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THE EFFECT OF HEAT TREATMENT ON THE MICROSTRUCTURE, MECHANICAL PROPERTIES AND DRY SLIDING WEAR BEHAVIOUR OF A356.O REINFORCED WITH GRAPHITE

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ABSTRACT: In this study, A356.0 alloys were reinforced with varied percentage of Graphite by liquid metallurgy route, heat treated (T6) and tested for microstructure, mechanical properties. Wear tests were conducted using Pin-on-Disc apparatus at a constant sliding velocity of 1m/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 ceramic reinforced alloys were found to have improvement in mechanical properties and wear resistance compared to unreinforced alloy which may be attributed to the uniform distribution and improved bonding of reinforcement in the matrix.

Keywords: Composites, MMC's, Microstructure, Mechanical behaviour, Heat treatment.

I. INTRODUCTION

Aluminium-Silicon alloys possess light weight, high specific strength and good heat transfer ability which make 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 Pistons. They find applications in aircraft pump parts, aircraft structure and control parts, automotive transmission, aircraft fittings, water cooled cylinder blocks and nuclear energy installations. Both hypo-eutectic and hyper-eutectic alloys can be used as useful engine block materials on account of their adequate resistance and high strength to weight ratio. There are quite large numbers of studies made on the mechanical behavior of Al-Si alloys. Attempts are made to increase the strength of Al-Si-Mg by various manufacturing processes, heat treatment, reinforcement of hard and soft reinforcements etc.
In this paper, an attempt is made to study the effect of heat treatment on microstructure, mechanical properties and dry sliding wear behavior of Graphite reinforced A356.0.

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II. MATERIALS

A356.0 alloys were reinforced with Graphite and were cast using liquid metallurgy route in the form of cylindrical bars of length 300mm and diameter 25mm. They were heat treated (T6).

Table I

CHEMICAL COMPOSITION OF A356.0

Element	Weight %
Si	7.25
Mg	0.45
Fe	0.086
Cu	0.010
Mn	0.018
Ni	0.025
Zinc	0.005
Others	0.028
Al	Balance

Table II

DESIGNATION OF GRAPHITE REINFORCED ALLOYS

Sl No	Alloy/Composite	Designation
1	A356.0	As cast A356.0
2	A356.0 +3% G	3G
3	A356.0+5% G	5G
4	A356.0+10% G	10G

III. TESTING

A: Microstructure

The samples for microstructure examination were prepared by following standard metallurgical procedures, etched in etchant prepared using 90 ml water, 4ml of HF, 4ml H2So4 and 2g CrO3 and were examined using Optical Microscope.

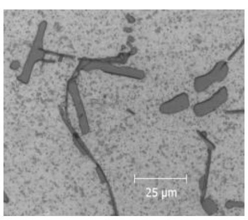

Fig.2.1
Microstructure of A356.0

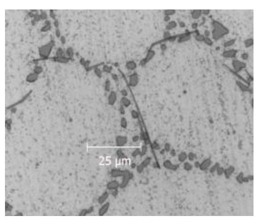

Fig. 2.2
Microstructure of 3G

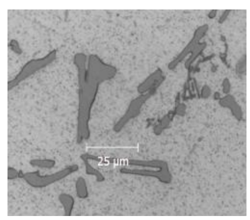

Fig. 2.3
Microstructure of G5

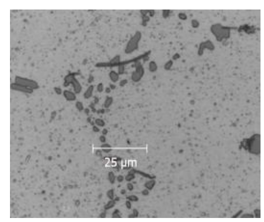

Fig. 2.4
Microstructure of G10

Figures 2.1 to 2.4 show the Microstructures of Heat treated A356.0 and its Composites depicting uniform distribution of ceramic reinforcement (Graphite).

B: Hardness test

The hardness tests were conducted as per ASTM E10 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.

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Fig.3.0: Hardness test specimens

Table III

Alloy Designation	Hardness (B H N)
A356.0	57
3G	97
5G	98
10G	77

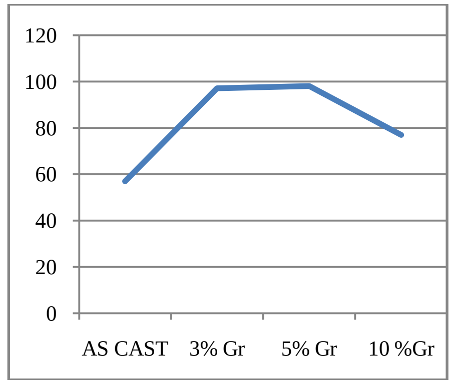

Fig.3.1 Hardness of A356.0 and its composites.

Table III Shows the hardness values of A356.0 alloy and its composites. The hardness of 3G (3% Graphite) is found to be 97 compared to A356.0 alloy with hardness 57 indicating 70.17% increase in hardness. 5G (5% Graphite) has largest value of 98 indicating 71.9% increase in hardness and 10G has hardness of 77 indicating 35.08% increase in hardness when compared to A356.0.

C: Tension test

Fig.3.2: Tensile test specimens

Table IV
Ultimate Tensile Strength (UTS) and ductility (elongation) of Heat treated A356.0 and its composites

Alloy Designation	UTS in MPa	% Elongation
A356.0	136	1.8
3G	277.73	3.60
5G	246.88	2.56
10G	195.54	3.64

Table IV shows plot of UTS and % elongation values of A356.0 and its composites. It is clear from the table that UTS and Ductility increases with Graphite reinforcement for all composites such as G3, G5 and G10 compared to A356.0. G3 has highest UTS compared to A356.0 and it's other composites. UTS of G3 is 277.73MPa which is 104.2% higher than UTS of A356.0. G10 has 195.54MPa showing 43.3% increase in strength. G5 has 246.88 showing 81.5% increase in strength. The Elongation of G3 is 3.60% which is 100% higher than that of A356.0. Composites G10 and G5 also have improved Ductility which are 102.2% and 42.2% respectively higher than A356.0.

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D: Wear test

Table V

	Wear rate, gm/m x10^{-5}				
Alloy Designation	**Sliding Distance, M**				
	300	**600**	**900**	**1200**	**1500**
As cast A356.0	1.01	1.22	1.44	1.54	1.75
G3	0.77	0.93	1.06	1.17	1.28
G5	0.65	0.71	0.83	0.89	1.03
G10	0.94	1.1	1.23	1.45	1.58

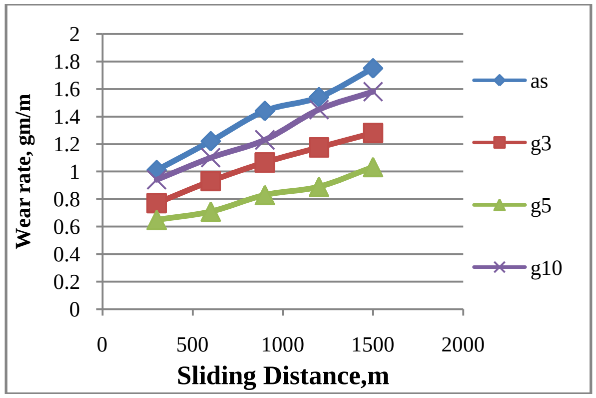

Fig.3.2
Wear rate of as-cast alloy and its composites.

Fig.3.2 shows the plot of Wear rate versus sliding distance of A356.0 and its composites. A356.0 has Wear rate of 1.75x10-5 gm/m where as G3 has 1.28x10-5 showing 26.85% reduction in Wear rate. This reduction in wear rate may be attributed to the increase in hardness achieved due to uniform distribution and bonding of the ceramic in the composite. Composites G5 and G10 have wear rate 1.03x10-5gm/m and 1.58 x10-5gm/m respectively. The decreased wear rate of G5 may be attributed to higher percentage of graphite in the composite which act as solid lubricant results in reducing wear rate.

IV. CONCLUSION

Microstructure indicates uniform distribution of ceramics in the matrix resulting in good bonding of the particulates. The composite with 5% Graphite has highest hardness. Composite with 10% Graphite has highest ductility. The composite with 3% Graphite has highest UTS. The composite with 5% Graphite has lesser wear rate when compared to A356.0 and it's other composites.

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