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Mechanical properties and Dry sliding wear behavior of A2014 reinforced with Alumina

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ABSTRACT: In this study, A2014 alloys were reinforced with varied percentage of Alumina by liquid metallurgy route and tested for microstructure, mechanical properties and wear behaviour. The wear tests were conducted using Pin-on-Disc apparatus at a constant sliding velocity of 1m/s and wear load of 30 N. Microstructure revealed uniform distribution of reinforcement in the matrix resulting in improved mechanical properties and wear resistance compared to un-reinforced material. This improvement in mechanical properties and wear resistance may be attributed to improved bonding of reinforcement in the matrix.

Keywords: Composites, MMC's, Microstructure, Mechanical properties, Wear 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 reinforcement of alumina on microstructure, mechanical properties and dry sliding wear behavior of A2014.

II. MATERIALS

A2014 alloys were reinforced with Alumina and were cast using liquid metallurgy route in the form of cylindrical bars of length 300mm and diameter 25mm.

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Table I
CHEMICAL COMPOSITION OF A2014

Element	Weight %
Cu	4.72
Si	1.10
Mg	0.58
Fe	0.75
Mn	1.03
Zn	0.22
Ti	0.12
Cr	0.12
Al	Balance

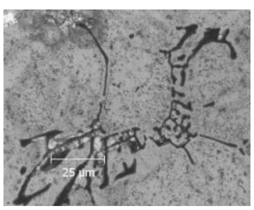
Table II
DESIGNATION OF ALUMINA REINFORCED ALLOYS

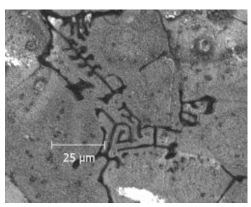
Sl no	Alloy/composite	Designation	Percentage of alumina (wt %)
1	As cast 2014	As cast 2014	-
2	A2014+5%alumina	A5	5
3	A2014+7.5%alumina	A7.5	5
4	A2014+10%alumina	A10	10

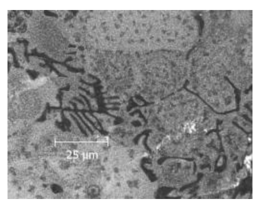
III. TESTING

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.







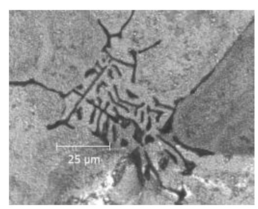


Fig 3.1 **Fig 3.2.** **Fig 3.3** **Fig 3.4.**

Microstructure of as cast A2014 **Microstructure of A5** **Microstructure of A7.5** **Microstructure of A10**

Figures 3.1 to 3.4 show the uniform distribution of ceramic reinforcement in A2014 matrix. The chinese script in the microstructure indicates the precipitates of Aluminium with Cu, Si and Mn.

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 3.5: Hardness test specimens

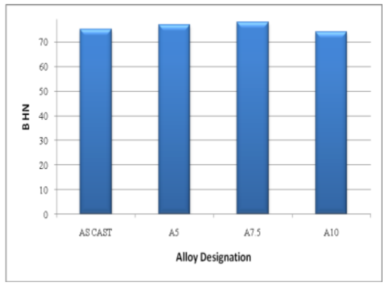


Fig 3.6: Variation of hardness with Alumina

TABLE III

Sl no	Alloy Designation	Hardness (BHN)
1	As cast 2014	75
2	A5	77
3	A7.5	78
4	A10	74

Fig 3.5 shows hardness test specimens having size 20 mm diameter and 15 mm length. Table 2 shows the hardness values of the A2014 composites and its alloys. Fig 3.6 shows the variation of hardness with the addition of Alumina.

The hardness of the alloy increases with Alumina addition up to 7.5 wt % there after a decrease in hardness is observed. A7.5 and A5 have hardness 78 and 77 which are 4% and 2.7% higher than As cast A2014.

C: Tension test

Table IV

Table IV gives the ultimate tensile strength (UTS) and ductility of A2014 and its composite.

Alloy Designation	UTS in MPa	% Elongation
As cast A2014	137.74	1.76
A5	136.52	2.11
A7.5	95.54	1.02
A10	143.0	1.29

Fig.3.7: Tension test specimens

Table IV shows plot of UTS and Ductility of A2014 and its composites.A2014 and A10 have UTS values 137.74 MPa and 143.0 MPa respectively. This indicates that with 10% addition of alumina there is 3.82% increment in the UTS values. In case of Elongation, A2014 and A5 have value 1.76% and 2.11% indicating a increase of 20%.

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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 A2014	1.735	1.546	1.48	1.363	1.45
A5	1.91	1.67	1.63	1.5	1.644
A7.5	1.66	1.49	1.42	1.26	1.31
A10	2.323	2.356	2.273	2.13	2.36

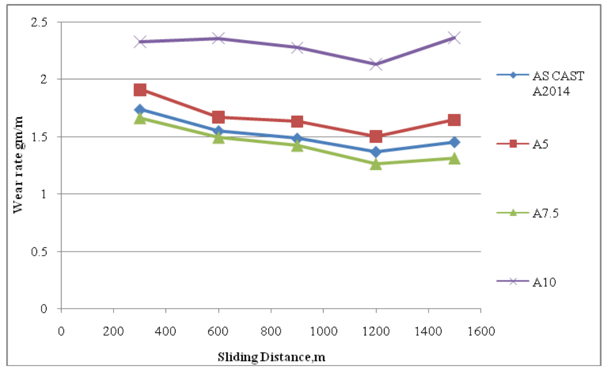

Fig 3.8: Wear Behavior of A2014 and its alloys

Fig 3.8 shows the plot of Wear rate versus sliding distance of A2014 and its composites. A2014.0 has Wear rate of 1.45x10-5 gm/m where as A5 has 1.644x10-5 showing 25.64% reduction in Wear rate. This reduction in wear rate may be attributed to the formation of MML and increase in hardness achieved due to uniform distribution and bonding of the ceramic in the composite. The steep increase in Wear rate of both A2014 and its Composite A10 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 A7.5 has highest hardness and Wear resistance compared to As cast material. A5 has highest UTS for the composites studied.

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