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Microstructure, Mechanical properties and Dry sliding Wear behaviour of Al-Si-Mg alloy 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 and tested for microstructure, mechanical properties. Wear tests were conducted using Pin-on-Disc apparatus at a constant sliding velocity of 1m/s and load of 30N. 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 which may be attributed to the improved bonding of reinforcement in the matrix.

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

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 behaviour 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 varied percentage of reinforcement of Graphite on microstructure, mechanical properties and dry sliding wear behavior of A356.0

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. Table I shows the chemical composition of A356.0 alloy and Table II shows the designation of the alloy and its composites.

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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	As cast A356.0	As cast A356.0
2	3% Graphite	3G
3	5% Graphite	5G
4	10% Graphite	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.

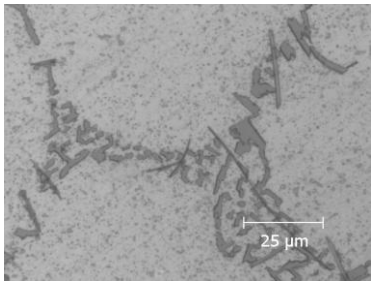

Fig.2.1
Microstructure of As Cast A356.0

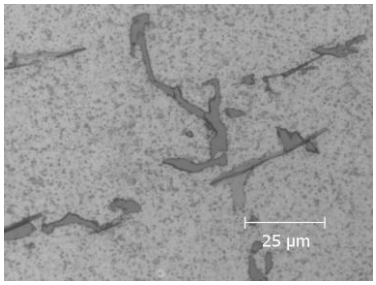

Fig. 2.2
Microstructure of 3G

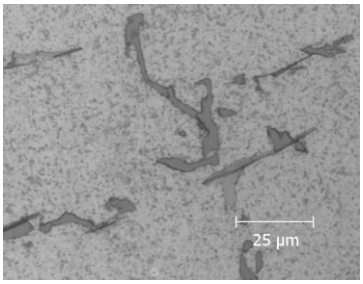

Fig. 2.3
Microstructure of 5G

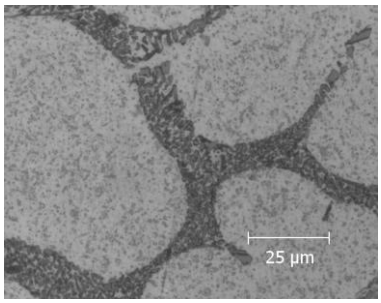

Fig. 2.4
Microstructure of 10G

Figures 2.1 to 2.4 show the uniform distribution of ceramic reinforcement Graphite in A356.0 matrix.

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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.

TABLE III

Fig.3.0: Hardness test specimens

Alloy Designation	Hardness (B H N)
As cast A356.0	51
3G	59
5G	60
10G	53

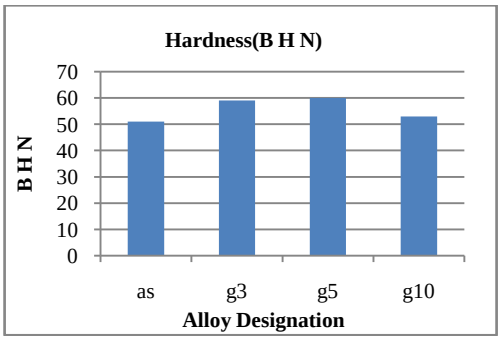

Fig.3.1: Hardness of as-cast alloy and its composites.

Table III Shows the hardness values of As cast A356.0 alloy and its composites. The hardness of 3G (3% Graphite) is found to be 59(BHN) compared to as cast alloy with hardness 51 indicating 15.69% increase in hardness. 5G (5% Graphite) has large value of 60. 10G has hardness of 53.

C: Tension test

Fig.3.2: Tension test specimens

TABLE IV

Sl no	Alloy Designation	UTS in MPa	% Elongation
1	As cast A356.0	78.05	1.3
2	3G	149.07	3.24
3	5G	117.69	2.52
4	10 G	126.56	2.84

Table IV gives the ultimate tensile strength (UTS) and ductility of A356.0 and its composites.

Table IV shows plot of UTS and % elongation values of as cast 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 as cast values G3 has highest UTS and ductility compared to as cast and other composites.

UTS of G3 are 149.07MPa which is 90.9% higher than UTS of as cast.G10 has 126.56MPa showing 61.43% increase in strength.

The Elongation of G3 is 3.24% which is 149.2% higher than as cast A356.0.Composites
G10 and G5 also have improved Ductility which are 118.46% and 93.8% respectively higher than as cast.

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D: Wear test

Table V

Alloy Designation	Wear rate, gm/m x10^{-5}				
	Sliding Distance, M				
	300	**600**	**900**	**1200**	**1500**
As cast A356.0	1.2	1.42	1.64	1.74	1.95
G3	0.88	0.94	1.1	1.23	1.45
G5	0.77	0.75	0.88	0.95	1.1
G10	1.01	1.3	1.43	1.58	1.82

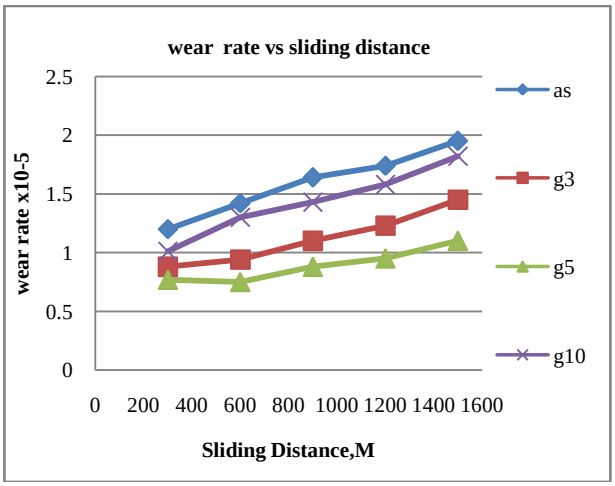

Fig.3.2 : Wear behaviour of as-cast alloy and its composites.

Fig 3.2 shows the plot of wear rate versus sliding distance of A356.0 and its composites. A356.0 has wear rate of 1.95x10-5 gm/m where as G3 has 1.45x10-5 showing 25.64% 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 1.1x10-5gm/m and 1.82 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 3% Graphite has highest UTS and ductility. Graphite reinforced aluminium alloys are proved to be better wear resistant materials compared to unreinforced alloys.

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