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Dry sliding wear behavior of heat treated A2014 reinforced with Graphite

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ABSTRACT: A2014 alloys were reinforced with varied percentage of Graphite by gravity casting using permanent moulds. They were heat treated (T6) and tested for microstructure, mechanical properties. The Pin-on-Disc apparatus was used to study Wear behaviour at a constant sliding velocity of 1m/s and pressure of 0.35MPa. The study of Microstructure revealed uniform distribution of Graphite in the matrix which in turn resulted in improved mechanical properties and wear resistance compared to un-reinforced material. Heat treatment resulted in further improvement in mechanical properties and wear resistance. The improvement in mechanical properties and wear resistance may be attributed to the uniform distribution of Graphite and its bonding in the matrix.

Key words: 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 Graphite and were cast using liquid metallurgy route using permanent Moulds in the form of cylindrical bars of length 300mm and diameter 25mm. They were heat treated (T6).

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Fig 3.1: A2014 Casting

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 GRAPHITE REINFORCED ALLOYS

Sl no	Alloy/composite	Designation	Percentage of Graphite (wt %)
1	As cast 2014	As cast 2014	-
2	A2014+3%Graphite	Gr3	3
3	A2014+5%Graphite	Gr5	5
4	A2014+7%Graphite	Gr7	7
5	A2014+9%Graphite	Gr9	9

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.

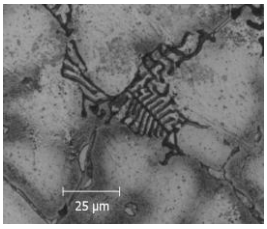

Fig 3.2
Microstructure of as cast A2014

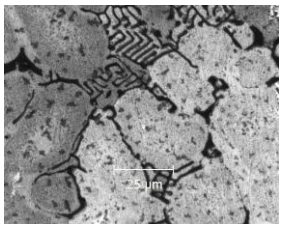

Fig 3.3
Microstructure of Gr3

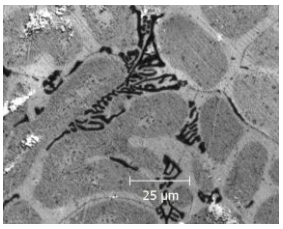

Fig 3.4
Microstructure of Gr5

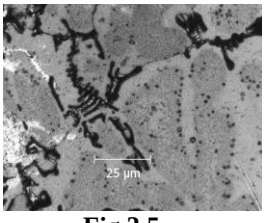

Fig 3.5
Microstructure of Gr7

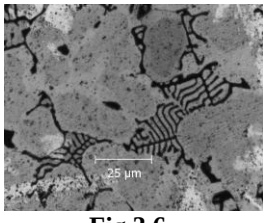

Fig 3.6
Microstructure of Gr9

Figures 3.2 to 3.6 show the uniform distribution of Graphite reinforcement in the heat treated alloy and its composite. The chinese script indicates the intermetallic compound of Aluminium with Cu, Si and Mn.

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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.

Fig 3.7
Hardness test specimens

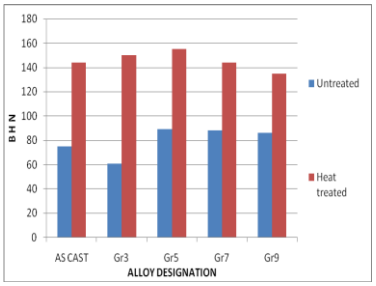

Fig 3.8
Variation of hardness with Graphite.

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	Gr3	61	150
3	Gr5	89	155
4	Gr7	88	144
5	Gr9	86	135

Fig 3.7 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 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 98.66% for the heat treated A2014 material.

C: Tension test

TABLE IV

Alloy Designation	Un treated	Heat treated
As cast A2014	137.74	344.19
Gr3	173.42	226.80
Gr5	138.36	282.28
Gr7	174.96	344.23
Gr9	146.56	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 Gr10 have UTS values 344.19 MPa and 296.32 MPa respectively after heat treatment compared to values of 137.74 and 146.56 MPa. This indicates that the heat treated composite with 7% Graphite, resulted in 150% increase in UTS value.

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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
Gr3	1.09	1.07	1.01	1.16	1.25
Gr5	1.6	1.56	1.5	1.65	1.76
Gr7	1.4	1.38	1.4	1.5	1.6
Gr9	2.09	2.42	2.32	2.28	2.38

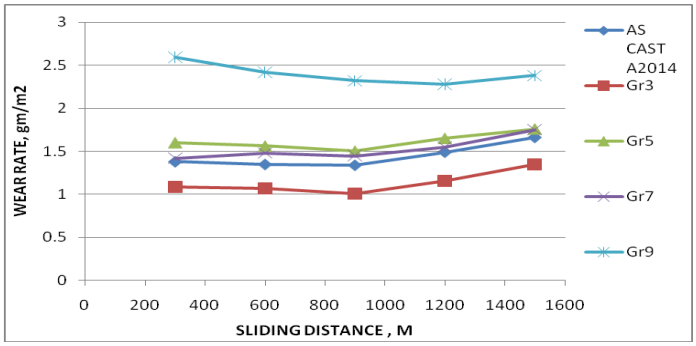

Fig 3.9: Wear rate of A2014 and its alloys

Fig 3.9 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 Gr5 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 Graphite 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 (Graphite) in the matrix resulting in good bonding of the particulates. The composite Gr5 has highest Wear resistance compared to heat treated A2014 and its composites.

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