ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology
Vol. 2, Issue 6, June 2013

Mechanical properties and Dry sliding wear behavior of A2014 reinforced with Graphite.

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ABSTRACT: In this study, A2014 alloys were reinforced with varied percentage of Graphite 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.

Key words: 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 Graphite on microstructure, mechanical properties and dry sliding wear behavior of A2014.

II. MATERIALS

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

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 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 (500X).

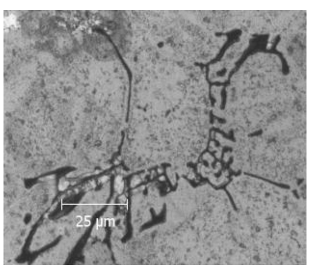

Fig 3.1
Microstructure of as cast A2014

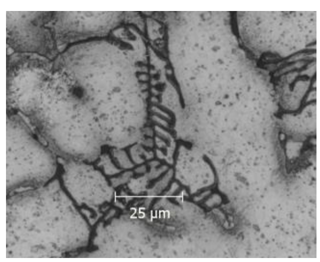

Fig 3.2.
Microstructure of Gr3

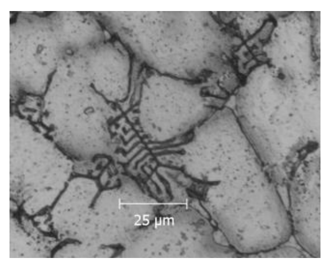

Fig 3.3
Microstructure of Gr5

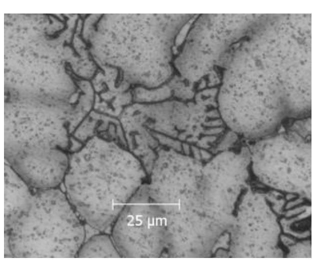

Fig 3.4.
Microstructure of Gr7

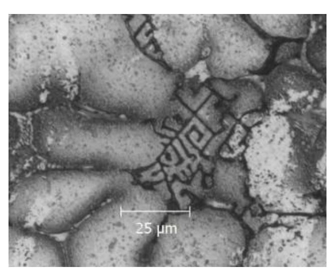

Fig 3.5.
Microstructure of Gr9

Figures 3.1 to 3.5 show the uniform distribution of Graphite reinforcement in A2014 matrix. The chinese script in the microstructure indicates the precipitates of Aluminium with Cu, Si and Mn.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology
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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.

TABLE III

Sl no	Alloy Designation	Hardness (BHN)
1	As cast 2014	75
2	Gr3	61
3	Gr5	89
4	Gr7	88
5	Gr9	86

Fig 3.6: Hardness test specimens

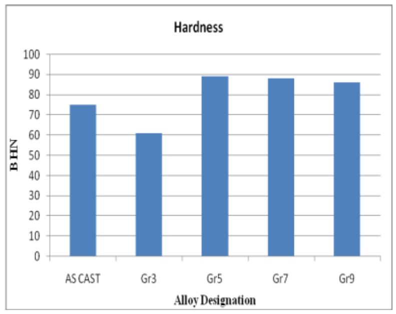

Fig 3.7: Variation of hardness with Graphite

Fig 3.6 shows hardness test specimens having size 20 mm diameter and 15 mm length. Table III shows the hardness values of the A2014 composites and its alloys. Fig 3.7 shows the variation of hardness with the addition of G.
The hardness of the alloy increased to highest value 89 (BHN) with 5 wt % there after a decrease in hardness is observed. Gr7 and Gr9 have hardness 88 and 86 which are 17.33% and 14.7% higher than As cast A2014. Addition on 3% Graphite to the alloy did not show any improvement in hardness and in fact a decrease of 18.67% was observed.

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
Gr3	173.42	4.07
Gr5	138.36	2.02
Gr7	174.96	2.84
Gr9	146.56	2.04

Fig.3.8: Tension test specimens

Table IV shows plot of UTS and Ductility of A2014 and its composites.A2014 and Gr7 have UTS values 137.74 MPa and 174.96 MPa respectively. This indicates that with 7% addition of Graphite there is 27% increment followed by Gr3 and Gr 9 with UTS values 173.42MPa and 146.56 MPa indicating 25.9% and 6.4% in the UTS values. In case of Elongation, A2014 and Gr3 has 1.76% Elongation indicating 131% a increase in Elongation.Gr5, and Gr9 have 15% higher Elongation compared to as cast 2014.

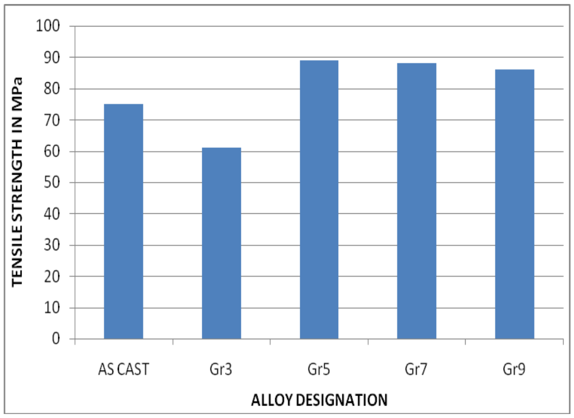

Fig 3.7: Variation of Tensile strength with Graphite

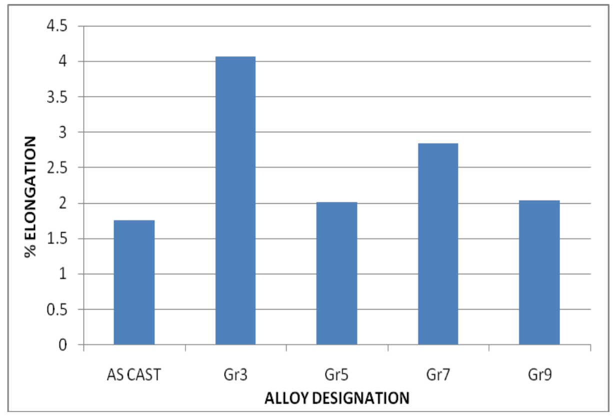

Fig 3.7: Variation of % Elongation with Graphite

D: Wear test

TABLE V

Alloy Designation	Wear rate, gm/m x10^{-5} Sliding Distance, M				
	300	**600**	**900**	**1200**	**1500**
As cast A2014	3.735	3.346	3.65	3.363	3.15
Gr3	2.9	2.6	2.8	2.5	2.7
Gr5	1.2	1.03	1.2	1.16	1.4
Gr7	1.8	1.69	1.5	1.67	1.7
Gr9	2.0	1.9	1.72	1.85	1.9

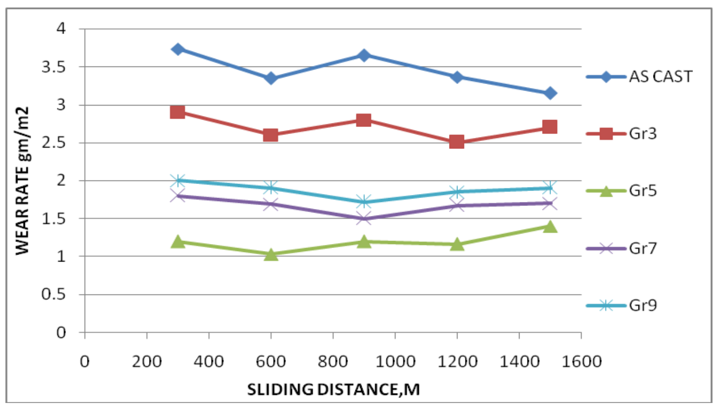

Fig 3.9: Wear Behavior of A2014 and its alloys

Fig 3.9 shows the plot of Wear rate versus sliding distance of A2014 and its composites. A2014.0 has Wear rate of 3.15x10-5 gm/m where as Gr5 has 1.4x10-5 showing 55.5% 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 Graphite in the composite. The steep increase in Wear rate of both A2014 and its Composite 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 Graphite in the matrix resulting in good bonding of the particulates. The composite with Gr5 has highest hardness and Wear resistance compared to as cast material. Gr7 has highest UTS for the composites studied.

ACKNOWLEDGEMENT

We thank Dr. H. D. Maheshappa, Principal, Management of Acharya institute of Technology, Bangalore and Dr K.Mahesha, Head Depatment of Mechanical Engineering for motivating and providing research facilities at the institute.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

Vol. 2, Issue 6, June 2013

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