

# The Effect of heat treatment on the Microstructure, Mechanical Properties and Dry Sliding Wear Behaviour of A356.0 Reinforced with Alumina

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**ABSTRACT:** In this study, A356.0 alloys were reinforced with varied percentage of alumina 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 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 heat treatment on microstructure, mechanical properties and dry sliding wear behavior of Alumina reinforced A356.0.

## II. MATERIALS

A356.0 alloys were reinforced with varied percentage of Alumina 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 ALUMINA REINFORCED ALLOYS

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

1. 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.

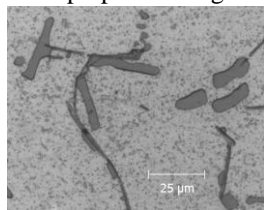


Fig.2.1

Microstructure of A356.0

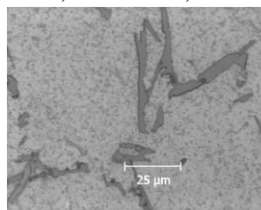


Fig. 2.2

Microstructure of 3G

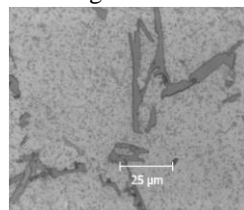


Fig. 2.3

Microstructure of G5

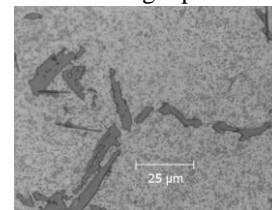


Fig.2.4

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 (Alumina).

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.



Fig.2.5: Hardness test specimens

Table III

Alloy Designation	Hardness (B H N)
A356.0	54
3A	86
5A	89
10A	55

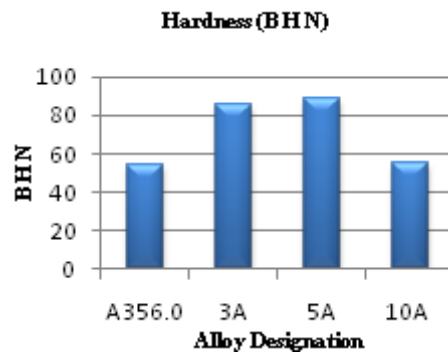


Fig.2.6 Hardness of A356.0 and its composites

Table III Shows the hardness values of A356.0 alloy and its composites. The hardness of 5A (5% Alumina) is found to be 89 compared to A356.0 alloy with hardness 54 indicating 64.81% increase in hardness. 3A (3% Alumina) has hardness 86 and 10A has hardness of 55 indicating 59.25% and 1.85% increase in hardness respectively when compared to A356.0.

C. Tension test



Fig.2.7: Tensile test specimens

**Table IV**

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

Alloy Designation	UTS of Untreated composites in MPa	UTS of Heat treated composites MPa	% Elongation Untreated composites	% Elongation Heat treated composites
A356	78.05	136	1.2	1.8
3A	111.67	164.09	2.56	3.56
5A	77.61	181.26	2.72	3.04
10A	107.80	109.60	4.56	3.73

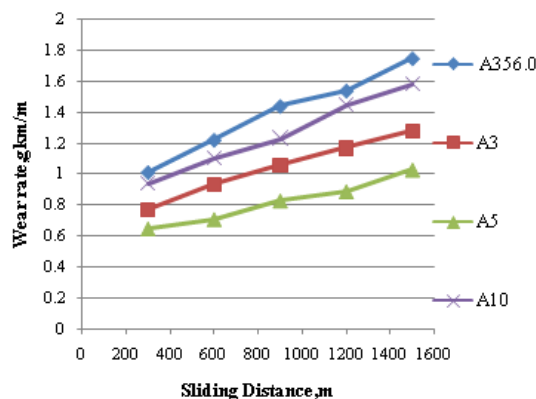
Table IV shows plot of UTS and % Elongation values of A356.0 and its composites. It is clear from the table that UTS and Ductility increases with Alumina reinforcement for composites such as 3A, 5A and 10A compared to A356.0. 3A has highest UTS compared to A356.0 and its other composites.

*D: Wear test*

**Table V**

Wear Rate of As-Cast Alloy and Its Composites

Alloy Designation	Wear rate, gm/m x10 <sup>-5</sup>				
	Sliding Distance, M				
	300	600	900	1200	1500
A356.0	1.01	1.22	1.44	1.54	1.75
A3	0.77	0.93	1.06	1.17	1.28
A5	0.65	0.71	0.83	0.89	1.03
A10	0.94	1.1	1.23	1.45	1.58



**Fig.2.8.** Wear rate of as-cast alloy and its composites.

Fig.2.8 shows the plot of Wear rate versus sliding distance of A356.0 and its composites. A356.0 has Wear rate of  $1.75 \times 10^{-5}$  gm/m where as 5A has  $1.03 \times 10^{-5}$  gm/m showing 69.9% reduction in Wear rate which may be attributed to the increased temperature at pin Disc interface resulting in softening of the pin materials.

#### IV. CONCLUSION

Microstructure indicates uniform distribution of ceramics in the matrix resulting in good bonding of the particulates. The composite with 5% Alumina has highest hardness and Wear resistance. The composite with 3% Alumina has highest UTS.

#### V. ACKNOWLEDGEMENT

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