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The effect of ceramic reinforcement on the Microstructure, Mechanical properties and Dry sliding wear behavior of hypo-eutectic Al-Si-Mg alloy

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ABSTRACT: In this study, Al-Si-Mg alloy A356.0 was reinforced with varied percentage of Alumina 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 pressure of 0.35MPa. 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 as-cast A356.0 which may be attributed to the improved bonding of reinforcement in the matrix.

Keywords*:* MMC's, Composites, Microstructure, Mechanical properties, Pin-on-Disc apparatus.

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 Alumina on microstructure, mechanical properties and dry sliding wear behaviour of A356.0.

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II. MATERIALS

A356.0 alloys were reinforced with Alumina 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 A356.0 and its Composites.

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	Alloy Designation
1.	As cast A356.0	As cast A356.0
2.	A356.0 +3% Alumina	3A
3.	A356.0 +5% Alumina	5A
4.	A356.0 +10% Alumina	10A

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.

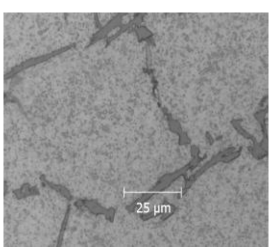

Fig. 2.1: Microstructure As Cast A356.0

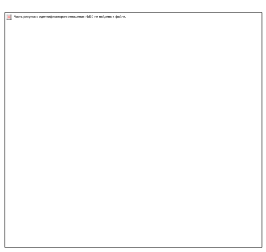

Fig. 2.2: Microstructure of 3A

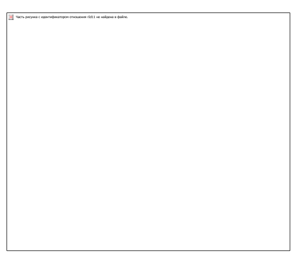

Fig. 2.3: Microstructure of 5A

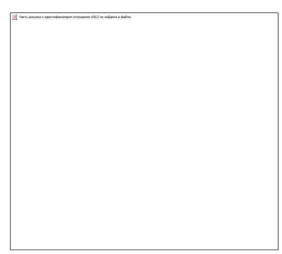

Fig. 2.4: Microstructure of of 10A

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

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

Sl.no	Alloy Designation	Hardness (BHN)
1.	A356.0	51
2.	3A	53
3.	5A	49
4.	10A	48

Fig.2.5: Hardness test specimens

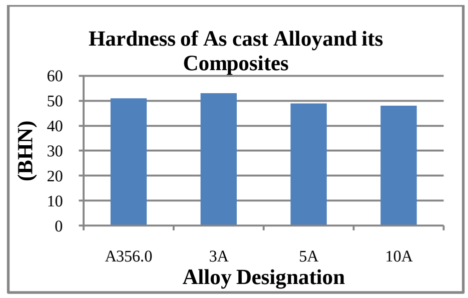

Fig.2.6: Hardness of as-cast alloy and its composites.

Table II Shows the hardness values of as cast A356.0 alloy and its composites. The hardness of 3A (3% Alumina) is found to be 53 compared to as cast alloy with hardness 51 indicating 3.92% increase in hardness. 5A (5% Alumina) has least value of 49. Composite 10A has hardness of 48.

C. Tension test

TABLE IV

Sl no	Alloy Designation	UTS in MPa	% Elongation
1.	A356.0	78.05	1.2
2.	3A	111.67	2.56
3.	5A	77.61	2.72
4.	10A	107.80	4.56

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

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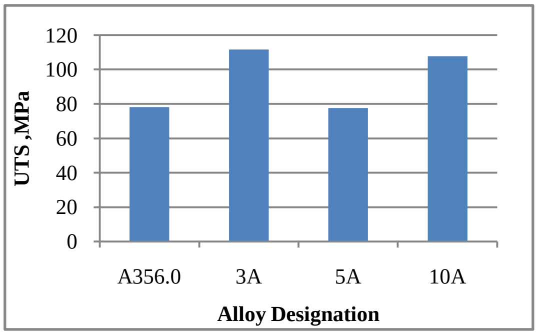

Fig.2.7: UTS of as-cast alloy and its composites

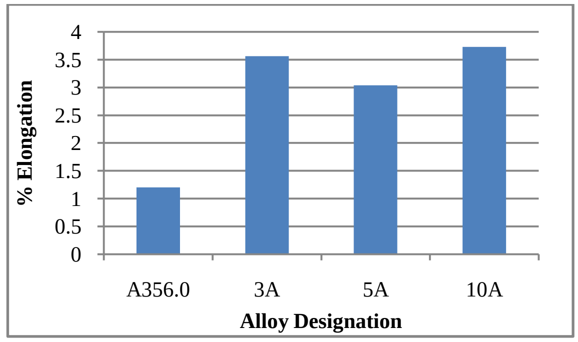

Fig.2.8: % Elongation of as-cast alloy and its composites

Fig 2.7 shows plot of UTS of as cast and its composites. Alloys 3A, 10A have UTS 111.67MPa and 107.8MPa indicating 43% and 38.89% increase respectively compared to as cast alloy with UTS 78.05MPa.

Fig 2.8 shows the plot of ductility of A356.0 and its composites with 10A having 4.56% elongation and 5A having 2.72% elongation is more ductile compared to A356.0.

D. Wear test

TABLE V

Table V shows plot of wear rate versus sliding distance of as-cast alloy and its composites.

	Wear rate, gm/m x10^{-5}				
Alloy Designation	**Sliding Distance, M**				
	300	**600**	**900**	**1200**	**1500**
As cast A356.0	1.2	1.42	1.64	1.74	1.95
A3	2.31	2.04	1.61	3.46	1.8
A5	2.21	2.66	4.53	2.06	2.84
A10	3.44	1.009	4.67	1.24	3.0

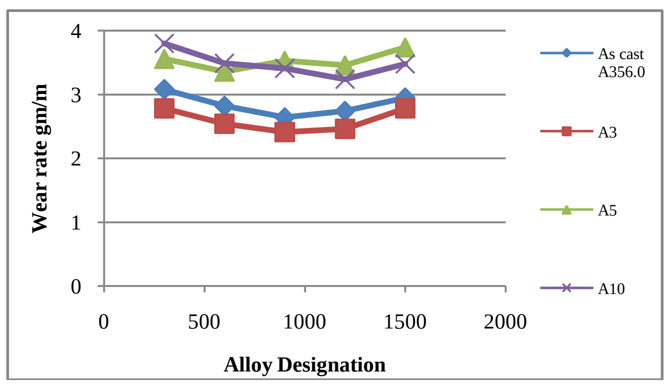

Fig.3.2: plot of wear rate versus sliding distance of as-cast alloy and its composites.

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 A3 has 1.8x10-5 showing % 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 A5 and

A10 have wear rate 2.84x10-5gm/m and 3.0 x10-5gm/m respectively. The decreased wear rate of A5 may be attributed to higher percentage of Alumina in the composite.

IV. CONCLUSION

Microstructure indicates uniform distribution of ceramics in the matrix resulting in good bonding of the particulates. The composite with 3A Alumina has highest hardness and ductility.

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