International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
(Vol. 30, Issue 01) and (Publishing Month: May 2016)
(An Indexed, Referred and Impact Factor Journal)
ISSN: 2319-6564
www.ijesonline.com

Mechanical and Metallurgical Characterization of AA6063 Metal Matrix Composites

Narinder kaushik[1] and Dr. Sandeep Singhal[2]

[1]Assistant Professor, Mechanical Engineering Deptt.
Vaish College of Engineering, Rohtak, Haryana (India)
[2]Associate Professor, Mechanical Engineering Deptt.
NIT Kurukshetra, Haryana (India)

Publishing Date: May 17, 2016

Abstract

Metal Matrix Composites (MMC's) play a vital role in the modern Automotive and Aerospace industries owing to their superior strength to weight ratio and high temperature resistance. Aluminum-silicon carbide (Al/SiC) MMC's is gradually becoming very important materials in the manufacturing industry due to their superior properties such as light weight, low density, high hardness, high temperature and superior wear and corrosive resistance etc. In this study Aluminum (Al-6063)/SiC Silicon Carbide reinforced particles MMC's are fabricated by stir casting technique. The MMC's rectangular plates are produced with varying the reinforced particles by weight fraction ranging from 0%, 5%, 10%, and 15%. The average reinforced particle size of SiC is 400mesh. The stirring process was carried out at 700rpm by SS304 Impeller for 20min. The microstructure and mechanical properties are investigated on prepared specimens of MMC's. It was observed that the hardness and tensile strength both are increased with increasing of reinforced particle weight fraction.

Keywords: *AA6063, stir casting, SiC, MMC's and weight fraction.*

1. Introduction

The development of simple, cost effective and technically efficient processing routes for the production of metal matrix composites continues to draw the attention of materials researchers. This quest is becoming more of a research paradigm in a good number of developing countries where there are sustained efforts to extend materials design beyond the use of traditional metals and alloys by the adoption of indigenous technologies (Singla et al., 2009). The attractive properties of MMCs and its higher performance potentials over traditional metals and alloys have given the impetus for many such research efforts (Miracle, 2005; Ray, 1993).

The advantages of metallic composites over their monolithic counterparts include but are not limited to their high specific strength and stiffness, better high temperature performance, low thermal expansion among others (Zhou and Xu, 1997; Hashim et al., 1999). Aluminum based matrix composites remain the most explored metal matrix material for the development of MMCs. This is primarily due to the broad spectrum of properties it offers at low processing cost (Surappa, 2003). They are currently applied in the design of a wide range of components for use in aerospace technology, defence, electronic heat sinks, solar panel substrates, antenna reflectors, automotive drive shaft fins, explosion engine components, sports among others (Surappa, 2003; Srivatsan et al., 2003).

Deriving optimized properties from any selected Al based matrix composite requires a sound knowledge of the material behavior of the composite which is influenced by such factors as the base Al alloy composition, the manufacturing process, the reactivity between the reinforcement and the matrix, the size, morphology and volume fraction of the reinforcement (Kumar et al., 2010; Christy et al., 2010; Hassan, 2007).

The current research work is an effort to study the viability of producing Al 6063/SiC composites using stir mixing and magnesium metal powder additive. This processing method is envisaged will reduce drastically the common problem of porosity which is observed in metal matrix composites produced by casting technique.

2. Materials and Experimental Procedure

In this present work, commercially available aluminum (AA6063) in T6 condition was used as matrix and reinforced with Silicon Carbide (SiC) particulates. The material employed for this study was AA6063 (25 x 6 mm strips) with following chemical composition (*wt*); Si (0.20%), Fe (0.35%), Cu (0.10%), Mn (0.10%), Mg (0.45%), Cr(0.10%), Zn (0.10%), Ti (0.10%) and Al (reminder). The melting was carried out in a clay-graphite crucible placed inside the top loading Muffale furnace (fig 1(a)). An induction resistance furnace with temperature regulator cum indicator is utilized for melting of Al/SiC-MMCs. Aluminum alloy (AA 6063) was first preheated at 450°C for 2 hours before melting and SiC particulates were preheated at 800°C for 1 hour 30 minutes. To improve the wetness properties by removing the absorbed hydroxide and other gases. The furnace temperature was first raised above the melting temperature, that is, 750°C, to melt the matrix completely and then it was cooled down to just below the melting temperature (upto 630 deg.celsius) to keep the slurry in a semi-solid state. At this stage the preheated SiC particles were added and mixed mechanically with the help of a mechanical stirrer fig 1 (c). Prior to particle addition (SiC), 1 wt% of Mg powder was added into the melt in order to improve the wettability. The composite slurry was then reheated to a fully liquid state and mechanical mixing was carried out for 20min at 400rpm average stirring speed. In the final stage of mixing, the furnace temperature was controlled within 760 ± 10°C and the temperature was controlled at 740°C. Moulds (size 100mm width ×300mm long x50mm depth) made of mild steel sheet were preheated to 350°C for pouring the molten Al/SiC -MMC. At this stage the molten Al/SiC slurry was poured into the preheated permanent mould or die manually. The casting was removed from the die when it cooled naturally. Similar process was adapted for preparing the specimens of varying weight fractions of SiC Fig 1(b).

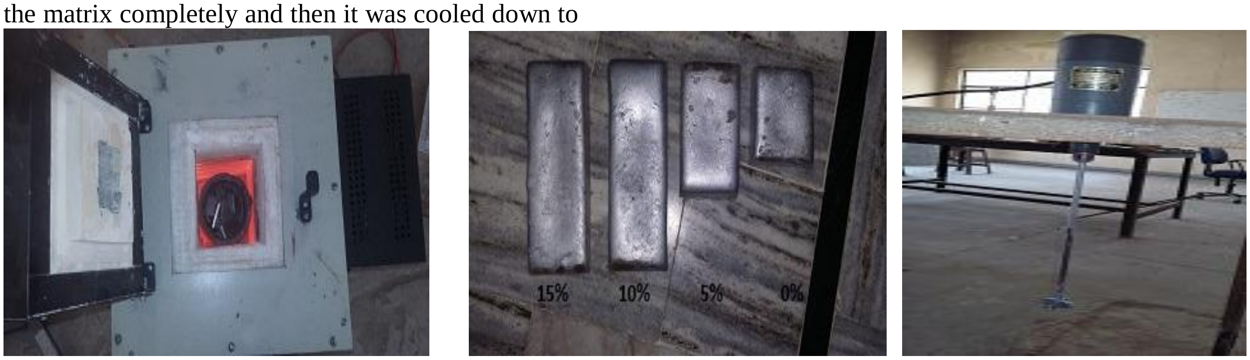


Figure 1 (a): Muffale Furnace **1(b) As cast samples** **1 (c) Stirrer**

3. Results and Discussion

Various Experiments were conducted on fabricated MMCs samples by varying weight fraction of SiC (0%, 5%, 10%, and 15%) and size of SiC particles is 400 mesh to analyze the casting performance characteristics of Al/SiC-MMCs.

3.1. Microstructure

Metallographic samples were sectioned from the rectangular specimens. Keller's etchant solution was used to etch the samples wherever required. To see the difference in distribution of SiC particles in the aluminium matrix, SEM analysis of samples is done to see the microstructure of the samples .Figure 2 (a, b, c) shows SEM Micrograph of Al/Sic-MMC's samples for different weight fraction (5%, 10%, and 15%) of SiC particles. SEM images showed reasonably uniform distribution of SiC particles.

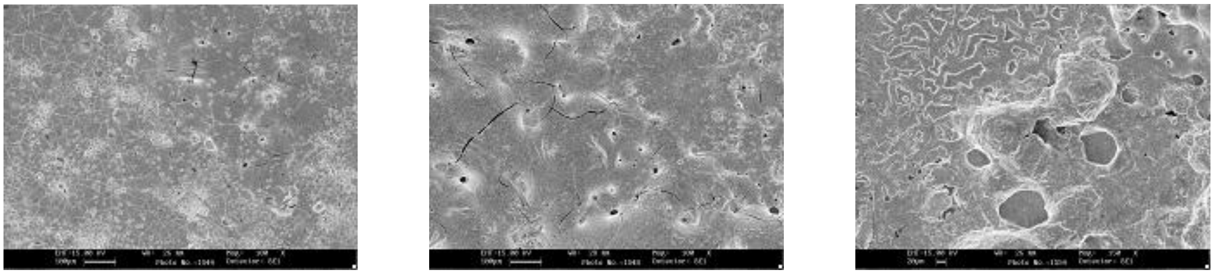


Figure 2 (a) (b) (c)
Composite SEM images of (a) AA6063+5%SiC (b) AA6063+10%SiC (c) AA6063+15%SiC

3.2. Tensile Strength

The tensile test was carried out at room temperature on Universal Testing Machine Model-UTN-20, Sr.No.-4/79/239, and Max. Capacity-2000 kgs, Make Blue Star Ltd. Figure 3 shows standard dimensions of specimen in accordance with ASTM E08M for Tensile Test. Test specimens of standard dimensions as shown in Figure 2 were prepared of Al/Sic-MMC's for different weight fraction (0%, 5%, 10%, and 15%) of SiC particles.

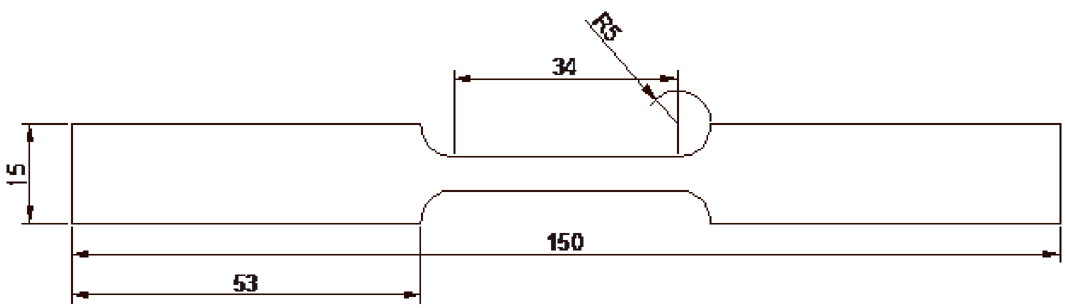


Figure 3: Standard Dimension of Specimen

Four Specimens for tensile testing are prepared. Graphs were plotted between tensile force (kgf) and Extension (mm) for four specimens against %age SiC Fig (4 a, b). The values of tensile force are plotted on vertical axes and extension on horizontal axes. The specimen passes through the clearly defined stages i.e. limit of proportionality, Upper yield value, lower yield value, ultimate stress value and finally fractures strength value.

Table 1: Four Specimens for Tensile Testing

Sample no.	%age of SiC	UTS(MPa)	% Elongation
1	0	85	14
2	5	102	12.8
3	10	114	12.2
4	15	124	11.8

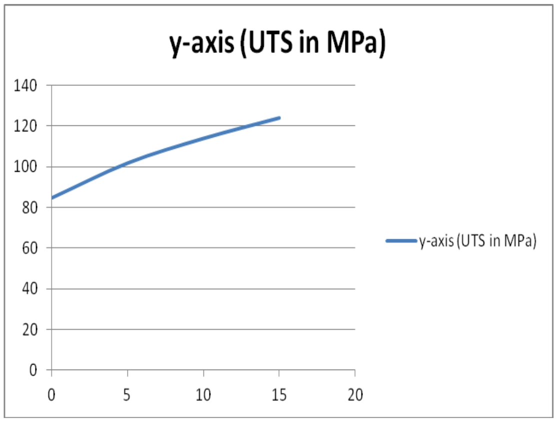


Figure 4 (a) %age of SiC

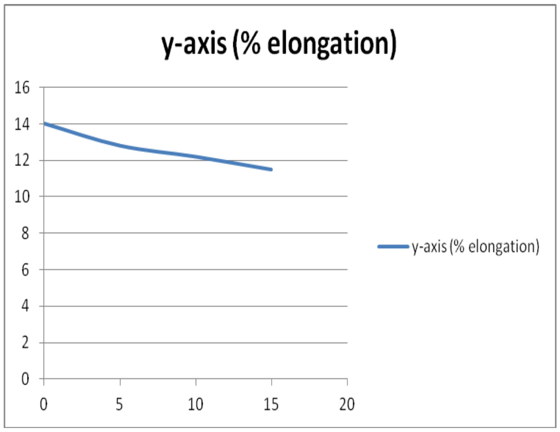


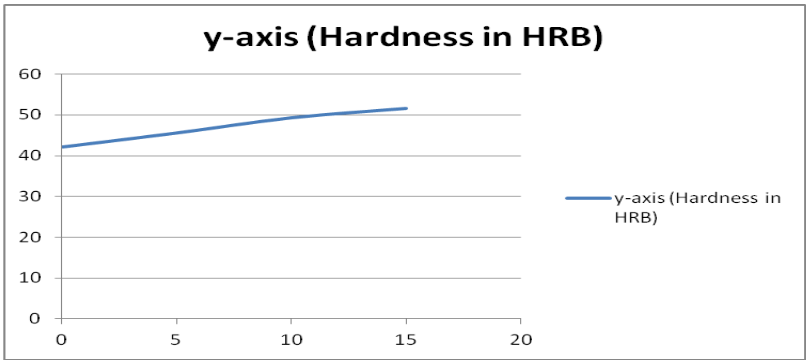
Figure 4 (b) %age SiC

3.3. Hardness

The Rockwell hardness test was done on Rockwell hardness tester as graph Hardness vs. % Sic is shown in Figure 5. Four samples of Al/Sic-MMC's for different weight fraction of SiC particles were prepared. Samples after test and hardness value on dial are presented in table below. The Rockwell hardness values with reference to scale HRB were taken for all samples and shown by graphs.

Table 2: HRB with %age of SiC

Sample no.	%age of SiC	Hardness(HRB)
1	0	42.16
2	5	45.6
3	10	49.3
4	15	51.6



%age of SiC

4. Conclusions

In the present work, AA 6063 wt. %SiC (0, 5, 10, and 15) composite was successfully fabricated by stir casting method. The effect of SiC reinforcement in the matrix in terms of microstructures, hardness, and tensile strength was investigated and reported in as-cast condition. From the results of this study, the following conclusions were drawn:

1. The scanning electron micrographs revealed the effect of reinforcement on the matrix grain size, distribution of reinforcement and clustering/agglomeration of reinforcement in the matrix.
2. The hardness, tensile strength, composite increases with increase in percentage of reinforcement in as-cast MMc's. This was attributed by uniform distribution of reinforcement and further increase diminished the mechanical properties due to clustering/agglomeration.
3. Highest hardness, tensile strength, was obtained for AA 6063-15 wt. % SiC composite.

References

[1] HansPeter Degischer,Peter Prader,Christopher Sanmarchi,Assessment of Metal matrix composites for Innovations- intermediate report of a Europen Thematic Network, Composites Part A: Applied Science and Manufacturing.32(2001)1161-1166.

[2] S Basavarajappa ,GChandramohan, JP Davim, M Prabu,KMukund,MAshwin, MP Kumar, Drilling of hybrid aluminium matrix composites, Int J AdvManuf Technol.35 (2008)1244–1250.

[3] Kok M. Production and mechanical properties of Al2O3 particle-reinforced2024 aluminium alloy composites, J Mater Process Technol.161 (2005) 381–387.

[4] G.B.Veeresh Kumar,C.S.P.Rao,N.Selvaraj,Studies on mechanical and dry sliding wear of Al6061–SiC composites, Compos Part B-Eng.43-3 (2011) 1185-1191.

[5] UmitCocen,KazimOnel,Ductility and strength of extruded SiCp/aluminium-alloy composites, Compos. Sci. Technol..62 (2002) 275–282.

[6] N.Parvina,R.Assadifarda,P.Safarzadeha,S.Sheibanib,P.Marashia,Preparation and mechanical properties of SiCreinforced Al6061composite by mechanical alloying, Mater Sci Eng A. 492(2008) 134–140.

[7] M.K.Surappa, Aluminium matrix composites:Challenges and opportunities, Sadhana, 28 (2003) 319–334.

[8] SBasavarajappa,G.Chandramohan,A.Mahadevan,M.Thangavelu,R.Subramanian,P.Gopalakrishnan, Influence of sliding speed on the dry sliding wear behaviour and the subsurface deformation on hybrid metal matrix composite,Wear,262(2007)1007–1012.

[9] S.A.Sajjadi,H.R.Ezatpour,Beygi,Microstructure and mechanical properties of Al–Al2O3 micro and nanocomposites fabricated by stir casting, Mater Sci Eng A.528(2011) 8765– 8771.

[10] L.J.Yang,Wear coefficient equation for aluminium based matrix composites against steel disc ,Wear.255(2003) 79–892.

[11] S.Natarajan,Sliding wear behaviour of Al 6063/TiB2 in situ composites at elevated temperatures, Mater. Des,30 (2009) 2521–2531.

[12] S.Suresha,B.K.Sridhara,Effect of addition of graphite particulates on the wear behavior in aluminium–silicon carbide–graphite composites, Mater. Des, 31(2010)1804–1812.

[13] Zhou, W. and Xu, Z.M., "Casting of SiC Reinforced Metal Matrix Composites," Journal of Materials Processing Technology, 63: 358-363. 1997.

[14] M.K. Surappa. J. Mater., "Fabrication of Al-Al2O3/Grp Metal Matrix Composites 3079 ," in Proc. Tech. 63, 325-333.1997.

[15] Hashim, J., Looney, L. and Hashmi, M.S.J.,"Metal Matrix Composites: Production by the Stir Casting Method," Journal of Materials Processing Technology, 92-93: 1-7. 1999.

[16] Hashim, J., Looney, L. and Hashmi, M.S.J., "Particle Distribution in Metal Matrix Composites," Part-I, Journal of Materials Processing Technology, 123: 251-257. 2002.

[17] Srivatsan, T.S., Sudarshan, T.S. and Lavernia, E.J., "Processing of Discontinuously-Reinforced Metal Matrix Composites," by Rapid Solidification, Progress in Material Science, 39: 317-409. 1995.

[18] Singla, M., Chawla, V., Dwivedi, D.D. and Lakhvit, S. ''Development of aluminium based SiC particulate metal matrix composite'', J. Miner. Matls Charac. Eng., 8(6), pp. 455–467 (2009). f composites

[19] Miracle, D.B. ‘‘Metal matrix composites-from science to technological significance’’,

[20] CVeeresh Kumar, G.B., Rao, C.S.P., Selvaraj, N. and Bhagyashekar, M.S. ‘‘Studies on Al(6061) and 7075-Al203 metal matrix composites’’, J. Miner. Matls Charac. Eng., 9(1), pp. 43–55 (2010).ompos. Sci. Technol., 65(15–16), pp. 2526–2540 (2005).

[21] Christy, T.V., Murugan, N. and Kumar, S. ‘‘A comparative study on the microstructures and mechanical properties of Al 6061 alloy and the MMC Al 6061/TiB2/12p’’, J. Miner. Matls Charac. Eng., 9(1), pp. 57–65 (2010).

[22] S.F. Hassan, and M. Gupta, J. Alloy. Compd., Vol 429, 2007, p 176

[23] Y. Liu, P.K. Rohatgi, and S. Ray, Tribological Characteristics of Aluminum-50 vol pct Graphite Composite, Metall. Mater. Trans. A, Vol 24 (No. 1), 1993, pp 151–159