AN EVALUATION OF MECHANICAL PROPERTIES AND MICROSTRUCTURE OF DISPERSION STRENGTHENED Al-6063 OBTAINED BY *IN -SITU* FABRICATION

Adalarasan R., Shanmuga Priya C., Arunachalam R., Sudhir R.

Department of Mechanical Engineering, Saveetha Engineering College, Chennai, India.
Email: adalno1@yahoo.co.in

ABSTRACT

Experimental works on SiC based technology has gained more importance in aerospace, nuclear, automobile, chemical and cryogenic applications. In the present work SiC particles of size of 10% is dispersed in a matrix of aluminium alloy (Al 6063) with varying weight fractions of 3, 6, 9 and 12% by using the process of stir casting. The molten MMC was then poured into a preheated die designed according to the specifications of the work piece. The cast component was machined by using WC insert. The quality of the cast AlSiCp was tested by radiography for discontinuities. An analysis of mechanical properties and Microstructure was carried out to find the effect of dispersion strengthening. The assessed properties were found to be superior when compared with the parent Al 6063 alloy.

Keywords: Dispersion strengthening, Al6063 alloy, Microstructure, Ultimate strength, Hardness, Radiography.

I. INTRODUCTION

Metal matrix composites (MMCs) are the class of composite materials finding vast applications in automotive, aircraft, defence appliance industries. Aluminium based MMC's have gained more importance because of their high strength to weight ratio. SiC is a tool material known for its high specific strength, high thermal stability and wear resistance. The study focuses on dispersion strengthening of Al 6063 alloy by SiC particles acting as reinforcement. The dispersoid acting as the reinforcement functions as a barrier to the movement of dislocations thereby strengthening the matrix.

II. EXPERIMENTAL SETUP

This involves incorporation of SiCp into liquid aluminium and allowing the mixture to solidify. Here, the crucial task is to create good wetting between the particulate reinforcement and the liquid aluminium alloy. The simplest and most commercially used technique is known as vortex technique or stir-casting technique. The process is not suitable for the incorporation of sub-micron size ceramic particles or whiskers. It is an inexpensive method for the fabrication of the metal matrix composites which involves the addition of particulate reinforcement into molten metal followed by stirring action where uniform distribution of the reinforcement particles is achieved.

Fig. 1. Muffle Furnace used for the casting process

Fig. 2. Die used for casting the work piece

Stir-casting results in a material with higher microhardness and lower wear rates than conventional cast alloy. The chemical composition of the aluminium alloy used is shown in the Table 1 below.

Table 1. Composition of Al-6063 showing the weight % of various elements

Element	Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Al
%	0.35	0.1	0.1	0.1	0.45-0.9	0.1	0.1	0.1	balance

The cast AlSiCp after solidification was taken out of the die and was machined using WC insert in lathe which aided in removing the runner and raiser from the work piece. After machining the work piece was subjected to grinding in order to achieve proper surface finish. The work piece was machined according to the ASTM standards of tensile testing. The work piece obtained before and after machining is shown in Fig 3 and Fig 4 below.

Fig. 3. Cast AlSiCp sample before machining

Fig. 4. Cast AlSiCp sample after machining

III. RESULTS AND DISCUSSIONS

A. Radiography

The Radiographic tests were conducted on all the samples to identify the location of discontinuities and voids. The results showed that the samples are free from voids and discontinuities. This ensured the quality of the casting for further processing. Fig 5 shows the radiographic films obtained in the radiography testing of AlSiCp composite.

Fig. 5. Radiographic Films of samples with varying percentage of SiCp

B. Micro Vickers Hardness

Microhardness test usually refers to static indentations made with loads with varying loads. An applied load ranging from 10 g to 1,000 g is used. The indenter is either the Vickers diamond pyramid or the Knoop elongated diamond pyramid. The procedure for testing is very similar to that of the standard Vickers hardness test, except that it is done on a microscopic

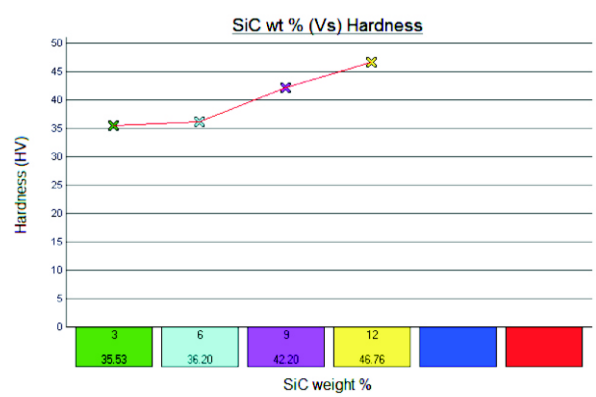

Fig. 6. Graph showing variation of hardness with increase in SiCp wt%

scale with higher precision instrument; these usually have a magnification of around X500 and measure to an accuracy of ±0.5 micrometers. It should, however, be added that considerable care and experience are necessary to obtain this accuracy.

C. Tensile Strength

As per ASTM B557M standard, tensile strength was determined by instron computerized tensile/compression testing. The specimen used for testing was machined according to ASTM B557 standards. The graph between stress and strain was obtained by using auto instrument software is shown in Fig 10 to Fig 13. The ultimate breaking load, elongation and ultimate stress were observed to be increasing with increasing percentage of SiCp. The cup and cone fracture obtained in the work piece by tensile testing is shown in Fig 9.

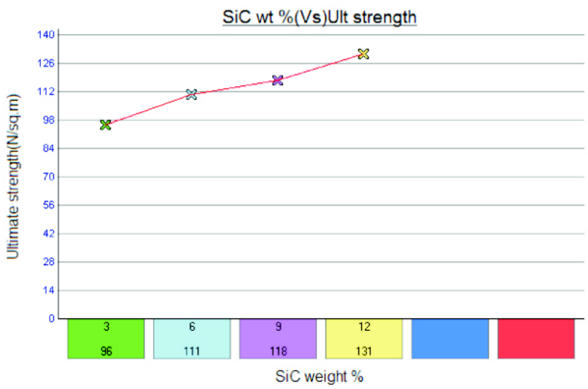

Fig. 7. Graph showing variation in ultimate strength with increase in SiCp wt%

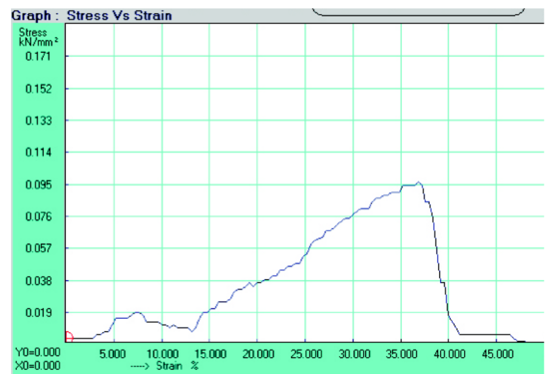

Fig. 8. Graph showing variation in elongation with increase in SiCp wt%

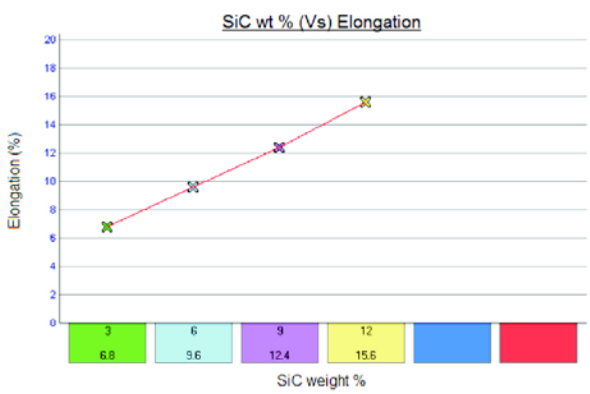

Fig. 9. Cup and Cone fracture in tensile testing

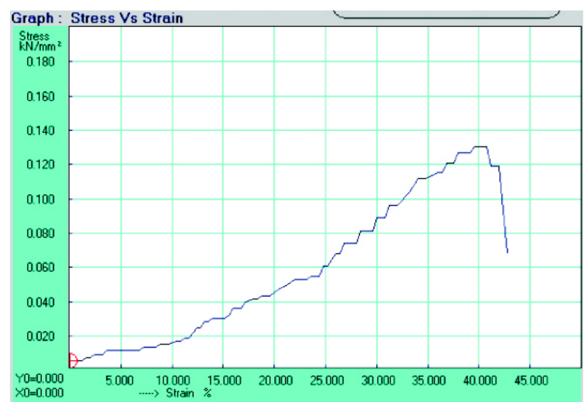

Fig. 10. Engineering Stress – Strain Curve for Sample with 3%SiC

Fig. 11. Engineering Stress – Strain Curve for Sample with 6%SiC

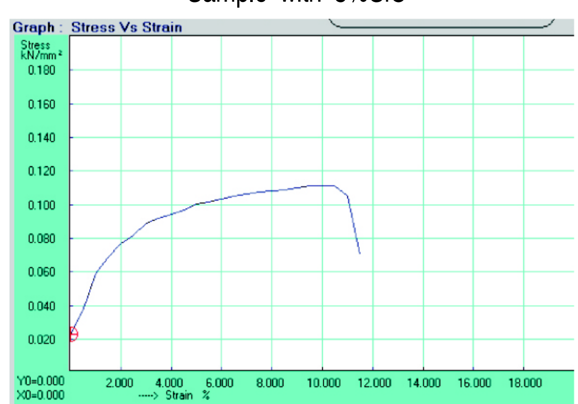

Fig. 12. Engineering Stress – Strain Curve for Sample with 9%SiC

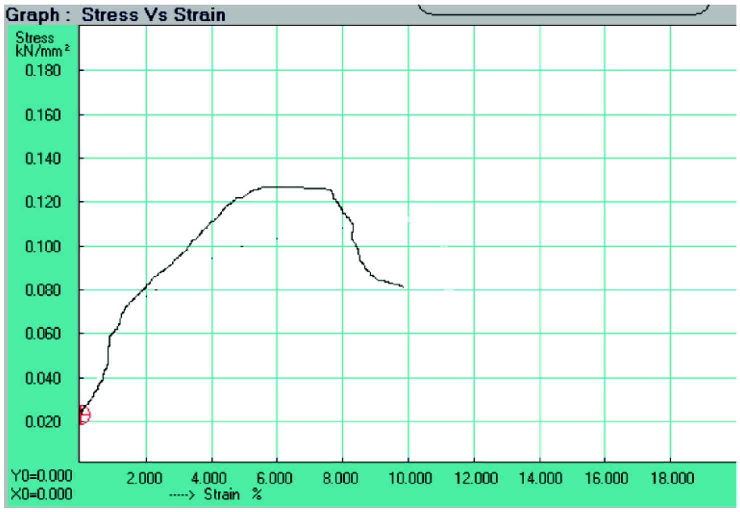

Fig. 13. Engineering Stress – Strain Curve for Sample with 12%SiC

D. Microstructure

Microstructure analysis was carried out with a magnification of 200X and the microstructure was determined with and without an etchant solution. The distribution of SiCp is clearly visible in the microstructure analysis. Though the presence of SiCp is found to be agglomerated the distribution of SiCp is clearly visible with increasing percentage of SiCp. The analysis was done at the centre of the specimen where a uniform distribution of SiCp is found.

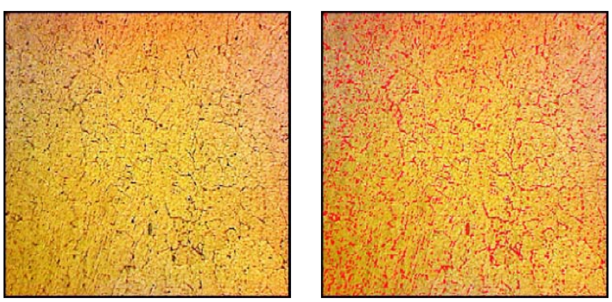

Fig. 14. Photograph revealing the presence of SiCp in the sample (Al6063-97% and SiC-3%)

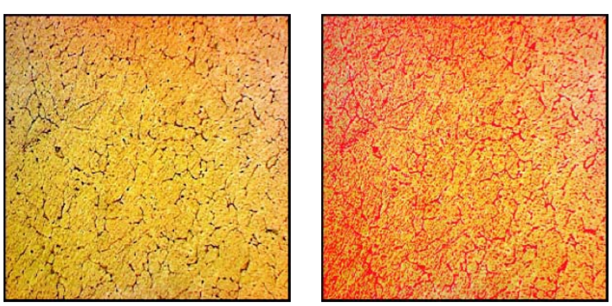

Fig. 15. Photograph revealing the presence of SiCp in the sample (Al6063-94% and SiC-6%)

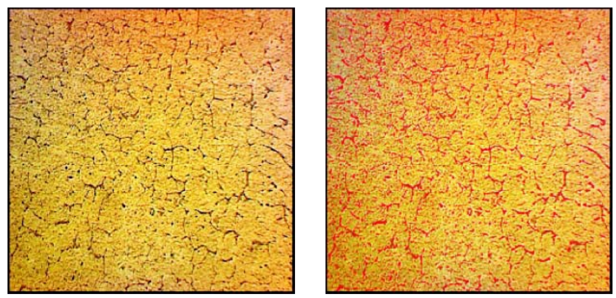

Fig. 16. Photograph revealing the presence of SiCp in the sample (Al6063-91% and SiC-9%)

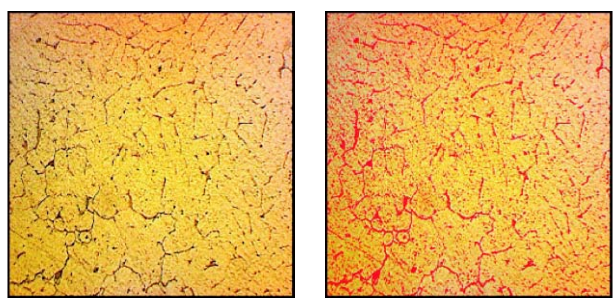

Fig. 17. Photograph revealing the presence of SiCp in the sample (Al6063-88% and SiC-12%)

IV. CONCLUSION

The matrix of Al6063 was dispersion strengthened by SiCp in varying wt%. The Experimental results show a marked increase in strength and hardness of the composite in comparison to the Al 6063 alloy. The Mechanical and Metallurgical properties can be further improved by proper heat treatments. Further investigations are possible in the area of dispersion strengthening of aluminium by varying the particle size and shape.

ACKNOWLEDGEMENT

We thank Dr. K. Kalaichelvan and Mr. C. NandaKumar of Madras Institute of Technology, Chrompet, Chennai for their help and guidance to carry out the casting process.

REFERENCES

[1] Anandakrishnan V. and Mahamani A. "Investigations of flank wear, cutting force, and surface roughness in the machining of Al-6061–TiB2 in situ metal matrix composites produced by flux-assisted synthesis", Int J Adv Manufacturing Technology

[2] Bobiæ B., Mitrovic S., Babic M. and Bobiæ I. 2009 "Corrosion of Aluminium and Zinc-Aluminium Alloys Based Metal-Matrix Composites", Tribology in industry, Volume 31, 3-4.

[3] Brian Ralph., Yuen H.C. and Lee W.B. 1997 "The processing of metal matrix composites — an overview Journal of Materials Processing Technology" Volume 63, Issues 1-3, 339-350.

[4] Jacob Aboudi 1987 "Closed form constitutive equations for metal matrix composites", International Journal of Engineering Science Volume 25, Issue 9, 1229-1240.

[5] Clyne T.W. and Withers P.J., 1993 "An Introduction to Metal Matrix Composites", Ed., Cambridge Solid State Science Series, Cambridge University Press.

[6] Lindroos V.K. and Talvitie M.J. 1995 "Recent advances in metal matrix composites Journal of Materials Processing Technology", Volume 53, Issues 1-2, 273-284.