment silica.

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

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

Table.2: Properties of reinforcement silica

Properties	**SiO_2**
UTS(MPa)	25
Density (g/cc)	2.65
Melting Temperature(°C)	1830
Compressive strength (MPa)	2070

III. PROCEDURE FOR TESTING PREPARED COMPOSITES

The specimen prepared for hardness and tesile test are according to ASTM standards. Zwick micro hardness tester used to measure hardness number. The mechanical properties were evaluated in BISS, Bengaluru, Karnataka. The specimens prepared for hardness as well as tensile test as shwn in figure1.

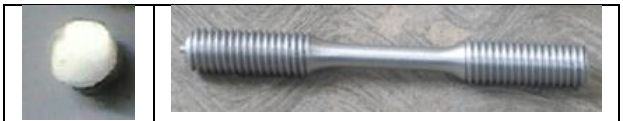
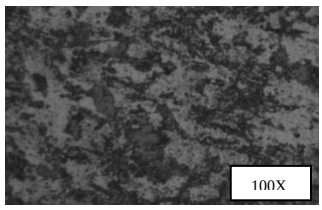


Figure:1: Hardness and tensile test specimens

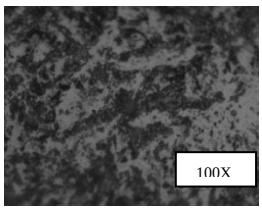
IV. RESULTS & DISCUSSION

Microstructure Examination

Microstructure is visualized with the help of optical microscope. The microstructure of the different specimens containing 3% weight of silica for the different microns size of 106µm, 150µm, 250µm and 355µm as shown in below figure 2. These are typical micrographs of the MMC's showing that the silica particles are uniformly dispersed in the aluminium alloy matrix. The micrograph clearly revels the increased reinforcement contents in the composites.

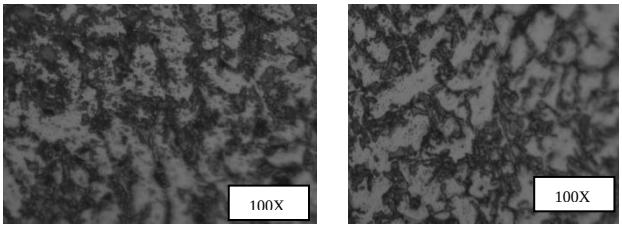


106µm



150µm

ISSN 2348 – 8034
Impact Factor- 4.022



250µm *355µm*

Figure 2: Microstructure of Al alloy LM13 with 3% weight of silica for four different micron size

Hardness

The vicker hardness test results for prepared composite are tabulated in Table 3. Hardness tests were performed on Al alloy LM13-SiO_2 of different micron size composites to know the effect of reinforcement in the matrix material. The specimens prepared were tested using Vickers microhardness testing machine. A load of 50 gram for 10 seconds was applied on specimens. The hardness was determined by recording the indentation produced. The test was carried out at three different locations, and the average value was taken as the hardness of the composite specimens. Figure 2 shows the results of microhardness test of the prepared composites.

Table.3 VHN for different micron size of reinforcement silica with weight percentage

Weight percentage	Different micron size			
	106	150	250	355
3%	141	143	144	138
6%	156	168	166	162
9%	171	193	183	188
12%	148	161	171	156

The composite containing different micron size and wt.% of silica in it. From the Figure 3, it is evident that the hardness of the composite material is much higher than that of its parent metal hardness 130VHN. It is also shown that the hardness of the composite material increases with wt.% of silica content. This may be because of addition of silica makes the ductile Al LM13 alloy more brittle.

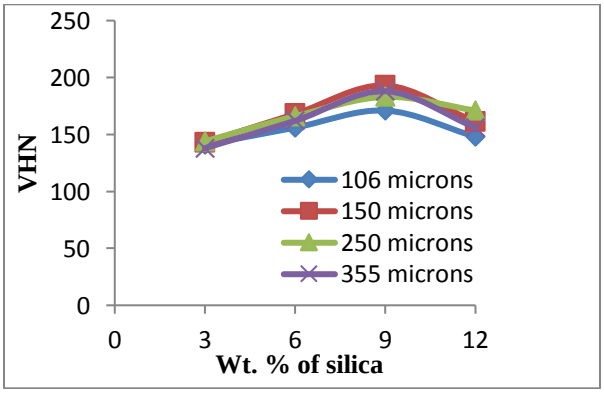


Figure.3: VHN v/s Wt.% of silica for all for microns

Tensile Test

The Table.4 shows the results obtained from tensile test for the prepared composite. The value of tensile strength and % of SiO_2 for four different micron size is shown in Figure 4. The tensile strength increased with increased wt.% of SiO_2. Because the increase in the percent of SiO_2 particulate reinforcement content would create more sites for crack initiation and hence lower down the load bearing capacity of the composite and the bonding between SiO_2 particulate increases with the base aluminum alloy matrix.

ISSN 2348 – 8034
Impact Factor- 4.022

Table.4: Tabulation of results is as follows showing tensile properties of different specimens in Mpa

Weight percentage	Different micron size			
	106	150	250	355
3%	192.823	170.888	169.488	179.339
6%	197.87	182.359	179.905	194.509
9%	209.894	190.461	195.457	200.44
12%	114.129	165.916	161.186	183.87

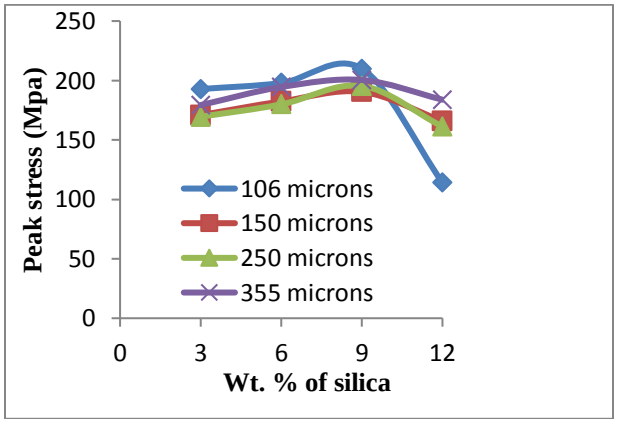


Figure.4: Peak stress v/s Wt.% of silica for all four microns

V. CONCLUSION

- The stirr casting method is adopted in the preparation of Al alloy LM13-Silica composites containing the filler contents up to 12 wt %'age.
- The microstructural studies revealed that there is uniform distribution of the silica particles (reinforcement) in the matrix material of aluminium base alloy.
- Prepared composites with weight of 9% of silica found that there is increased microhardness and tensile strength for all different micron size of silica.
- In overall, from the studies it is concluded that Al alloy LM13-Silica exhibits superior mechanical properties compare to base alloy of aluminium.

REFERENCES

1) *A.M.S. Hamouda , S. Sulaiman , T.R Vijayaram , M. Sayuti , M.H.M. Ahmad, "Processing and characterisationof particulate reinforced aluminium silicon matrix composite", Journal of Achievements in Materials and Manufacturing Engineering, volume 25 Issue 2 December 2007.*
2) *Manoj Singla, D.Deepak Dwivedi et al, "Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite", Journal of Minerals & Materials Characterization & Engineering, Vol. 8, No.6, pp 455-467, 2009.*
3) *Mallikarjuna G B, K V Srinivas, "Preparation and property evaluation of Aluminium-Silica composite by casting route", ISSN 2278 – 0149, Vol. 1, No. 3, October 2012, IJMERR.*
4) *M. N. Wahab, A. R. Daud and M. J. Ghazali, "Preparation And Characterization of Stir Cast-Aluminum Nitride Reinforced Aluminum Metal Matrix Composites", International Journal of Mechanical and Materials Engineering (IJMME), Vol. 4 (2009), No. 2, 115-117.*
5) *H. Zuhailawati*, P. Samayamutthirian and C.H. Mohd Haizu, "Fabrication of Low Cost Of Aluminium Matrix Composite Reinforced With Silica Sand", Journal of Physical Science, Vol. 18(1), 47–55, 2007.*

6) *J. Babu Rao*, D. Venkata Rao and N.R.M.R. Bhargava, "Development of light weight ALFA composites", International Journal of Engineering, Science and Technology Vol. 2, No. 11, 2010, pp. 50-59.*
7) *Joel Hemanth, "Quartz (SiO2p) reinforced chilled metal matrix composite (CMMC) for automotive applications" Materials and Design 30 (2009) 323–329 @ Elsevier Ltd.*
8) *Sudarshan and M.K. Surappa, "Dry sliding wear of fly ash particle reinforced A356 Al composites", Wear 265 (2008) 349–360 at www.sciencedirect.com.*