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The Effect of Heat Treatment on the Dry Sliding Wear Behaviour of Grain Refined and Modified Al-7Si-0.45Mg Reinforced with B_4C

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ABSTRACT: In this research paper, Grain refined and modified Al-7Si-0.45Mg cast through liquid metallurgy and reinforced with B_4C was heat treated (T_6). The heat treatment consists of solutionising alloy/composites at 540°C for 9 hours, quenching in water at 70°C and ageing for 5 hours at 180°C. The wear studies were carried out on both heat treated and untreated alloy/composites as per ASTM standards. A quantum enhancement in wear resistance was observed in heat treated alloy/composites compared to alloys/composites without heat treatment. The improvement in wear resistance may be attributed to the change in microstructure due to Grain refinement and modification, uniform distribution of hard particles of Boron Carbide in the matrix and spherodisation of Silicon particles due to Heat treatment.

KEYWORDS: Heat Treatment, Boron Carbide, Dry sliding Wear.

I. INTRODUCTION

Aluminium-Silicon alloys and their composites are known for their excellent combination of characteristics namely, low density, excellent castability, formability, good mechanical properties, cryogenic properties and good machinability. Aluminium and its alloys have wide range of applications particularly in automobile, aerospace and marine sectors on account of their light weight, good surface finish, resistance to wear and corrosion high strength-to-weight ratio. As components with complex geometriescan be produced cost effectively, they find enhanced utility particularly in Aerospace sectors. Reduction in weight due to low density leads to increased load capacity, increased mileage, reduced pollution of environment and higher profits to the manufacturers. The low melting temperature, ease of handling, easy formability, has led to increased demand for aluminium alloy/composites components.

II. MATERIALS

Grain refined and modified Al-7Si-0.45Mg were cast in pre- heated permanent mold in the form of cylindrical rods of diameter 25 mm and length 300 mm. They were further heat treated (T6).Test specimens for hardness and wear were obtained by machining the rods and tested as per ASTM standards.

III. METHODOLOGY

a. Microstructure

Microstructure specimens were prepared as per standard metallurgical procedures, etched in etchant prepared using 90 ml water, 4 ml HF, 4 ml H_2S0_4 and 2g C_r0_3 and photographed using Optical Microscope.

b. Hardness test

The hardness tests were conducted as per ASTM E10 norms using Rockwell Hardness tester. The tests were performed at randomly selected points on the surface of the samples by providing sufficient space between indentations and distance from the edge of the specimen.

The hardness values of as-cast Al-7Si-0.45Mg alloy grain refined and modified, reinforced with B_4C and heat treated composites are shown in Table 1.

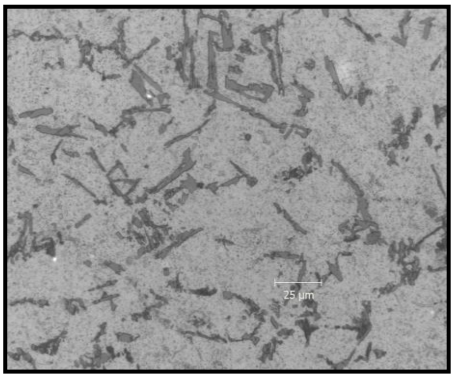
c. Wear test

Dry sliding Wear tests were conducted at room temperature using a Pin-on-Disc apparatus at a sliding velocity of 1m/s for varied sliding loads, distances.

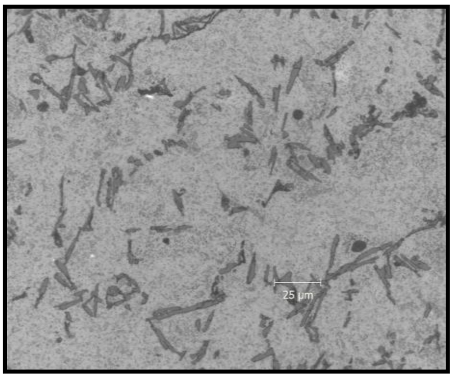
The wear rates were evaluated using weight loss method by dividing the loss of weight of specimen by the sliding distance covered for a known sliding time. The loss of weight was measured using an Electronic weighing machine to the accuracy of 0.0001gm. The wear rate was based on the average value of 5 test results. The worn surfaces were taken and analysed for type of wear.

IV. RESULTS AND DISCUSSION

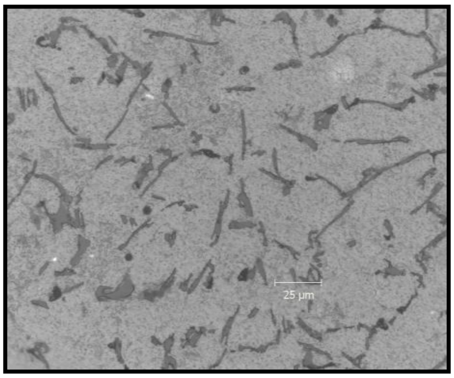
a. Microstructure



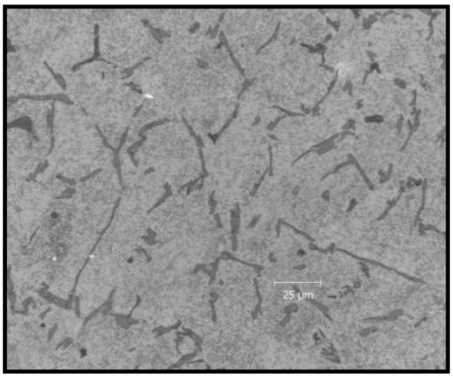
1 (a)



1(b)



1(c)



1(d)

Plate 1: Microstructures of A_{GRM} (Grain Refined and Modified Al-7Si-0.45Mg alloy) reinforced with 1%, 3%, 5% and 7% B_4C

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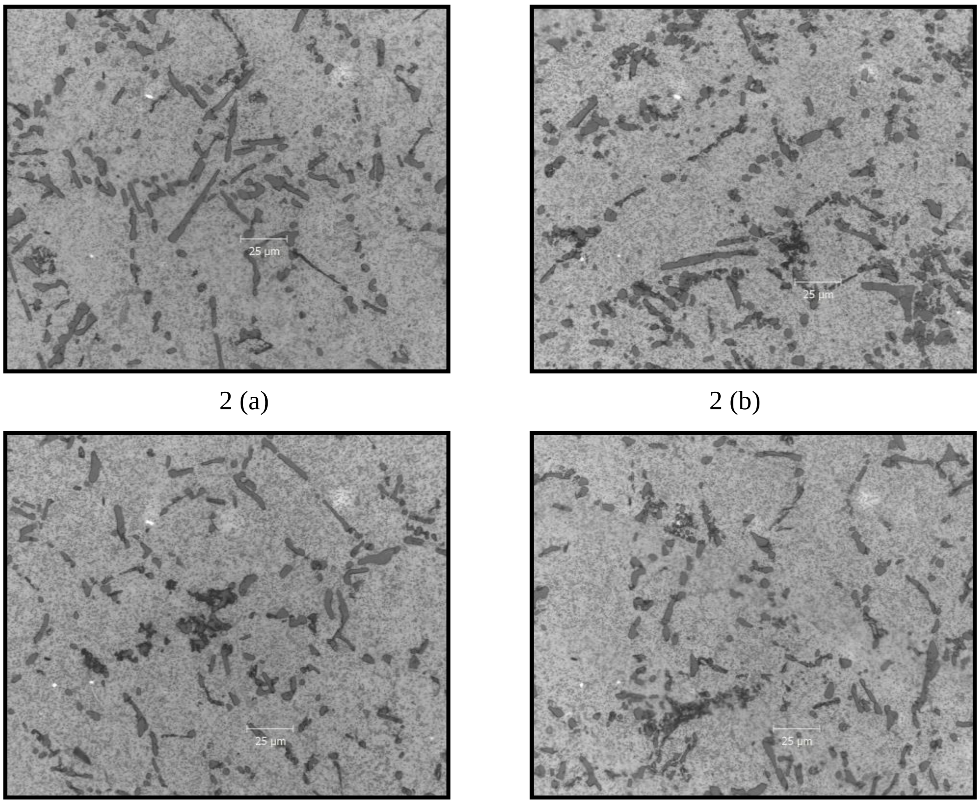
Plate 1(a), 1(b), 1(c) and 1(d) show the microstructure of A_{GRM} reinforced with 1%, 3%, 5% and 7% B_4C indicating uniform distribution of B_4C in the matrix



2 (a) 2 (b) 2 (c) 2 (d)

Plate 2: Microstructures of A_{GRM} reinforced with 1%, 3%, 5% and 7% B_4C (Heat Treated)

Plate 2(a), 2(b), 2(c) and 2(d) show the microstructure of A_{GRM} reinforced with 1%, 3%, 5% and 7% B_4C (Heat Treated) indicating spherodisation of Si and uniform distribution of B_4C in the matrix.

b. Hardness

Table 1: Table of Hardness

Sl No	Alloys/Composite	Designation	Hardness, R_B
1	A_{GRM} with 1% B_4C	A1	63
2	A_{GRM} with 3% B_4C	A3	78
3	A_{GRM} with 5% B_4C	A5	74
4	A_{GRM} with 7% B_4C	A7	72
5	Heat Treated A_{GRM} with 1% B_4C	A1-H	92
6	Heat Treated A_{GRM} with 3% B_4C	A3-H	91
7	Heat Treated A_{GRM} with 5% B_4C	A5-H	83
8	Heat Treated A_{GRM} with 7% B_4C	A7-H	89

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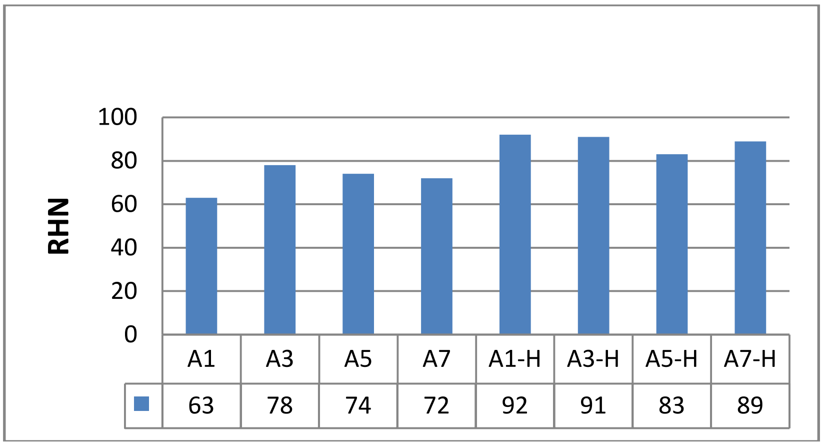

Fig 1: Hardness values of A1, A3, A5, A7 and A1H, A3H, A5H and A7H

Fig 1shows the Hardness values of A1 to A7 where hardness increases with Heat treatment for all alloys reinforced with B_4C with A_1-H and A_3-H indicating maximum values of hardness. The increased hardness may be attributed to the spherodisation of Si particles, presence of B_4C and its uniform distribution in the matrix with composites of A_{GRM} with 3% B_4C with and without Heat Treatment resulting in maximum hardness

c. Wear test

i. Effect of sliding distance and wear rate

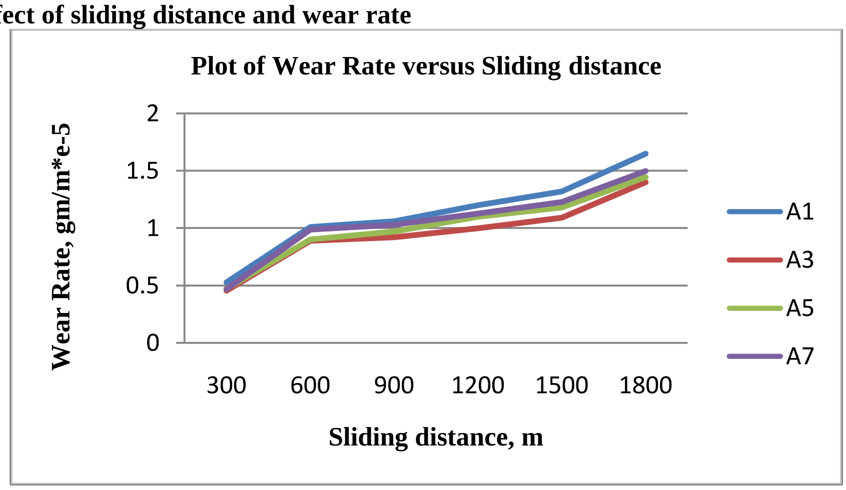

Fig 2: The effect of sliding distance on the wear rate of gravtiy cast A_{GRM} reinforced with B_4C

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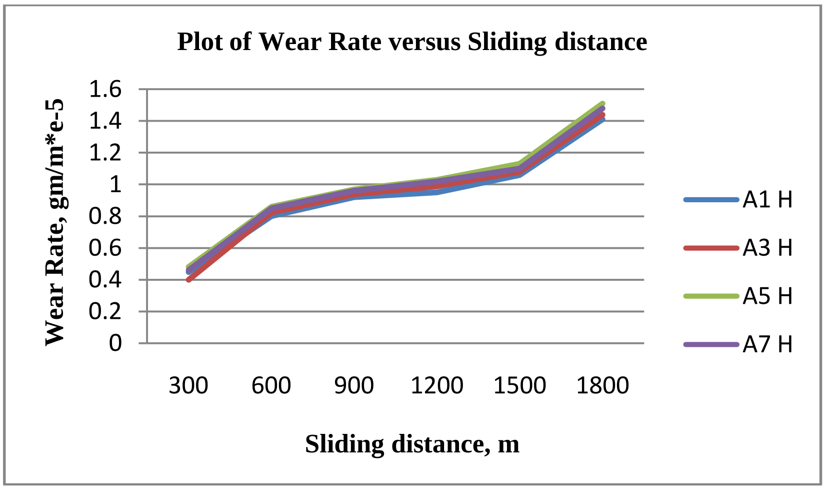

Fig 3: The effect of sliding distance on the wear rate of gravtiy cast A_{GRM} reinforced with B_4C (Heat Treated)

Fig 2 and Fig 3 shows the plot of wear rate versus sliding distance of both A1 to A7 both in as cast and heat treated condition with A3 and A3H indicating maximum wear resistance. Beyond addition of B_4C increased hardness upto 3% beyond which no increase in hardness is observed. This may be attributed to the decreased solubility of B_4C in matrix.

ii. Effect of load on wear rate

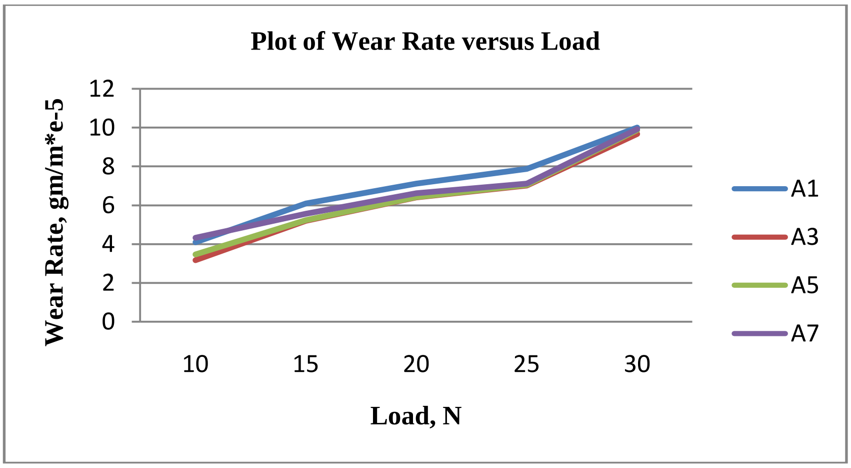

Fig 4: The effect of load on wear rate of gravity cast A_{GRM} reinforced with B_4C

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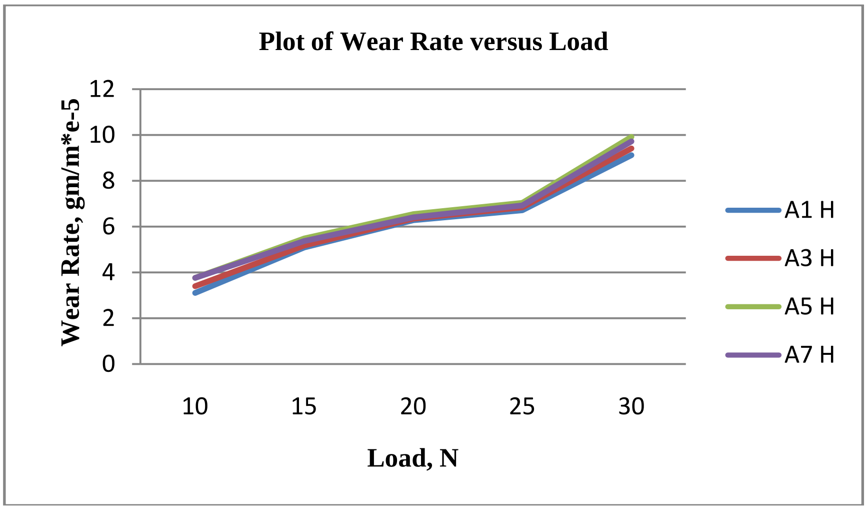
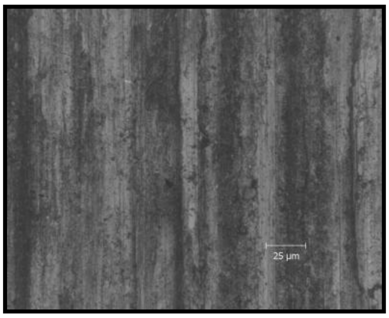


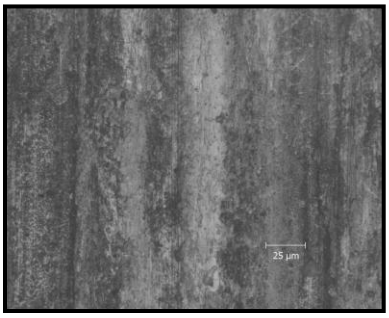
Fig 5: The effect of load on wear rate of gravity cast A_{GRM} reinforced with B_4C (Heat Treated)

Fig 4 and Fig 5 show the plot of Wear rate versus Load for as cast A_{GRM} reinforced with B_4C and heat treated A_{GRM} where the wear rate increases with load. Beyond 25N load, a steep rise in wear rate is observed in both as cast and heat treated composites. This may be attributed to the softening of pin material due to excessive heat produced at the pin disc interface.

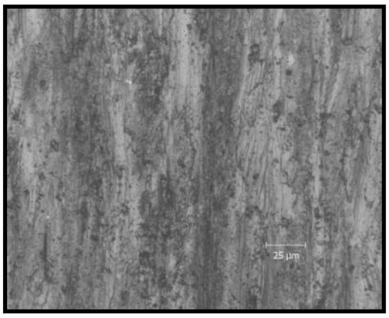
d. Light optical micrographs of worn surfaces



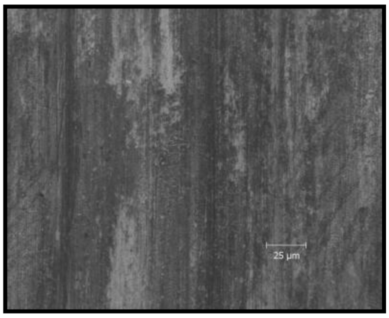
3 (a)



3(b)



3(c)



3(d)

Plate 3 shows theOptical micrographs of Al-7Si-0.45Mg alloy reinforced with 1, 3, 5, and 7% B_4C (untreated)

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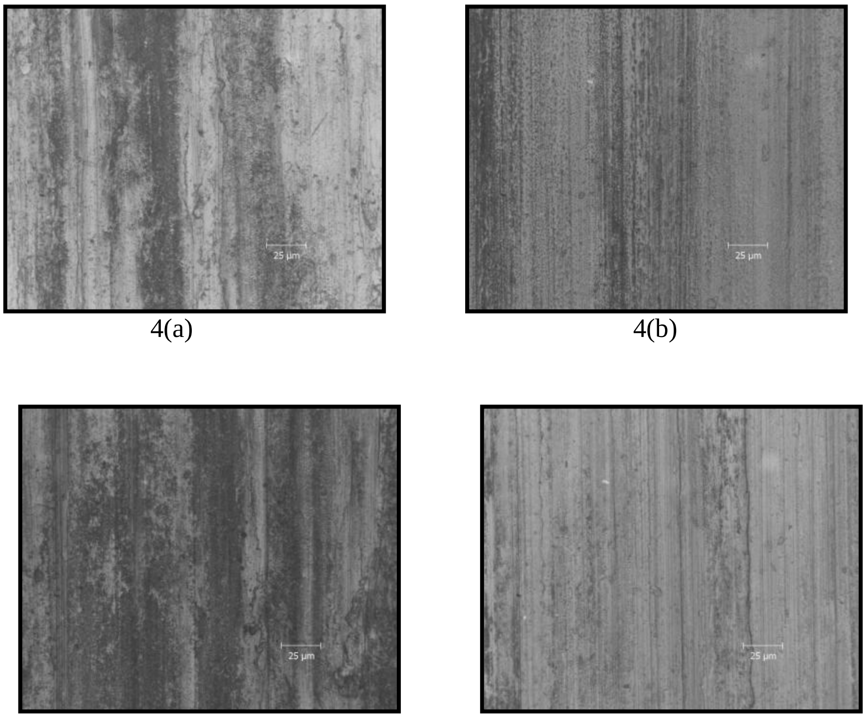

4(a) 4(b) 4(c) 4(d)

Plate 4: Optical micrographs of worn surfaces of A_{GRM} reinforced with 1%, 3%, 5% and 7% B_4C (Heat Treated)

Plate 3 (untreated composite) and Plate 4 (heat treated composite) show the Light Optical micrographs of worn surfaces of A_{GRM} reinforced with 1%, 3%, 5% and 7% B_4C respectively with A3 and A3H showing shining worn surfaces, indicating hard surfaces with least wear in comparison with A1, A5, A7 and A1H, A3H, A7H (for both as cast and heat treated condition)

V. CONCLUSION

1. Sound and dense castings with uniform distribution of B4C in the matrix were obtained successfully.
2. The hardness and hence the wear resistance increased with addition of B4C where, composite with 3% B4C resulted in maximum hardness.
3. The wear rate increased with increased B4C (upto 3%) for parameters load and sliding distance. Heat treated composites offered better resistance to wear compared to untreated composites.

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