A Study on Wear and Microstructure Properties of AA7075 Reinforced with SiC MMC by Powder Metallurgy Technique

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Abstract:- In this research, the composites of AA7075 reinforced with SiC processed by powder metallurgy technique. The composites are prepared by constant load and constant sintering temperature. Thorough investigations about the microstructure and characterization of Al alloy/SiC composite are carried out that metal matrix composites (MMCs) fabricated as per ASTM standards. The objective of this research work is to fabricate and characterize wear and microstructure properties of AA7075–SiC MMCs. AA7075 alloy is reinforced with Sic for various percentage *4, 6, and 10 Wt.% SiC of size 70 μm.* The results shows that, the effect of heat treatment revealed that there is a considerable increment in the tribological and microstructure properties. Wear test revealed that composites offer superior wear resistance compared to base alloy.

Key words: MMC, AA7075, Reinforcement, SiC, Microstructure and Wear.

1. INTRODUCTION

Today, aluminum-reinforced ceramic particles are in great demand, due to its excellent mechanical properties such as hardness, density, light weight and wear resistance. These Metal matrix composites have been considered to be a very good material for use as structural material in the automotive and aerospace [1, 4]. Some of the manufacturing technology of composite materials, such as aerosol decomposition, liquid metal infiltration, powder metallurgy, die-casting, casting and Mechanical alloying compo. Powder Metallurgy (PM) is a highly developed technology for the manufacture of composite materials; the technology consists of three steps; mixed powder, the elements that powder compressed in one chip at room temperature, heat, and then in a controlled atmosphere furnace, creating a bond between the powder components [2]. The formed out composite material of aluminum alloy has a wide range of interest, due to their high strength and fracture toughness, abrasion resistance, and rigidity. In addition, these compounds are excellent in nature with high temperature applications of ceramic particles [7.8], the ceramic particles enhanced composite materials find application as a cylinder blocks, insert the piston and piston rings, rotors and calipers. It is reported that the of composite increases abrasion, increase the volume fraction of the reinforcements. The abrasion resistance of the compound was found to be much higher than that of the alloy matrix. It is the expansion of the expanded elements of content as a particle of resistance to wear and abrasion resistant, and in order to protect its surface, which means that, as the content increases, the resistance to abrasion will increase.

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. Hence this study is aimed at the fabrication of Al7075–SiC composites by powder metallurgy technique containing various weight percentages of particles and to study their density, microstructure, hardness, mechanical, and wear resistance properties.

2. EXPERIMENTAL DETAILS.

The silicon carbide composite material of powder metallurgy technology, pure aluminum powder with 74 micron was used as a matrix. Silicon Carbide (SIC) particles are used as reinforcement, with a size of 70 microns. Pure aluminum powder mixed with ceramic composite material particles, and is prepared to work with percentage of reinforcement as (0, 4, 6 & 10%). 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. The Al/SiC composites cylindrical rods were cut in the transverse directions for micro structural examinations using optical and scanning electron microscopes (SEM). Wear tests (dry sliding) were conducted on different grades of emery paper namely 320, 400, and 800 pasted on the surface of the disc of "pin-on-disc wear tester" for 0%SiC, 4%SiC, 6%SiC, and 10%SiC. EN31 is counter disc material. Before initiating the test, the surface of disc is to be cleaned thoroughly with acetone and paste the emery paper of required grit size, then places the specimen in the holder in an accurate manner such that the mating surfaces of specimen and disc should maintain zero clearance hence the wear takes place throughout the specimens.

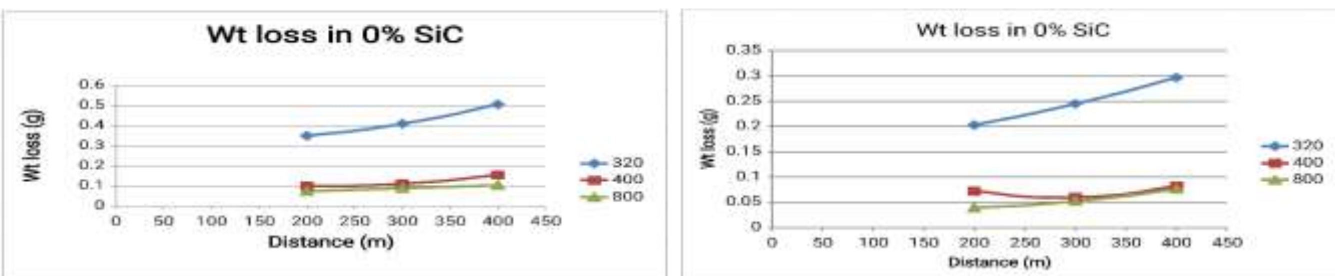
Table 2.1 Chemical composition of AA7075

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

3. RESULTS AND DISCUSSIONS

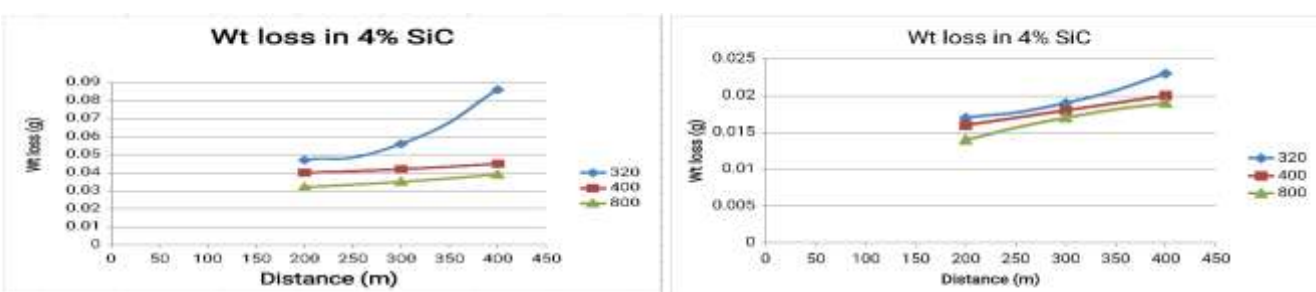
3.1 Wear test

Tribological experiments to learn about the behavior of the wear, AA 7075/Silicon Carbide composite is tested on pin on disc machine. Wear testing has been going on for 3 different grades of sand paper to paste the file on disk in a wear testing machine. The composite material can be calculated by measuring the initial and final weight of composite materials. Here, Speed and load are maintained constant and testing are provided by a varying of different slide away as a 200m, 300m and 400m.



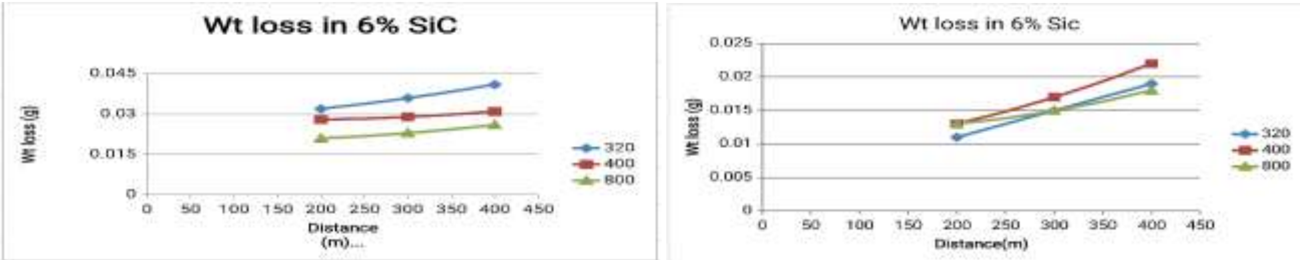
[BHT] [AHT]

Figure 3.1 Weight loss in 0% SiC varying with sliding distance



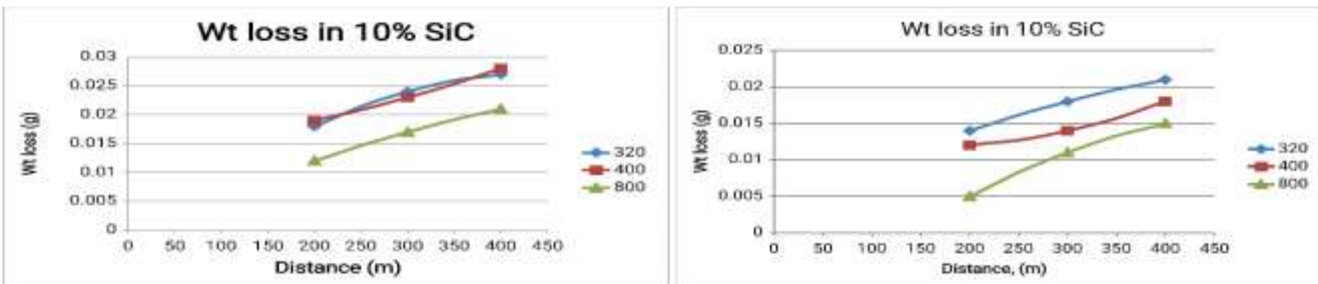
[BHT] [AHT]

Figure 3.2 Weight loss in 4% SiC varying with sliding distance



[BHT] [AHT]

Figure 3.3 Weight loss in 6% SiC varying with sliding distance

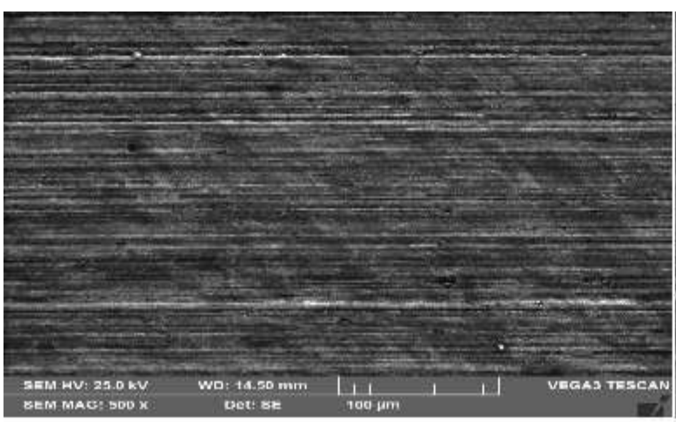


[BHT] [AHT]

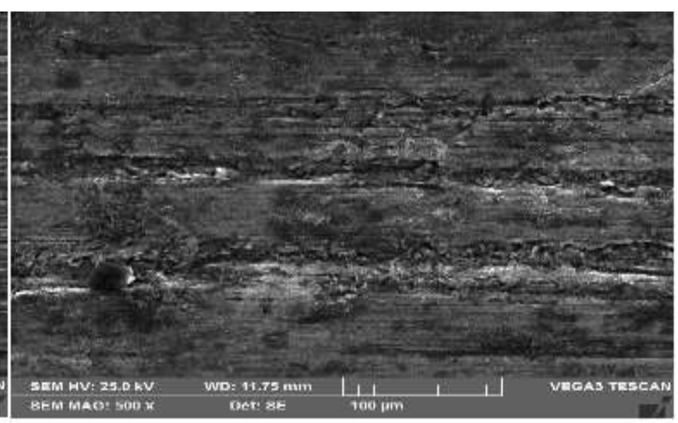
Figure 3.4 Weight loss in 10% SiC varying with sliding distance

From the results and curves, wear tests have shown that there is a gradual increase in the weight loss of the worn specimens, by increasing the distance from the slide. The wear tests on the different grades of sand paper for 320, 400, and 800. In this case, the 320 sand paper with a high rate of weight loss than the 400 and 800 grit paper for the same distance, it demonstrates that weight loss depends upon the material of the mating surface roughness. Here the heat treatment process [t6] specimens, will mitigate the loss of materials, it can be done by comparing the weight loss analysis graph of the heat treated "before" and "after" heat treatment. From the wear test results, we can conclude that the increase in the silicon carbide with AA7075 reduce the rate of weight loss.

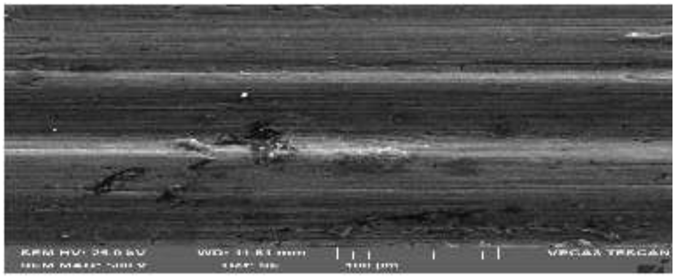
3.2 MICROSTRUCTURE OF WEAR TEST SPECIMENS.



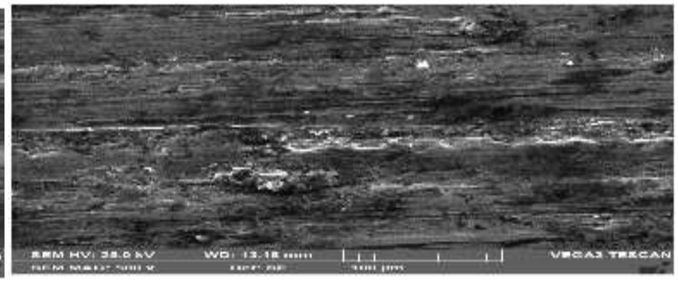
AA7075+0%SiC



AA7075+4%SiC



AA7075+6%SiC



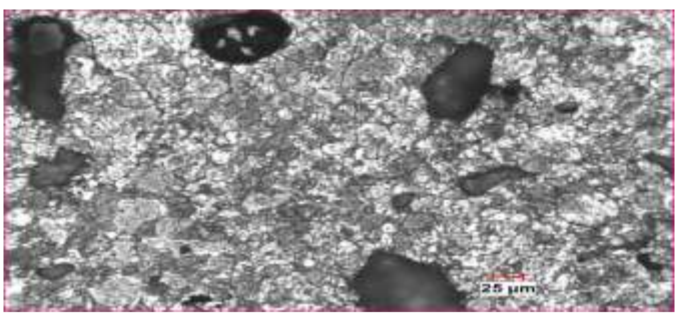
AA7075+10%SiC

Figure 3.5 Microstructure images of wear surfaces

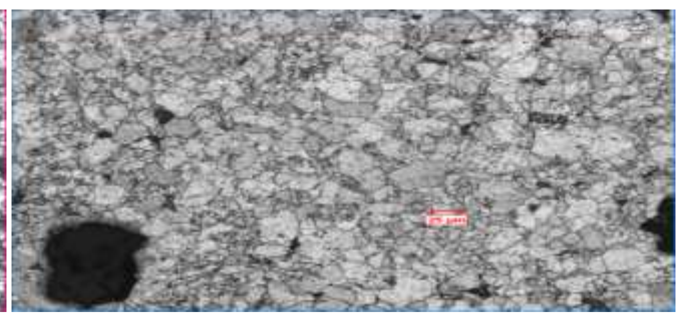
From SEM images shown in figure 3.5, it is understood that the particles broken off the surface during wear test are adhered to the surface again. Besides that, local material losses occurred on the surface can be seen. The formation of micro cracks is observed on the surface under the influence of deformation in addition to the material losses. During wear test it was identified that micro cracks occurred with the effect of increasing temperature and deformation on sample contact surface. When the worn surfaces are generally examined adhesive and abrasive mechanisms are observed to be dominant damage type.

3.3 MICROSTRUCTURE OF SPECIMENS USING OPTICAL MICROSCOPE.

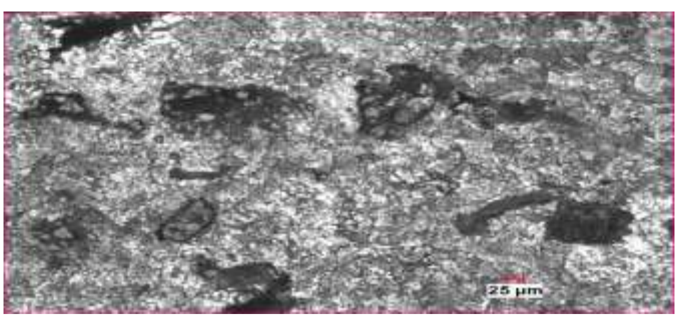
The images obtained from the microscope reveled that there is a uniform distribution of reinforcement in the base alloy matrix. And the images of microstructures show that there is a decrease in the porosity in heat treated specimens than in the as sintered specimens. Figure 3.6 shows the microstructure images of the composite specimens in both as sintered and heat treated conditions.



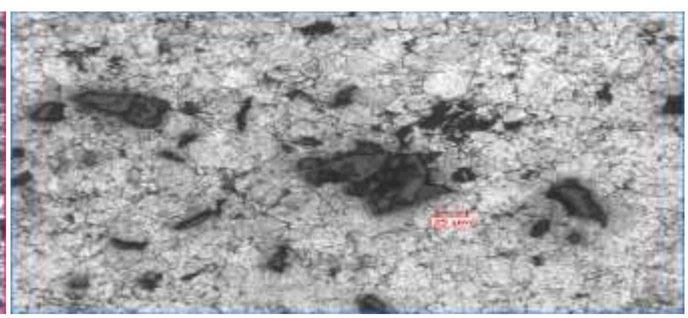
(a) AA7075+0%SiC BHT[200x]



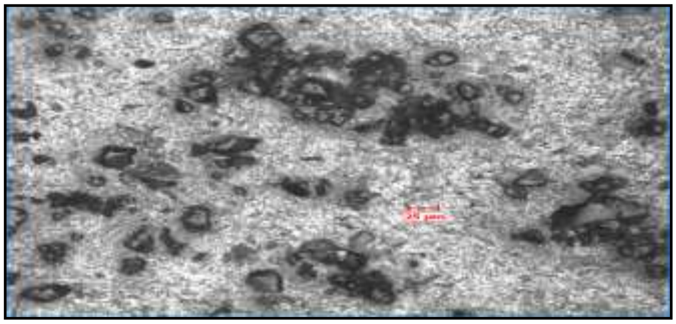
(b) AA7075+0%SiC AHT[200x]



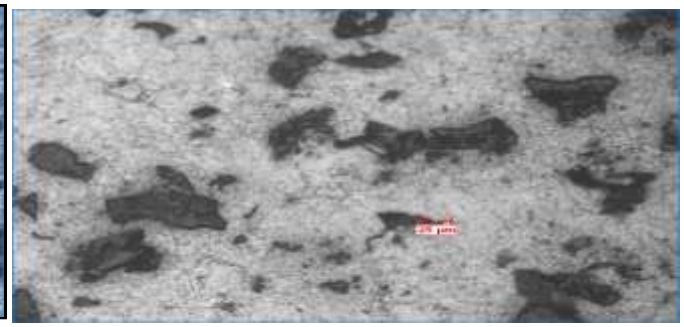
[C]AA7075+0%SiC BHT[200x]



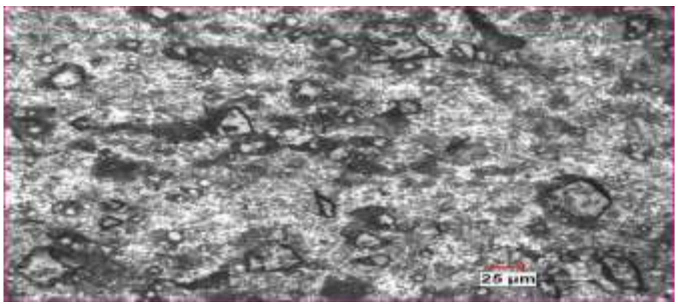
(d) AA7075+0%SiC AHT[200x]



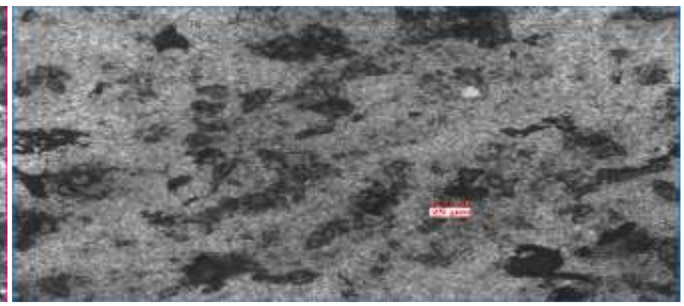
(e) AA7075+6%SiC BHT [200x]



(f) AA7075+6%SiC AHT [200x]



(g) AA7075+10%SiC BHT [200x]



(h) AA7075+10%SiC AHT [200x]

Figure 3.6 (a-h) Microstructure images of specimens using Optical Microscope

3.4 EDAX RESULTS

Energy dispersive X-ray spectroscopy (EDS) is a powerful technology that is ideal for exposed what elements and chemical compounds of the inference -- also appears in a specific example. Basically, the EDS contains features that will detect X-ray, each of these elements, the blowing up of a sample, the use of high-energy electron beam in an electron microscope. This process is known as X-ray mapping, information elements of a sample can then be overlaid on top of the magnified image of the Sample.

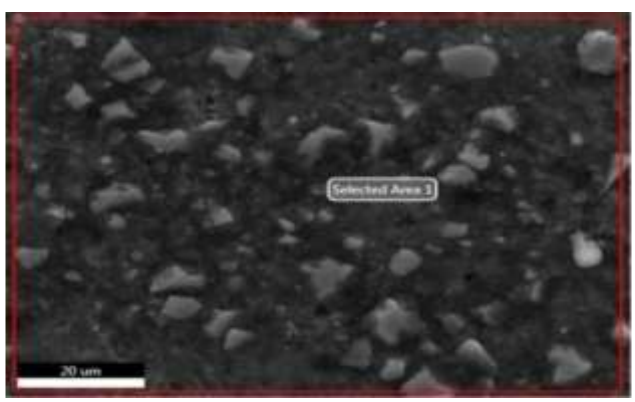


Figure 3.7 (a)

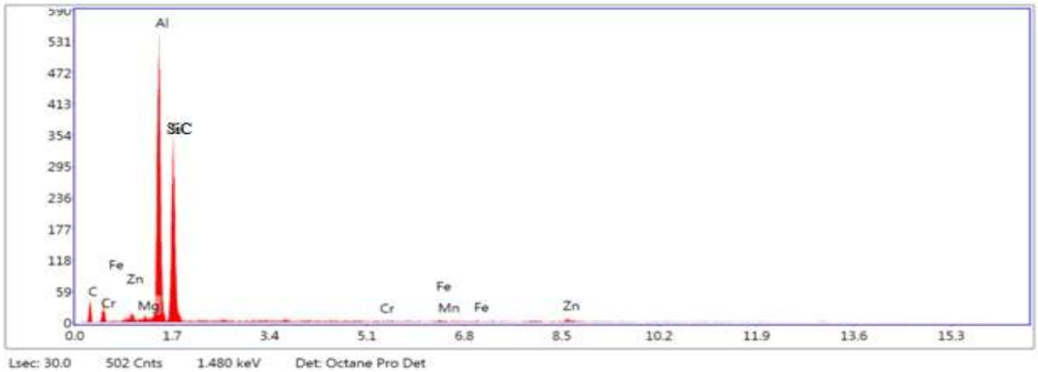
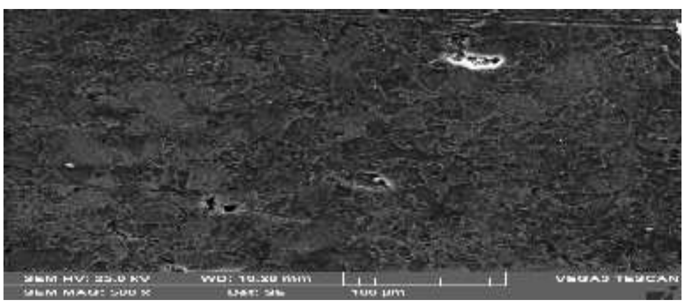


Figure 3.7 (b)

EDAX is useful for the determination of the morphology of a material and the occurrence and distribution of compositional elements within it. EDAX analysis showed that these agglomerates contained major amounts of the elements Al and SiC, with trace amounts of Fe, Cu, Cr, Mg and Mn. The SEM image and EDAX are shown in figure 3.7(a) and 3.7(b) respectively for AA7075 + 10% SiC.

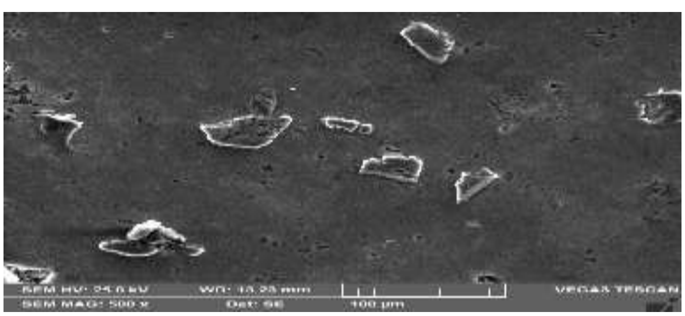
3.5 MICROSTRUCTURE OF SPECIMENS USING SEM.

Figure 3.8(a-h) shows 0%, 4%, 6% and 10% SiC particles in AA7075 matrix alloy. SEM analysis revealed that there was near to uniform distribution of SiC particles in AA7075 matrix alloy. When the microstructure images are compared with as sintered and heat treated conditions the level of porosity is decreased in heat treated specimens. It can be seen in the images below.

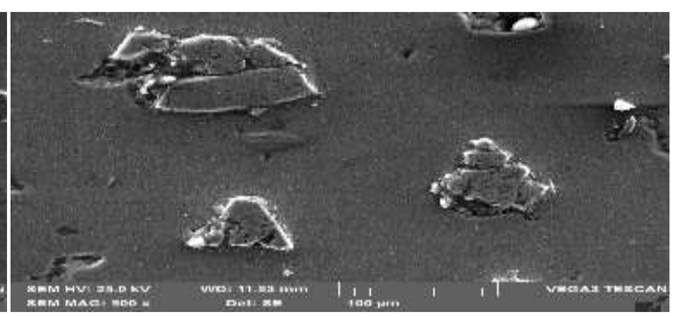


(a) AA7075+0%SiC BHT

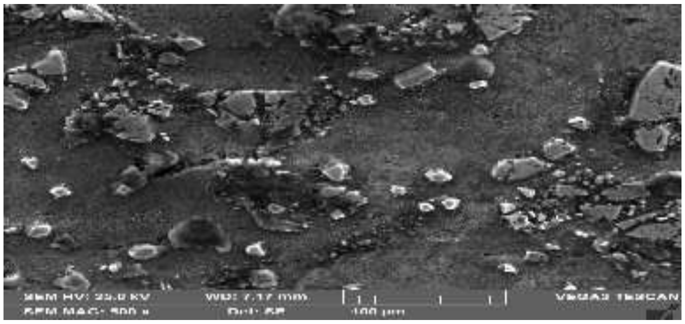
(b) AA7075+0%SiC AHT



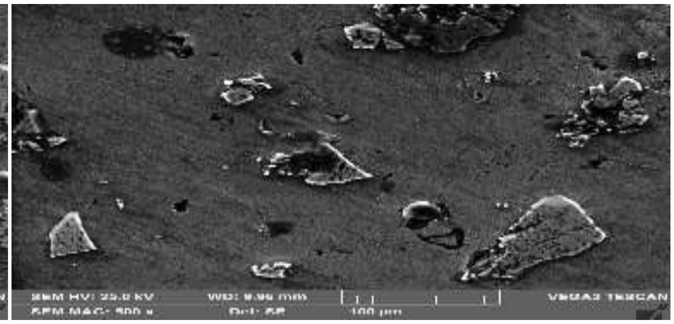
(c) AA7075+4%SiC BHT



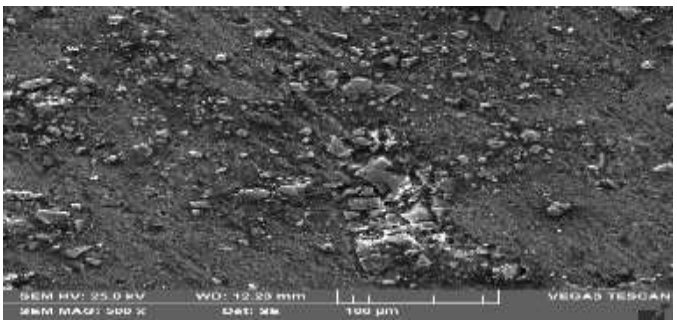
(d) AA7075+4%SiC AHT



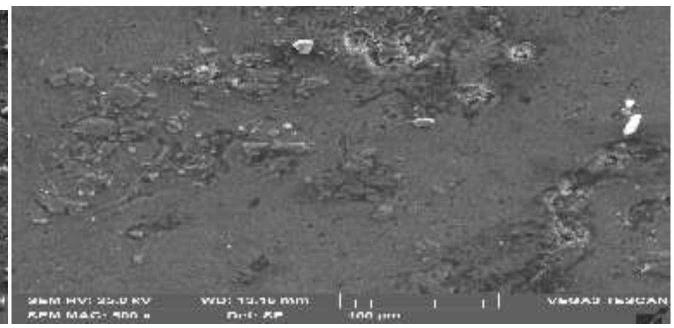
(e)AA7075+6% SiC BHT `



(f) AA7075+6% SiC AHT



(g) AA7075+10% SiC BHT



(h) AA7075+10% SiC AHT

Figure 3.8 (a-h) Microstructure images of composite specimens from SEM

4. CONCLUSIONS

- Wear results showed that addition of wt% SiC increased wear resistance significantly. Also, wear test on different grades of emery papers revealed that rough surfaces lead to a large amount of weight loss than smooth surfaces. Hence increment in the content of reinforcement and providing smooth mating surfaces leads to improved wear resistance.
- Heat treatment to the composite specimens increases the overall strength of the composites when compared to as sintered specimens. Overall we can conclude that AA7075/SiC showcase better tribological properties than conventional metals.
- The images obtained from the Optical microscope reveled that there is a uniform distribution of reinforcement in the base alloy matrix.
- EDAX analysis showed that these agglomerates contained major amounts of the elements Al and SiC, with trace amounts of Fe, Cu, Cr, Mg and Mn.
- SEM analysis shows that there was near to uniform distribution of SiC particles in AA7075 matrix alloy.
- From microstructure images there is a gradual decrease in the percentage of porosity in heat treated specimens than same in the as sintered specimens.

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