

# The Effect on the Microstructure, Mechanical Properties and Dry Sliding Wear Behaviour of A-356 Alloy by Adding the Grainrefiner Al-5Ti-1b in Varied Weight Percentage

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**ABSTRACT:** In this study A-356, alloys were reinforced with varied percentage of grain refiners Al-5Ti-1B by gravity casting route, unheat treated and tested for microstructure, mechanical properties. Wear tests were conducted using pin-on disc apparatus at a constant sliding velocity of 1 m/s and pressure of 0.35 Mpa. Microstructure revealed uniform distribution of reinforcement in the matrix resulting in improved mechanical properties and wear resistance compared to un-reinforced material. The grain refiner reinforced alloys were found to have improvement in mechanical properties and wear resistance compared to reinforced alloy which may be attributed to the uniform distribution and improved bonding of reinforcement in the matrix.

**KEY WORDS:** Composites MMC's Microstructure, Mechanical behaviour.

## I. INTRODUCTION

Aluminium silicon alloys possess light weight, high specific strength and good heat transfer ability which makes them suitable material to replace components made of ferrous alloys Al-Si alloys are widely used in all types of IC engines such as cylinder blocks, cylinder heads and piston. They find application in aircraft pump parts, aircraft structure and control parts, automotive transmission, aircraft fittings, water cooled cylinder blocks and nuclear energy installation. Both hypo-eutectic and hyper-eutectic alloys can be used as useful engine block materials on account of their adequate resistance of high strength to weight ratio. There are quite large numbers of studies made on the mechanical behaviour of Al-Si alloys attempts are made to increase the strength of Al-Si-Mg by various manufacturing processes heat treated, reinforcement of hard and soft reinforcements.

In this paper, an attempt is made to study the effect of adding grain refiner to the metal on microstructure, mechanical properties and dry sliding wear behaviour of grain refiner Al-5Ti-1B reinforced A-356.

## II. EXPERIMENTAL DETAILS

### A. MATERIALS

A-356 alloys were reinforced with grain refiners Al-5Ti-1B and were cast using gravity casting route in the form of cylindrical bars of length 300mm and diameter 25mm.

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**Table I**

Chemical composition of A-356

Element	Weight %
Si	7.25
Mg	0.4
Fe	0.086
Cu	0.010
Mn	0.018
Ni	0.025
Zn	0.005
Others	0.028

**Table II**

Designation of grain refiners added to the alloys

Sl no	Alloy/composite	Designation
1	A 356	0GR
2	A 356+0.1% Al-5Ti-1B	0.1 GR
3	A 356+0.3% Al-5Ti-1B	0.3 GR
4	A-356+0.5% Al-5Ti-1B	0.5 GR

**Table I** and **Table II** shows the chemical composition of A-356 and designation of grain refineries added to the alloys.

## III. RESULTS AND DISCUSSION

### A. Micro structural Study

The samples for microstructure examination were prepared by following standard metallurgical procedure, etched in etchant prepared using 90 ml water 4ml of H<sub>2</sub>SO<sub>4</sub> and CrO<sub>3</sub> and were examined using optical microscope.

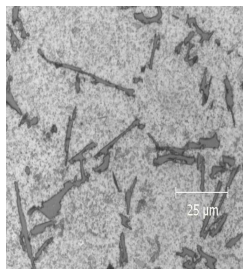


Fig.2.1A356-0GR

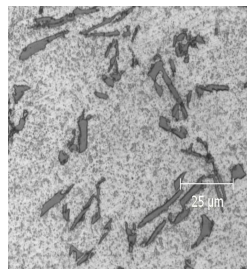


Fig.2.2 0.1GR

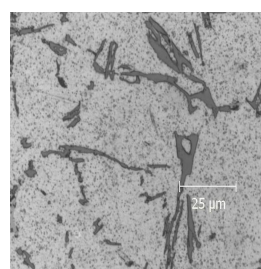


Fig.2.30.3 GR

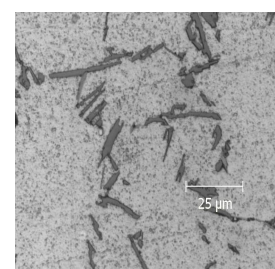


Fig.2.4 0.5 GR

Figure 2.1 to 2.4 shows the microstructures of unheat treated A-356 and its composites depicting uniform distribution of grain refiner (Al-5Ti-1B).

### B. HARDNESS RESULTS

The hardness tests were conducted as per ASTM E8 norms using Brinell hardness tester. Tests were performed at randomly selected points on the surface by maintaining sufficient spacing between indentations and distance from the edge of the specimen.

**Table III**  
Alloy designation vs Hardness

Alloy designation	Hardness (BHN)
0GR	41.53875
0.1 GR	65.63133
0.3 GR	56.82166
0.5 GR	60.69672

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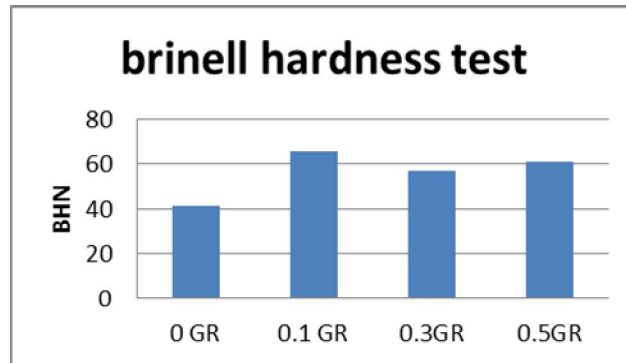


Fig 3.1 Percentage of Graphite vs BHN

**Table III** shows the hardness value of A-356 alloy and its composites. The hardness of 0.1 GR (0.1% grain refiner) is found to be 65.63 compared to A-356 0GR alloy with hardness 41.53 indicating 58% increase in hardness. 0.3 GR (0.3% grain refiners) has the value of 56.82 indicating 36.79% increase in hardness and 0.5 GR indicating 60.69 has 46.12% increase in hardness when compared to A-356 0GR.

### C. TENSILE RESULTS



Fig 4.1

Table IV  
Ultimate Tensile Strength and Ductility.

Alloy designation	UTS in Mpa	% elongation
A-356	133.44	1.8
0.1GR	153.16	5.56
0.3GR	166.13	2.48
0.5GR	171.32	4.92

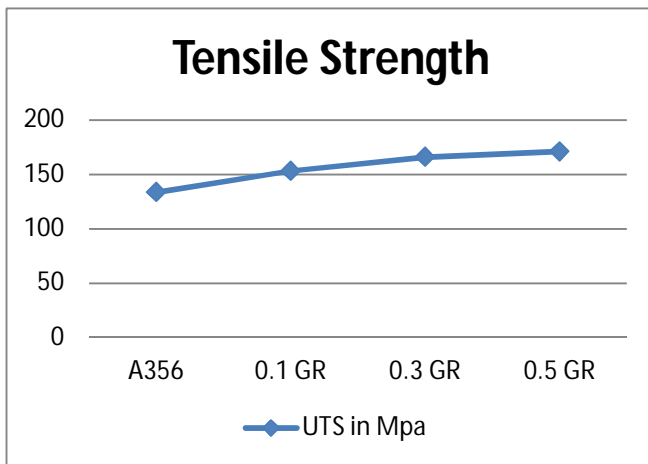


Fig 4.2 Ultimate tensile Strength

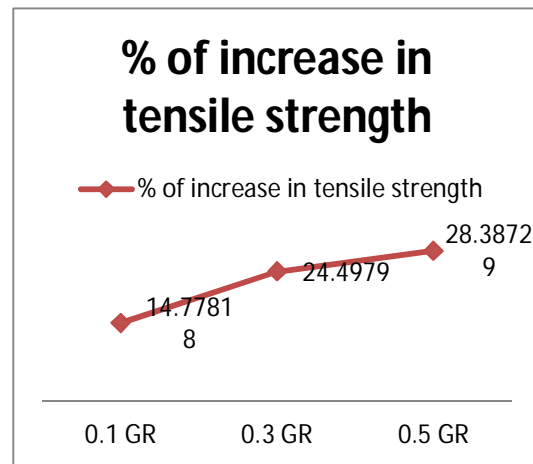


Fig 4.3 Percentage increase in tensile strength

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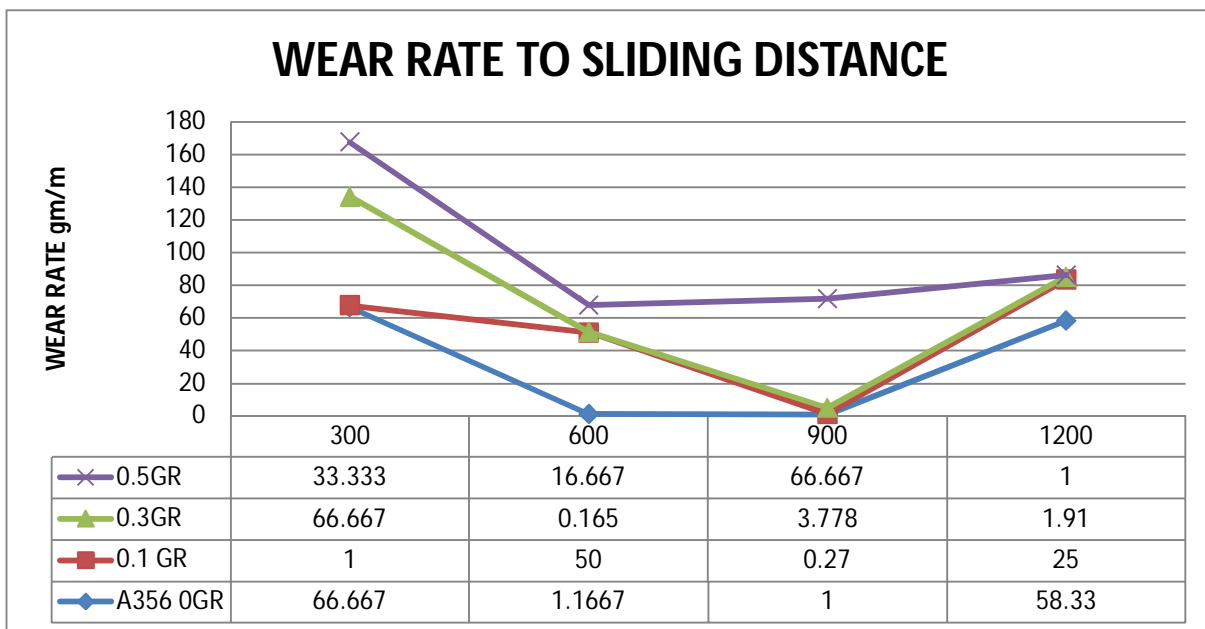
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**Table IV** shows plot of UTS and % elongation values of A-356 and its composites. It is clear from the table that UTS and ductility increases with adding of grain refiners for all composites such as 0.1 GR 0.3GR 0.5GR compared to A-356 0GR. 0.5 GR has the highest UTS compared to all other compositions. UTS of 0.1GR has 153.16Mpa showing 14.7781% increase of tensile strength. 0.3GR has 166.16Mpa showing 24.4979% increase of tensile strength. 0.5GR has 171.32Mpa showing 28.38729% increase in tensile strength. The elongation of 0.1GR is 14.77% which is 208.889% higher than A-356 0GR, as like the same the composites 0.3GR and 0.5GR are also shown improved ductility of 37.778% and 173.333% respectively higher than A-356 0GR.

### D: WEAR TEST

**Table V** : Alloy designation vs wear rate

Alloy designation	Wear rate to the sliding distance $10^{-5}$ gm/m			
Sliding distance	300m	600m	900m	1200m
A-356 0GR	66.667	1.1667	1	58.333
0.1GR	1	50	0.27	25
0.3GR	66.667	0.165	3.778	1.9167
0.5GR	33.33	16.667	66.667	1



**Fig 5.1** wear rate of as-cast alloy and its composites.

Fig 5.1 shows the plot of wear rate v/s sliding distance of A-356 and its components. A-356 0GR has wear rate of  $33.333 \times 10^{-5}$  gm/m where as 0.1GR has wear rate  $16.667 \times 10^{-5}$  showing 49.99% reduction in wear rate. This reduction in wear rate may be attributed to the increase achieved due to uniform distribution and bonding of the grain refiners in the composite. Composites 0.3GR and 0.5GR have wear rate  $66.667 \times 10^{-5}$  and  $1 \times 10^{-5}$  gm/m respectively. The decreased wear rate of 0.5GR may be attributed to higher percentage of grain refiner Al-5Ti-1B in the composites which act as toughening agent in not allowing the component to wear readily.

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## IV. CONCLUSION

Microstructure indicates uniform distribution of ceramics in the matrix with good bonding of the particulates. The composite with 0.1% grain refiner has the highest hardness. Composites with 0.5% grain refiner has the highest UTS the composites with 0.5% has lesser wear rate when compared to A356 and its other composites.

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