A Study on Various Properties of Sic Reinforced with AA7075 MMC by Powder Metallurgy Technique

Mr. Nishanth Patel GM[1], Dr. K G Satish[2]
[1]*Lecturer, DOS in Mechanical Engineering, UBDTCE*
[2]*Assistant Professor Department of Mechanical Engineering, UBDTCE*

***Abstract-* In this research, the metal matrix composite of AA7075 reinforced with SiC is processed by powder metallurgy technique as per ASTM standard. The composites are prepared by constant load constant sintering temperature. Thorough investigations about the microstructure and characterization of Al alloy/SiC composite are needed so that metal matrix composites (MMCs) fabricated for aircraft and space industries are defect free and have sound microstructure. The objective of this research work are the fabrication and Mechanical properties of AA7075–SiC MMCs. AA7075 alloy is reinforced with 4, 6, and 10 weight percentages SiC of size 70 µm. From the study, it is revealed that increasing the amount of SiC improves the strength, stiffness, and hardness of the compacted specimens. Also the effect of heat treatment revealed that there is an improvement in the properties of Aluminum MMC.**

***Index terms-* MMC, AA7075, Reinforcement, SiC, Powder metallurgy, Compression Test**

1. INTRODUCTION

Nowadays, aluminum reinforced with ceramic particles is on huge demand, due to its superior mechanical characteristics like hardness, density, and wear resistance. These metal matrix composites have been considered as excellent materials, used as structural materials to the automobile industry and aerospace [1,4]. Some of the manufacturing techniques to produce composite materials such as spray decomposition, liquid metal infiltration, powder metallurgy, squeeze casting, mechanical alloying and compo casting. Powder Metallurgy (PM) is a highly-developed technique for manufacturing composites; this technology consists of three steps; mixing powder elements, compacting those powder elements in a die at room temperature and then heating in a controlled atmosphere furnace to create a bond between the powder elements[2,6].The composites formed out of aluminum alloys are of wide interest owing totheir high strength, fracture toughness, wear resistance,and stiffness. Also, these composites are of superior in nature for elevated temperature applications when reinforced with ceramic particles[7,8].The ceramic particulate reinforced composites find applications as cylinderblocks, pistons, piston insert rings, brake discs, and calipers[12].

From the literatures, the most preferred particle reinforcements for the production of metal–matrix composites (MMCs) are the hard ceramics, namely, zirconia, alumina, and siliconcarbide (SiC) that enhance the properties like strength, stiffness, wear, corrosion resistance, fatigue life, and also elevated temperature properties. The SiC reinforcement in the Al–matrix composites is the most fracture resistant when compared with Al2o3and Si. From the above discussion, it can be concluded that there are no enough data available on the mechanical properties of particulate-reinforced AA7075 composites. Hence, this study is aimed at the fabrication of AA7075–SiC composites containing various weight percentages of particles and to study their density, hardness, and mechanical properties.

2. PREPARATION OF SPECIMENS

Once the powders are thoroughly mixed according to different volume fractions then the compaction process is carried out where large loads are applied to this powder mix. “Universal testing machine” (UTM) is used for compaction. It has the load carrying capacity of 1000 KN. First, the inner die cavity where the powder is to be filled should be cleaned thoroughly with the cloth to remove out any dust particles if present. Then the die cavity is to be cleaned using very fine mesh emery paper. The small quantity of grease is applied to the die cavity, which acts as a lubricant and helps in easy removal of specimens. A plunger is cleaned properly and a small amount of grease is applied to plunger for smooth operation. Next, the known amount of mixed powder is filled in the die cavity. Die is assembled correctly and it is placed on a base plate of the universal testing machine (UTM) as shown in the figure below.

Stages of compaction process are given below:

1. Charging of weighed powder mix into the die cavity.
2. Application of constant load by punch.
3. Removal of applied load.
4. Ejection process of green compact

Once the specimen is ejected the die cavity has to be cleaned thoroughly and the process must be repeated for different combination of powder.

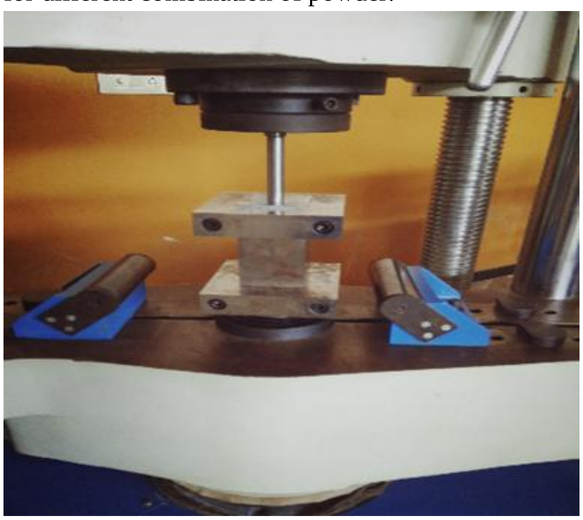
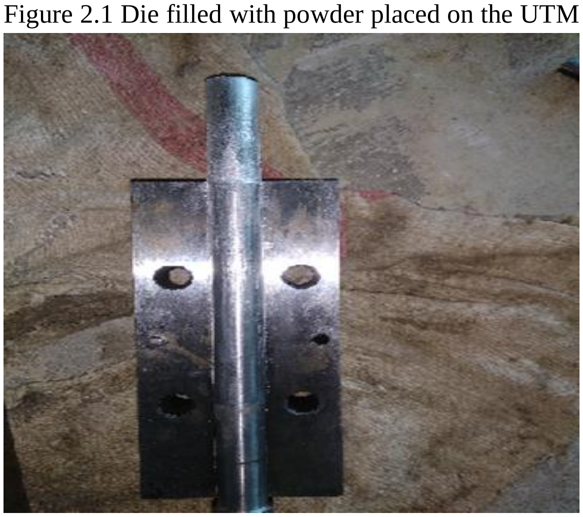


Figure 2.1 Die filled with powder placed on the UTM



. Figure 2.2 Removal of the green compact

3. EXPERIMENTAL DETAILS

Al–SiC composites were prepared by powder metallurgy technique, pure aluminum powders with 74 microns were used as a matrix. Silicon Carbide (SiC) particles were used as reinforcement, with a size of 70microns. Pure aluminum powders were mixed with the ceramic particles to prepare composites with about (0, 4, 6, 10) vol. %reinforcement, mixing was done by ball milling. Composites were fabricated by powder metallurgy technique. The powder mixtures were compressed at a load of 150 KN and sintered with temperature 600°C for 120mins. Facing and surface finishing operations were done using lathe machine. Brinell hardness tests were conducted hardness testing machine. Each specimen here is subjected to hardness test with 2.5 mm ball indenter, 60 kgf load and 10 seconds of dwell time. Tests are carried at three distinct positions on single compacted specimen and average is calculated to get the specimens hardness. The sintered specimens were subjected to compression test. For carrying test “computerized universal testing machine (UTM)” was used. All the tests here were carried at the room temperature. Since the UTM was computerized one it was able to get accurate readings of ultimate compressive strength.

Element	Chemical composition
Zinc	5.1-6.1
Magnesium	2.1-2.9
Copper	1.2-2
Iron	0.5
Silicon	0.4
Manganese	0.3
Chromium	0.18-0.28
Titanium	0.20
Aluminium	Balance

Table 3.1 Chemical composition of AA7075

4. RESULTS AND DISCUSSIONS

4.1 Hardness test.

In present study Brinell hardness scale is used for measuring hardness value. Each specimen is subjected to hardness test with 2.5 mm ball indenter, 60kgf load and 20 seconds of dwell time. The figure 3.1 shows the variation in the hardness value of samples tested with respect to different percentage of reinforcement material. It was, noticed that hardness value of the prepared composite goes on increasing with expansion in the content of SiC particles. The increased hardness can be because of presence of silicon carbide reinforcement particles which are basically very hard. The uniform distribution of SiC in the formed composites is also responsible for increasing hardness of the AA7075- SiC composite.

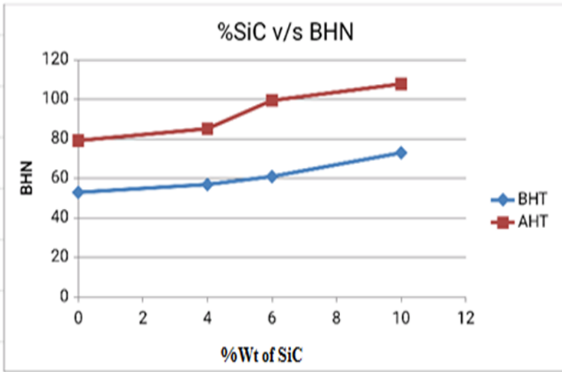


Fig.4.1 Variation of Hardness number with weight fraction of SiC

4.2 Density test

By using ‘rule of mixtures the theoretical density of sintered specimens’ was calculated. By utilizing mass and volume [ρ =m/v] relations experimental density is calculated. From the Figure 4.2, it can be noticed that the theoretical density of reinforced AA7075 is increasing linearly with increase in the amount of SiC reinforcement. In this work, theoretical density was maximum for 10% SiC-AA7075 specimen.

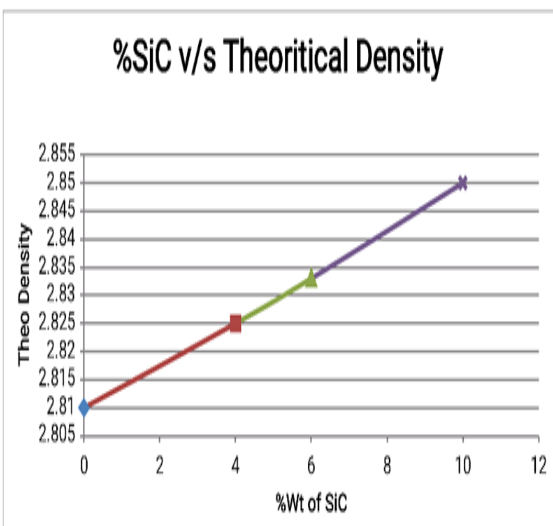
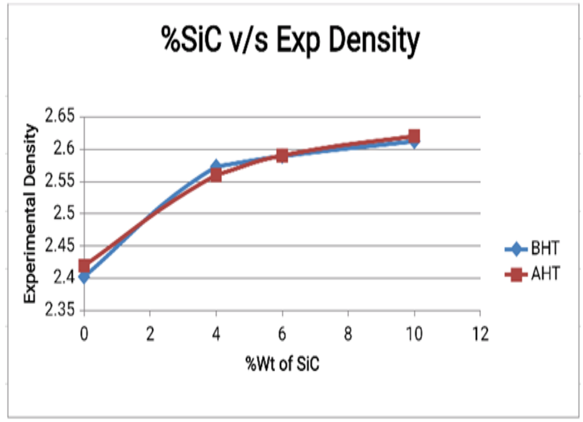


Fig.4.2 Variation of theoretical density with varying % SiC



Fig, 4.3 Variation in experimental density with varying % SiC for both conditions i.e, Before and After Heat Treatment.

From the figure 4.3, shows that the experimental densities increase with increasing SiC content. The reason behind increased theoretical as well as experimental density is attributed to addition of reinforcement particles SiC which has high density compared to base metal AA7075. Heat treated specimen’s shows that higher values of experimental densities when compared to as sintered and as compacted specimens.

4.3 Porosity test

The porosity measurement shows that there is a gradual decrease in the percentage of porosity by increase in the rate of reinforcement to the base alloy. And also the heat treatment influences the decrease in porosity level. Graph below shows that decrease in porosity.

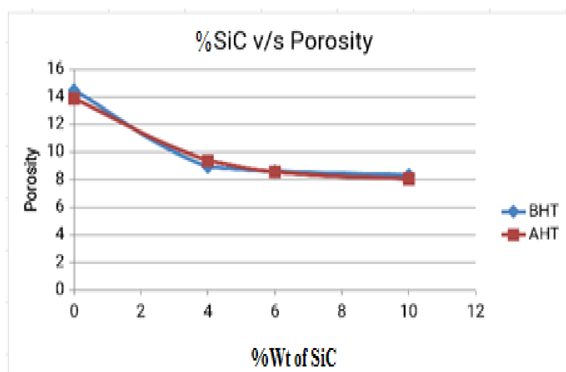


Fig. 4.4 Decrease in porosity with increasing %SiC

4.4 Compression test

The sintered specimens were subjected to compression test. For carrying test “computerized universal testing machine (UTM)" was used. All the tests here were carried at the room temperature. Since the UTM was computerized one it was able to get accurate readings of ultimate compressive strength. All tests were carried with 0.5 mm/min cross head speed. The specimen was placed on base plate and load was applied until the crack was noticed. The reading of load applied to cause a crack in specimen was noted. Same procedure was adapted for all other reinforcement content and compaction loads.

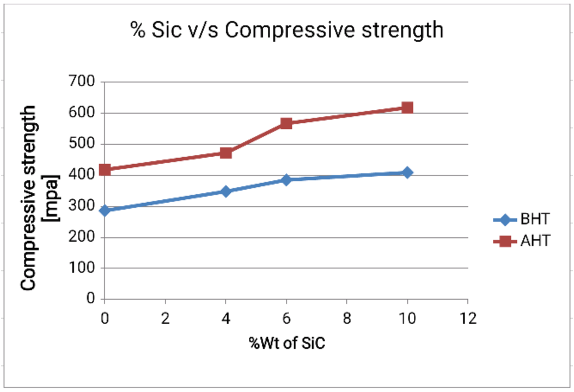


Fig. 4.5 Variation in ultimate compressive strength with varying %SiC

The above graph shows that variation of ultimate compressive strength with varying reinforcement content. With the addition of SiC particles the Compressive strength increased, this is mainly because of AA7075/SiC composite becomes tougher with increasing %SiC content. Since SiC particles are hard and brittle which may cause dispersion hardening of the matrix. SiC particles in matrix resist the motion of dislocations as a resulting composite is hardened. Minimum compressive strength was recorded at 0%SiC content and maximum compressive strength was recorded at 10% SiC content. The above said results are appeared in both the cases namely, before heat treatment [BHT] and after heat treatment [AHT].

5. CONCLUSIONS

An attempt was made to investigate properties of AMC's reinforced with silicon carbide. Powder metallurgy (P/M) technique was employed for composite fabrication. The sintering temperature is kept constant at 600^0C and load also constant of 150KN.

These are the conclusions of this study,

[1] Hardness test results revealed that with the increase in reinforcement content (from 0% to 10%), the hardness of fabricated composite increased when compared to base 7075 alloy matrix.

[2] Study on Density studies revealed there was an increase in Theoretical density (2.81 to 2.85g/cc) and Experimental density with the increase in %SiC content from 0% to 10%.

[3] Compression strength results revealed that ultimate compressive strength increases with increase in %SiC from 0% to 10% SiC.

[4] Porosity decreases with increase in the %SiC from 0% to 10% SiC.

REFERENCES

[1] Sunny chung and Bing H. Hwang "A microstructural study of wear behavior of SiC /Al composites" Institute of Materials Science and Engineering National Sun Yat-Sen University, Kaohsiung, Taiwan

[2] AykutCanakci and TemelVarol "Microstructure and properties of AA7075/Al–SiC composites fabricated using powder metallurgy and hot pressing" Powder Technology 268 (2014) 72–79

[3] C. Garcia-Cordovilla J. Narciso E. Louis "Abrasive wear resistance of aluminum alloy/ceramic particulate composites" Wear 192 (1996) 170-177

[4] Rajesh Kumar Bhushan & Sudhir Kumar & S. Das "Fabrication and characterization of 7075 Al alloy reinforced with SiC particulates" Int J AdvManufTechnol (2013) 65:611–624.

[5] V.Balaji, N.Sateesh, M.ManzoorHussain "Manufacture of Aluminium Metal Matrix Composite (Al7075-SiC) by Stir Casting Technique" Materials Today: Proceedings 2 (2015) 3403 – 3408.

[6] Amal E. Nassar, Eman E. Nassar "Properties of aluminum matrix Nano composites prepared by powder metallurgy processing" Journal of King Saud University– Engineering Sciences (2015).

[7] A. Atrian, G.H. Majzoobi, M.H. Enayati, and H. Bakhtiari "Mechanical and microstructural characterization of Al7075/SiC nano composites fabricated by dynamic compaction.

[8] G.B. Veeresh Kumar, C.S.P. Rao and N. Selvaraj "Mechanical and dry sliding wear behaviour of Al7075 alloy-reinforced with SiC particles"
[9] P.B.Pawar, Abhay A. Utpat "Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite for Spur Gear".
[10] Aswin N Varghese, Pradeep P V "Experimental Investigation of Wear Characteristics on AL/SIC/GR Composite Material"
[11] G. B. Veeresh Kumar, C. S. P. Rao, N. Selvaraj, M. S. Bhagyashekar "Studies on Al6061-SiC and Al7075-Al2O3 Metal Matrix Composites"
[12] Z.Hasan, R.K.Pandey, D.K.Sehgal "Wear Characteristics in Al-SiC Particulate Composites and the Al-Si Piston Alloy"
[13] ahman, H. M. Mamun Al Rashed "Characterization of silicon carbide reinforced aluminum matrix Composites"
[14] Mahmoud M. Tash, S. Alkahtani "Aging and Mechanical Behavior of Be-Treated 7075 Aluminum Alloys"
[15] Adeyemi DayoIsadarea, BolajiAremob, MosobalajeOyebamijiAdeoyec, Oluyemi John Olawalec*, MoshoodDehindeShittu "Effect of Heat Treatment on Some Mechanical Properties of 7075 Aluminium Alloy"

AUTHORS DETAILS

First Author,

Mr. Nishanth Patel G M. has received his M.Tech in Machine Design in 2017 and B.E in Mechanical Engineering in 2014 from VTU Belgaum, Karnataka, India. He is currently working as a Lecturer in the DOS in Mechanical Engineering Department. University BDT College of Engineering, Davanagere, Karnataka, India. His research interests are Composite materials, MMC, Mechanical properties.

Corresponding Author,

Dr. K.G Satish has received M.Tech in Production Engineering and Systems Technology in1997 and Ph.d From Kuvempu University, Karnataka, India in 2010. He is an Assistant Professor in the DOS in Mechanical Engineering Department. University BDT College of Engineering, Davanagere, Karnataka, India. His research interest includes Hybrid Composites, Machinability and Property characterization.