EXPERIMENTAL INVESTIGATION OF ALUMINIUM SILICON CARBIDE COMPOSITES BY POWDER METALLURGY TECHNIQUE

M.Jayaram

Department of mechanical Engineering, University college of Engineering, Villupuram

1. **ABSTRACT**

The acceptance of particulate metal matrix composites (MMCs) for engineering applications has been hampered by the high cost involved in producing components. Although several technical challenges exist in the casting technology, yet it can be used to overcome this problem. One of the major challenges is the uniform distribution of reinforcement within the matrix, which directly affects the properties and quality of composite material. In the present topic a modest effort has been made to develop Aluminium based Silicon Carbide particulate MMCs with two main objectives are develop a conventional low cost technique of producing MMCs and obtain homogenous dispersion of ceramic material. To achieve the above said objectives Mechanical alloying method of Powder Metallurgy has been adopted and consequently its property analysis has been made. Various Experiments have been conducted by varying weight fraction of Sic (0%, 10%, 20% and 30%), while keeping all the other parameters constant. Mechanical alloying of powders resulted in improvement in hardness and compressive strength of Al-SiC composites with 0 to 30 weight % of SiC.

Key words: Aluminium alloy, Silicon carbide, Powder metallurgy, SEM, Mechanical properties.

2. INTRODUCTION

Metal Matrix Composites are composed of a metallic matrix (Al,Mg,Fe,Cu etc.) and a dispersed ceramic (oxide, carbides) or metallic phase(Pb,Mo,Wetc). Ceramic reinforcement may be silicon carbide, alumina, silicon nitride, boron carbide, boron nitride etc. whereas Metallic Reinforcement may be tungsten, beryllium etc. MMCs are used for space shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs and a variety of other applications. From a material point of view, when compared to polymer matrix composites, the advantages of MMCs are strength and stiffness at elevated temperature, good abrasion and creep resistance properties. Most MMCs are still in the development stage or the early stages of production and are not so widely established as polymer matrix composites. The biggest disadvantages of MMCs are their high costs of fabrication, which has placed limitations on their actual applications. There are also advantages in some of the physical attributes of MMCs such as no significant moisture absorption properties, non-inflammability, low electrical and thermal conductivities and resistance to most radiations.

3. EXPERIMENTAL PROCEDURE

3.1 RAW MATERIALS

The aluminium and silicon carbide pure powders have particle sizes in the range of 220 Mesh and 325 mesh respectively are prepared.

3.2 SAMPLE PREPARATION

Equivalent quantities of the metal powders were taken by weight. The weighing was done in a very precise weighing balance. 7.15 gm batches were prepared for each sample.

Sample Aluminium Silicon carbide

Sample	Aluminium		Silicon carbide	
	Percentage(%)	Weight(gms)	Percentage(%)	Weight(gms)
A	100	7.15	0	0
B	90	6.44	10	0.8
C	80	5.71	20	1.7
D	70	5.0	30	2.6

Table 3.1 Sample preparation

3.3 BLENDING

It is the process of mixing the powders either manually or other mixers. Al-SiC powders are manually mixed and putting the die.

3.4 COMPACTING

The purpose of the compacting is to consolidate the powder into the desired shape and as closely as possible to final dimensions, it is designed to impart the desired level and type of porosity and to provide adequate strength for hardening. Compacting was done in UTM (Universal Testing Machine).The compacting pressure 50KN and at room temperature for 2min.

3.5SINTERING

The green specimen compacts were sintered in an electric furnace by gradually raising the temperature to 610oC and the specimens were kept at this temperature decreasing for 100oC. The compacts were furnace cooled.

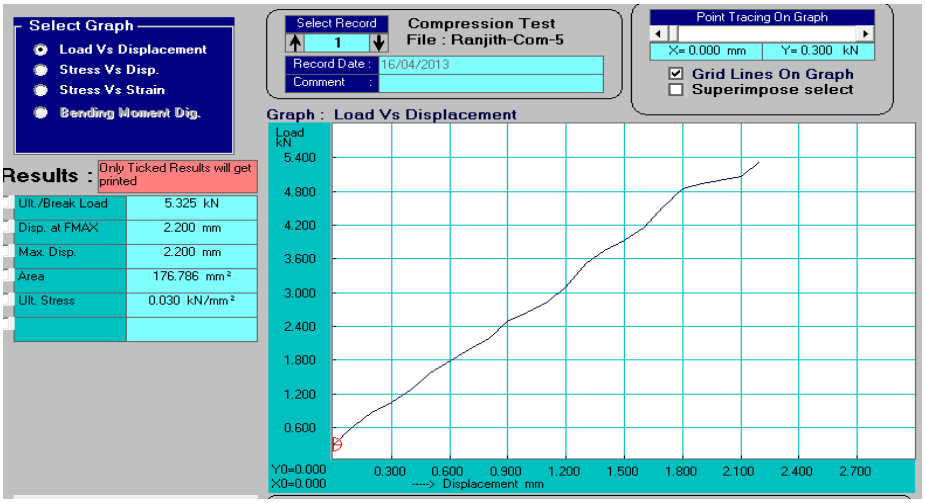
4. RESULTS AND DISCUSSION

4.1. SAMPLE A (10%Sic)

4.1.1.VICKERS HARDNESS: (2.50 dia ball)

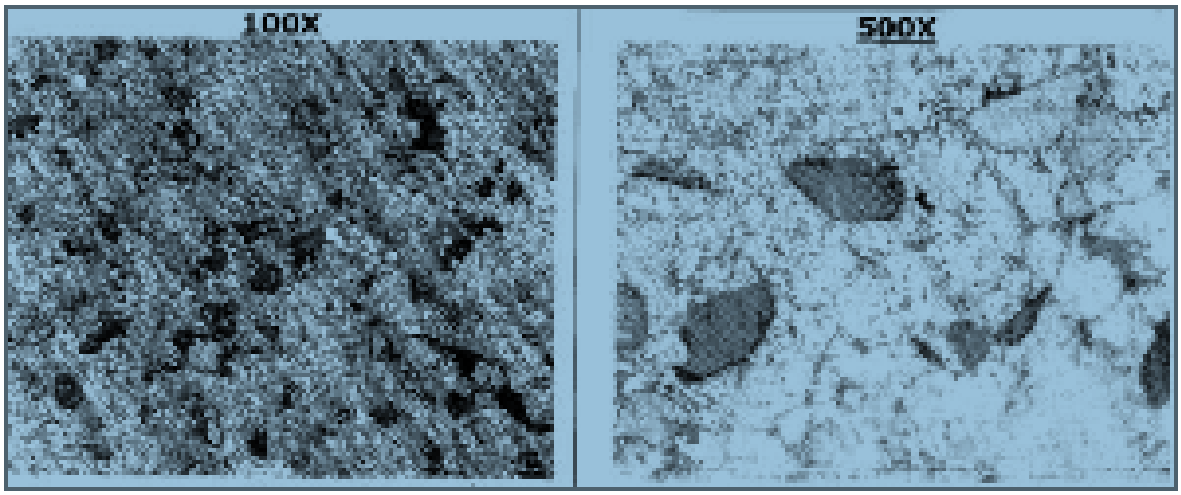
1. 37.5HBW @ 62.5 Kgf Load
2. 36.3 HBW @ 62.5 Kgf Load
3. 37.2 HBW @ 62.5 Kgf Load

4.1.2 CRUSH TEST: with 10mm Ball



Graph 4.1Crush Test For Sample A

4.1.3.MICROSTRUCTURE



Magnification 100X Magnification 500X

Figure 4.1 Sample A microstructure

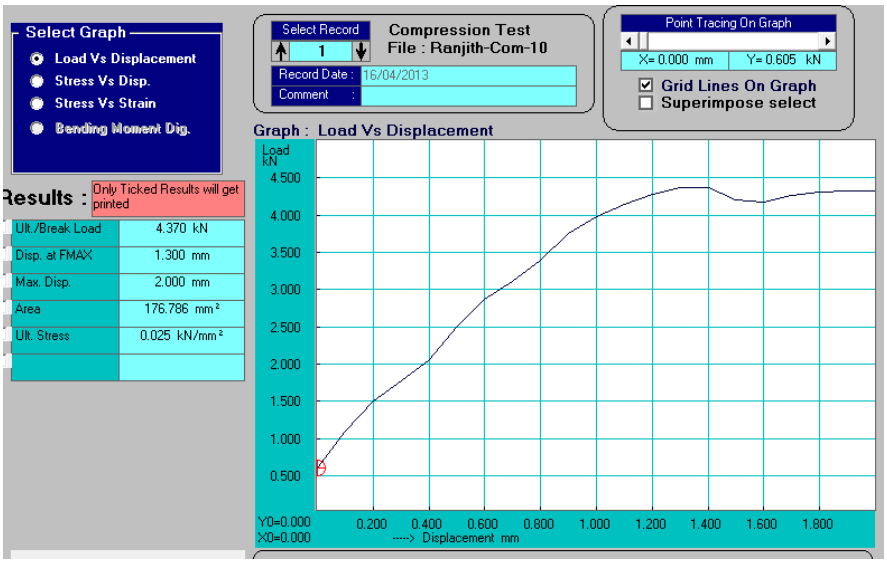
The image shows compacted and sintered Aluminium powder metallurgical product. The photo micrograph shows some pores and good fusion aluminium powder. As the mix is with SiC powders aluminium powder the matrix shows the uniform distribution of the Sic in aluminium matrix. The powder size of the Sic is seemed to be not of same sizes and some are larger.

4.2. SAMPLE B (20%Sic)

4.2.1 VICKERS HARDNESS:(2.50mm dia ball)

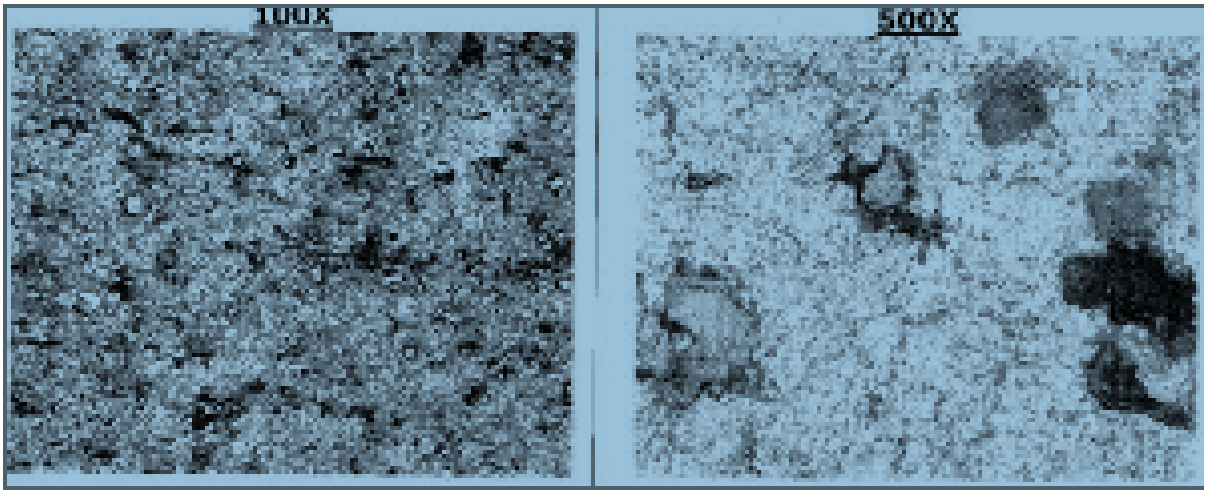
1. 32.3HBW @ 62.5 Kgf Load
2. 31.8 HBW @ 62.5 Kgf Load
3. 31.9 HBW @ 62.5 Kgf Load

4.2.2 CRUSH TEST: with 10mm Ball



Graph 4.2 Crush Test For Sample B

4.2.3.MICROSTRUCTURE



Magnification 100X Magnification 500X

Figure 4.2 Sample B Microstructure

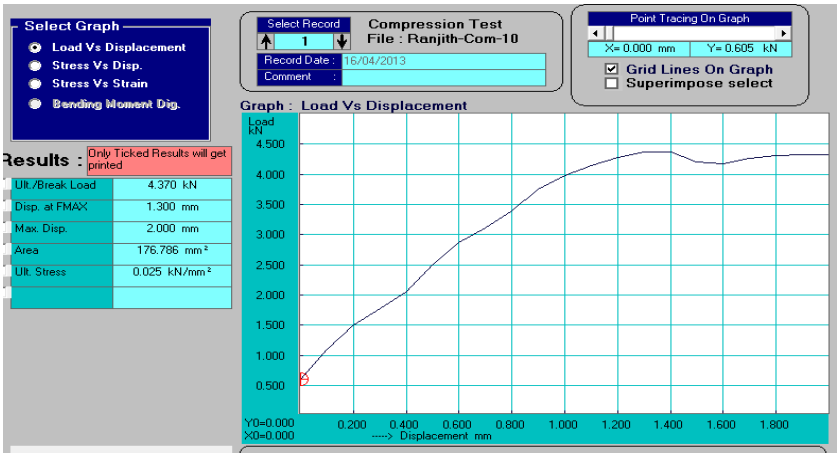
The image shows compacted and sintered Aluminium powder metallurgical product. The photo micrograph shows some pores and good fusion aluminium powder. As the mix is with SiC powders aluminium powder the matrix shows the uniform distribution of the Sic in aluminium matrix. The powder size of the Sic is seemed to be not of same sizes and some are larger. As the percentage of the composite particles is higher the matrix is with more particles of SiC.

4.3. SAMPLE C (30%Sic)

4.3.1 VICKERS HARDNESS: (2.50mm dia ball)

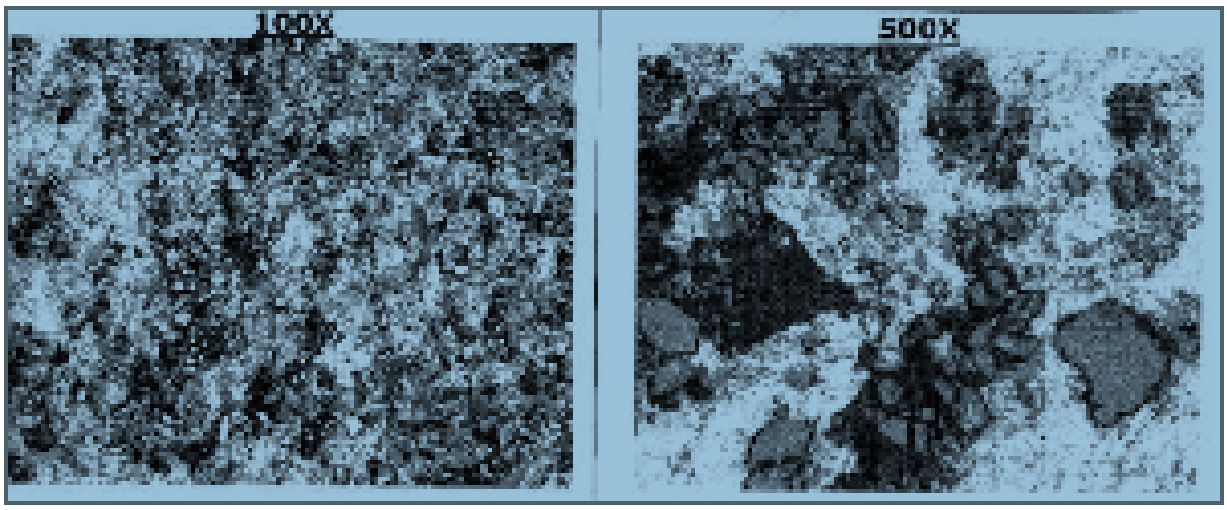
1. 37.4HBW @ 62.5 Kgf Load
2. 36.7 HBW @ 62.5 Kgf Load
3. 36.2 HBW @ 62.5 Kgf Load

4.3.2 CRUSH TEST: with 10mm Ball



Graph 4.3 Crush Test For Sample C

4.3.3. MICROSTRUCTURE



Magnification 100X Magnification 500X

Figure 4.3 Sample C Microstructure

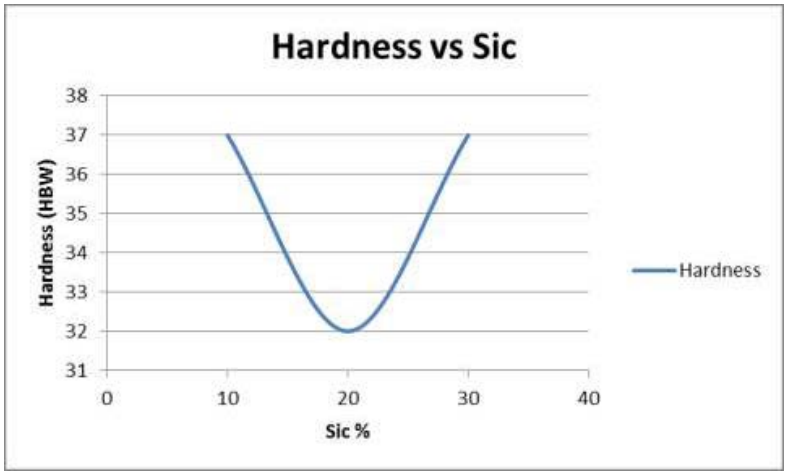
The image shows compacted and sintered Aluminium powder metallurgical product. The photo micrograph shows some pores and good fusion aluminium powder. As the mix is with SiC powders aluminium powder the matrix shows the uniform distribution of the Sic in aluminium matrix. The powder size of the Sic is seemed to be not of same sizes and some are larger. As the percentage of the composite particles is higher the matrix is with more particles of SiC.

4.4. HARDNESS VS SILICON CARBIDE

In Table 4.1, graph 4.4 the hardness shows the variation with % of Sic It is clear from the graph (6.4) that as the % of Sic increases in aluminium, hardness of the sample‟s increases on VHN scale.

Sic %	Hardness
10	37
20	32
30	37

Table 4.1 Hardness value



Graph 4.4 Hardness vs SiC

5. CONCLUSION

Preparation of Al-Sic MMC"s composites by powder metallurgy technique is attempted during this course of work. Composites are prepared by varying different composition of silicon carbide such as 0%, 10%, 20%,30%. The composition of composite prepared are 100%Al + 0% Sic, 90%Al + 10% Sic, 80%Al+20% Sic , 70%Al + 30% Sic. This composite was compacted using UTM under the compacting pressure 50KN, 60KN and 70KN used for compaction. Sintering is done by conventional sintering techniques. Sintering was done in temperature 837K. In Al-Sic MMC the maximum sintered hardness obtained was 30% of Sic composites 37 HBW @ 2.50mm dia ball ; 62.50 Kgf Load for the sintered samples using the compacting pressure of 50KN, 60KN and 70KN.

REFERENCES

1. Anklekar.R.M, Agrawal.D. K, and Roy.R (2001), "Microwave Sintering and Mechanical Properties of P/M Copper Steel", Powder Metallurgy, Vol. 44, pp.355-362.
2. Bescher.P, Urmimalasarkar and John D. Mackenzie (1992), "Microwave Processing of Aluminum-Silicon Carbide Cermets", Department of Materials Science and Engineering, University of California Los Angeles, CA 90024, Mat. Res. Soc. Symp. Proc. Vol. 269, pp. 371-378.
3. Charles, Arunachalam (2004), "Property analysis and mathematical properties of aluminium alloy hybrid (Al-alloy/SiC/flyash) composites produced by liquid metallurgy and powder metallurgy techniques", Indian Journal of Engineering and Materials Sciences, Vol.11, pp.473-480.
4. Dinesh Agrawal (2006), "Microwave Sintering, Brazing And Melting of Metallic Materials" Advanced processing of metals and materials, Vol. 4, pp. 183-191.
5. Guo R.Q, Rohatgi.P.K (1997), "Preparation of Aluminium–Fly Ash Particulate Composite by Powder Metallurgy Technique", Journal of materials science, Vol.32, pp.3971–3974.
6. Gokce.A, Findik.F (2008), "Mechanical and physical properties of sintered aluminum powders", Journal of Achievements in Materials and Manufacturing Engineering, volume 3, pp. 157-164.
7. Jiping Chen, Dinesh Agrawal, Rustum Roy and Jayan. P.S, (2000), "Continuous Microwave Sintering of Alumina Abrasive Grits", Journal of Materials Processing Technology Vol.108, pp.26-29.
8. Rajkumar.K, Aravindan.S (2009), "Microwave Sintering of Copper– Graphite Composites", Journal of Materials Processing Technology, Vol. 209, pp.5601–5605.
9. C.Suryanarayana, (2001)," Mechanical alloying and milling", Progress in Materials Science 46, 11841.
10.Neelima Devi.C, Mahesh.V, Selvaraj.N (2011),"Mechanical characterization of Aluminium silicon carbide composite", International Journal of Applied Engineering Research, Dindigul, Volume 1, No 4,ISSN 0976-4259.