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The Effect of Heat Treatment on 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 using permanent moulds. They were Heat treated (T6) 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. Improved Mechanical Properties, Wear resistance were observed for Heat treated A2014 and its Composites.

Keywords: Composites, MMC's, Microstructure, Mechanical properties, Wear 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 the Mechanical Properties and Tribological Behavior of A2014 and its Composites.

II. MATERIALS

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

Fig 3.1: A2014 Casting

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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	7.5
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.

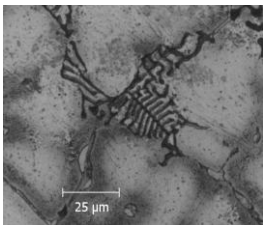

Fig 3.1
Microstructure of as cast A2014

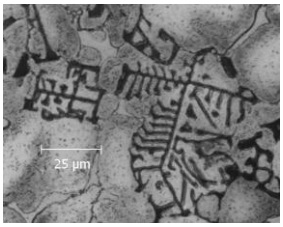

Fig 3.2.
Microstructure of A5

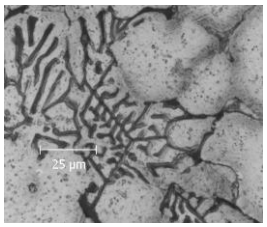

Fig 3.3
Microstructure of A7.5

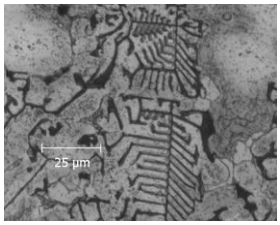

Fig 3.4.
Microstructure of A10

Figures 3.1 to 3.4 show the uniform distribution of ceramic reinforcement in A2014 matrix. The chinese script indicates the intermetallic compound 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.

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TABLE III

Table III Hardness values of A2014 and its Composites.

Sl no	Alloy Designation	Untreated	Heat treated
1	As cast 2014	75	144
2	A5	77	121
3	A7.5	78	142
4	A10	74	120

Fig 3.5: Hardness test specimens

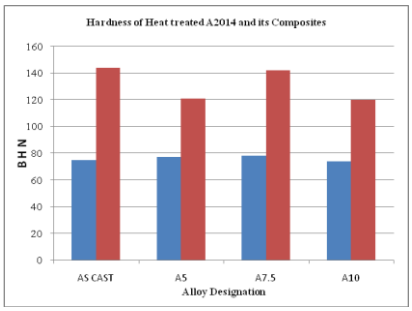

Fig 3.6: Variation of hardness with Alumina.

Fig 3.5 shows hardness test specimens having size 20 mm diameter and 15 mm length.
Fig shows the hardness values of as cast and heat treated composites. The hardness values increases with increased particulate addition up to 7.5% and thereafter a decrease in hardness value is observed. A quantum increase in hardness was observed with heat treatment with values as high as 92% for the heat treated A2014 material.

C: Tension test

TABLE IV

Alloy Designation	Un treated	Heat treated
As cast A2014	137.74	344.19
A5	136.52	256.2
A7.5	95.54	273.34
A10	143	296.32

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

Table IV shows plot of UTS of A2014 and its composites in as cast and heat treated condition. A2014 and A10 have UTS values 344.19 MPa and 296.32 MPa respectively after heat treatment compared to values of 137.74 and 143 MPa. This indicates that with 10% addition of Alumina heat treatment has resulted in 150% and 107% increase in UTS values.

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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	1.38	1.35	1.34	1.49	1.66
A5	1.09	1.07	1.01	1.16	1.25
A7.5	1.6	1.56	1.5	1.65	1.76
A10	2.09	1.89	1.83	1.88	1.95

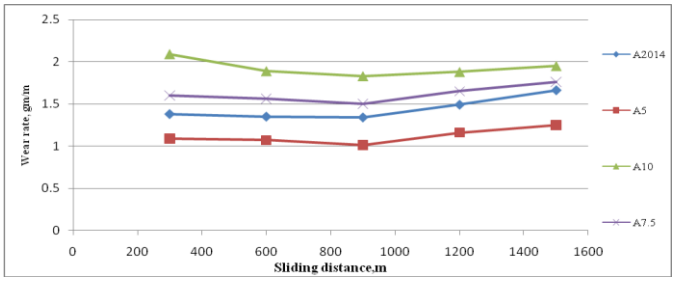

Fig 3.8: Wear rate of A2014 and its alloys

Fig 3.8 shows the plot of Wear rate versus sliding distance of A2014 and its composites. A2014.0 has Wear rate of 1.66x10-5 gm/m where as A5 has 1.25x10-5 showing 32.8% reduction in Wear rate. This reduction in wear rate may be attributed to the formation of MML (Mechanically mixed layer) of A2014 and Alumina 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 after traversing through 1500M 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 ceramic (Alumina) in the matrix resulting in good bonding of the particulates. The composite A5 has highest Wear resistance compared to heat treated A2014 and its composites.

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