Performance of Hyper Eutectic Al-Si alloys at high Temperature during wear siliding.

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Abstract**—** Al–Si alloys area unit wide employed in completely different fields of trade. High wear resistance, high strength-to-weight ratio, low coefficient of thermal expansion, high thermal conductivity, high corrosion resistance, excellent castability, hot tearing resistance, good weld ability etc. make hypereutectic aluminium silicon alloys very attractive candidate in aerospace and other engineering sectors. Aluminium silicon alloys can be strengthened by adding small amount of Cu, Ni or Mg and the presence of silicon provides good casting properties. It has been documented extensively that the microstructure of hypereutectic Al-Si alloys, ready by standard casting routines, sometimes contains a rough primary Si innovate a fibrous mixture matrix.**Keywords:- eutectic, hypereutectic**

Introduction

In alloy material the metallic atoms must dominate in its chemical composition and the metallic bond in its crystal structure. Aluminium alloys square measure distinguished in keeping with their major alloying components. Silicon is good in metallic alloys. This is because it increases the fluidity of the melt, reduces the melting temperature, decreases the shrinkage during solidification and is very inexpensive as a raw material. Silicon includes a terribly low solubility in aluminium; it thus precipitates as just about pure semiconducting material, that is tough and thus improves the abrasion resistance. Aluminium-silicon alloys form a eutectic at 12.6 wt% silicon, the eutectic temperature being 577°C.

A. Phase Diagram:

Aluminium-Silicon system is a simple binary eutectic with limited solubility of aluminium in silicon and limited solubility of silicon in aluminium. There is only one invariant reaction in this diagram,

$$L \rightarrow \alpha + \beta \text{ (eutectic)} \qquad (1)$$

L is that the liquid section, α is preponderantly Al, and β is preponderantly element.

Depending on the Si concentration in weight percentage, the Al-Si alloy systems are divided into three major categories:

(i) Hypoeutectic (<12 wt % Si)
(ii) Eutectic (12-13 wt % Si)

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(iii) Hypereutectic (14-25 wt % Si)

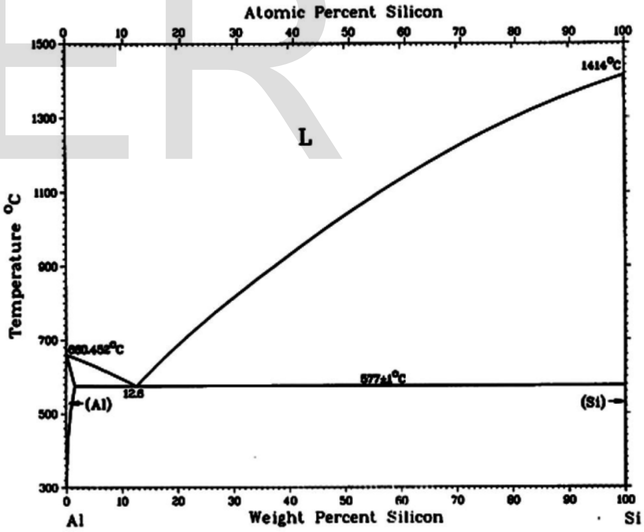

Figure 1 Al-Si phase diagram

B.Refinement and modification in Al-Si alloys

The eutectic in aluminum silicon alloy system occurs at 12% Si; therefore, one would expect that all alloys containing more than about 12% Si should exhibit a normal hypereutectic microstructure consisting of primary silicon phase in a binary eutectic matrix.

The complex microstructures are frequently observed, which are difficult to explain simply in terms of the equilibrium phase diagram into three categories.

(i)Primary Al dendrites may occur in alloys which are just slightly hypereutectic (12% < Si< 14%).

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(ii)Some hypereutectic alloys which contain up to 0.1% Sr exhibit a completely eutectic microstructure.

(iii)Hypereutectic alloys often contain primary aluminum dendrites in addition to primary silicon and eutectic.

II.EXPERIMENTAL METHODOLOGY

Aluminum-silicon alloys were prepared by stir casting method with different weight percentage of silicon in heating furnace. Samples of different dimensions were prepared for different tests. By using optical emission spectrometer their composition was analysed. Wear behavior of different composition samples were studied by conducting several wear tests on computerized Ducom wear and friction monitor pin on-disc wear test machine.

B. Preparation of the Alloys

Al-Si alloys are prepared by foundry technique. Commercially pure aluminium (99.7 Wt % purity) and Al-20 Wt % Si master alloy are melted in a resistance furnace under a cover flux (45% NaCl+45% KCl+10% NaF). The melt is held at 7200C±50°C. After degassing the melt with solid hexachloroethane (C_2Cl_6) the melt is poured into cylindrical graphite mould (25 mm diameter and 100 mm height) surrounded by fire clay brick with its top open for pouring (for preparing the specimen for macro and micro structural studies) and also the melt is poured into the graphite split mould (12.5 mm diameter and 125 mm height- for preparing the specimen for wear pins). Similarly for preparing grain refined specimen, after degassing with hexachloroethane (C_2Cl_6), the melt was stirred for 30 seconds with zircon coated iron rod. Melts were poured after holding for about 30 minutes into cylindrical graphite mould (25 mm diameter and 100 mm height) surrounded by fire clay brick with its top open for pouring and also the melt is poured into graphite split mould (12.5 mm diameter 125 mm height).

Table 1:- Preparation of Al-Si alloys

	
(a)Stir casting set up	(b)Graphite mould
	
© Degassifier	(d)Cover flux

	
(e) Al-Si alloys after casting	(f)Specimen used for wear test

C. Wear test setup

Wear tests were conducted using pin on disc wear testing machine (TR-20LE-PHM-600, DUCOM, and PIN-ON-DISC MACHINE).

The disc is formed of low carbon steel (EN-32 Steel, one hundred sixty millimetre diameter and eight millimetre thickness) having hardness worth of concerning 62RC.

Wear pins of 30 mm length and 8 mm diameter were machined from the cast specimen obtained from graphite split mould (12.5 mm diameter and 125 mm length). Wear losses were recorded. Wear losses were measured with a linear variable differential transformer (LVDT) and it was monitored by the loss of length due to wear of the specimen of the fixed diameter. The wear loss was measured in microns (μm). Weight loss method is followed to get the more accurate results. In this method using an electronic weighing machine weight of the wear pin before and after conducting the wear test is recorded. Difference between the initial and final weight gives the weight loss due to wear

Wear tests were conducted using pin on disc wear testing machine (TR-20LE-PHM-600, DUCOM, and PIN-ON-DISC MACHINE). The disc is made of low carbon alloy steel (EN-32 Steel, 160 mm diameter and 8 mm thickness) having hardness value of about 62RC. Wear pins of 30 mm length and 8 mm diameter were machined from the cast specimen obtained from graphite split mould (12.5 mm diameter and 125 mm length). Wear losses were recorded. Wear losses were measured with a linear variable differential transformer (LVDT) and it was monitored by the loss of length due to wear of the specimen of the fixed diameter. The wear loss was measured in microns (μm). Weight loss method is followed to get the more accurate results. In this method using an electronic weighing machine weight of the wear pin before and after conducting the wear test is recorded. Difference between the initial and final weight gives the weight loss due to wear.

Three sets of experiments are:

- Normal pressure dependent experiments.
- Sliding speed dependent experiments.

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- Sliding distance dependent experiments

D. RESULTS AND DISCUSSION

Sliding wear behaviour of Al-Si alloys is obtained from the experimental study conducted. The experiment is carried out on the Ducom wear and friction monitor pin on-disc wear test machine. The sliding behaviour of hypereutectic Al-Si alloys at room and elevated temperature is carried out and volume loss of Al-Si alloys is obtained from the experiment. The plots for volume loss, pressure, sliding distance and sliding distance at room and elevated temperature are obtained for Al-Si alloys.

Dry sliding wear test

The wear tests of Al-Si alloys were carried out with varying applied load, sliding speed and sliding distance. The experiments are carried at room and elevated temperature. In the present study, hyper eutectic aluminium based alloys containing 13% and 20% weight of Silicon.

(a)Effect of sliding velocity

The fig 2(a), (b), and (c) shows the plot for volume loss versus sliding velocity. The sliding velocity is varied from 0.94 m/sec to 3.77 m/sec with constant normal pressure (0.975 N/mm2) and at constant sliding distance (565.486 m). The volume loss decreases as the sliding velocity is increased from 0.94 m/sec to 3.77 m/sec. As the sliding speed increases there is increase in the interface temperature and this may lead to the formation of oxide layer at higher interface temperatures. This prevents direct metal-to-metal contact of sliding surfaces during sliding. This volume loss decrease may also be due to the fact that, at low sliding speeds, more time is available for formation and growth of micro welds, which increases the force required to shear off the micro welds to maintain the relative motion, due to which specific wear rate increases. However, at higher speeds, there is less residential time for the growth of micro welds leading to lesser wear rate.

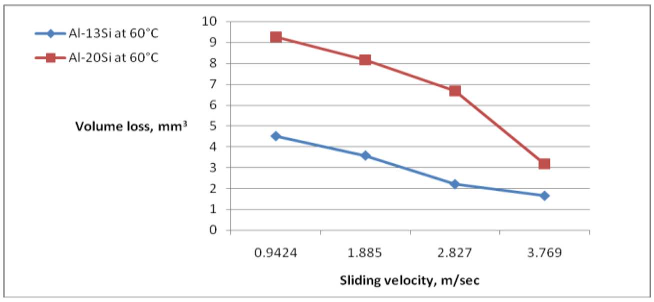

Fig 2(a)

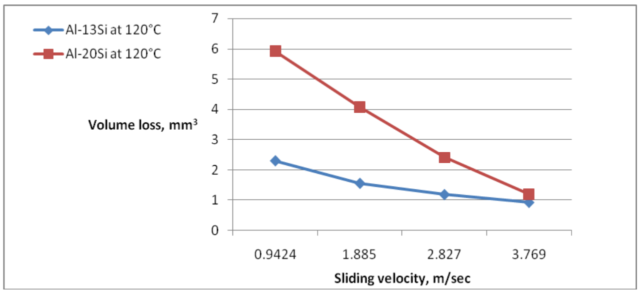

Fig 2(b)

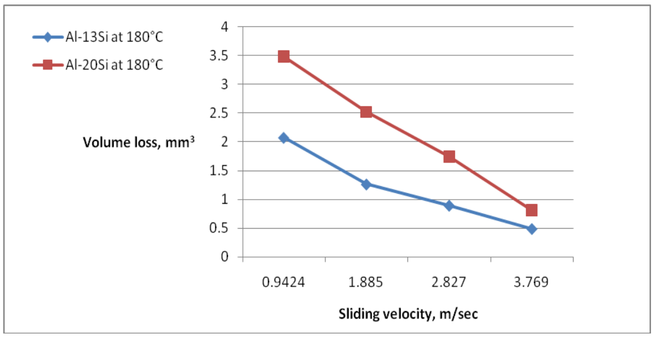

Fig 2(c)

Fig 2: Sliding velocity v/s Volume loss of Al-13, 20Si alloy at 60°C, 120°C and 180°C.

(b)Effect of sliding velocity distance on Al-20Si alloy at elevated temperatures.

The comparison of Al-20Si alloy is made at 60°C, 120°C and 180°C. From fig. 4.5 (b) it is clear that, wear resistance increases as temperature increases.

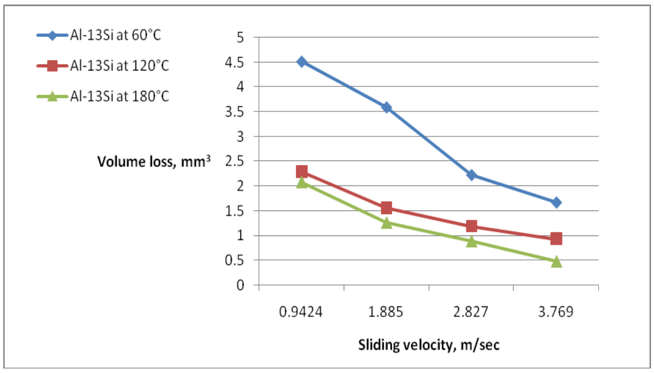

Figure 3 Sliding velocity v/s Volume loss of Al-13Si alloy at 60°C, 120°C and 180°C.

Frictional Force v/s sliding velocity at elevated temperatures of Al-13Si alloys and Al-20Si alloys

The following graphs are plotted for frictional force against and sliding velocity at elevated temperatures i.e at 60°C [Fig4.6(a), (b) and (c)] , 120°C [Fig4.7(a), (b) and (c)] and 180°C [Fig4.8(a), (b) and (c)] .

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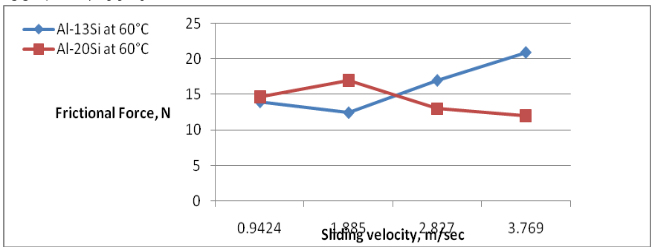
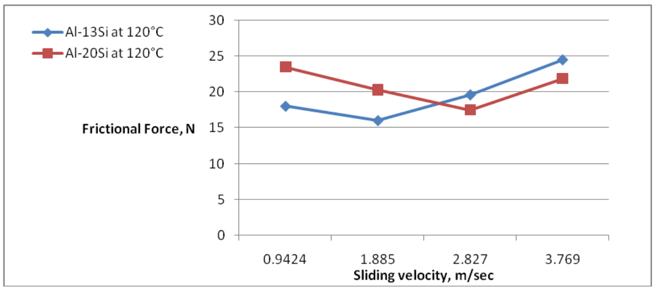


Fig



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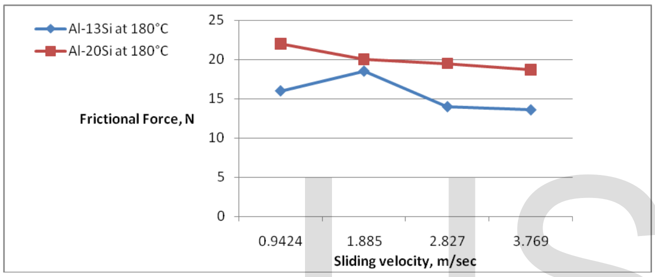
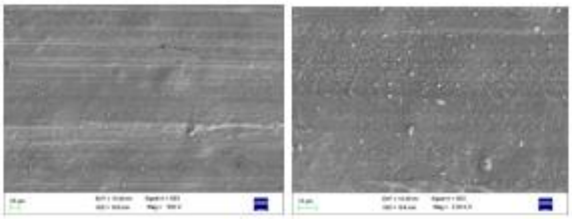


Fig

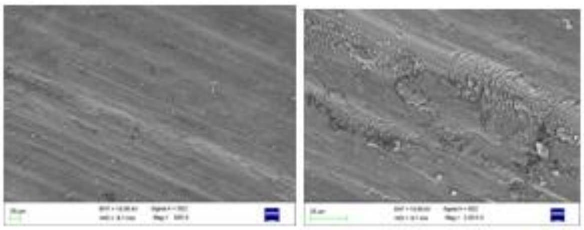
For Sliding velocity 0.9424m/sec:

Wear Topography

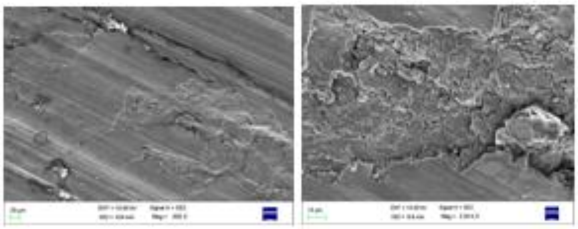
At 60° C:



At 120°C:

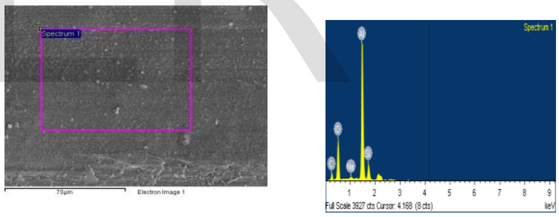


At 180°C:



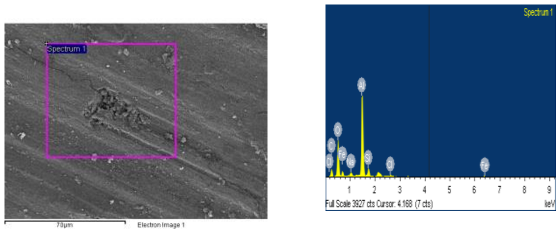
EDS

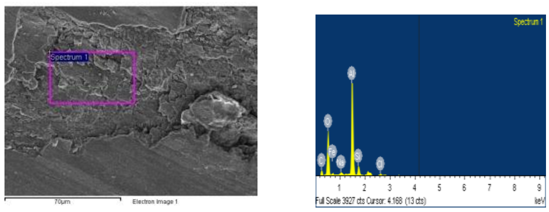
At 60° C:



Oxygen content: 13.95%

At 120°C:





Oxygen content: 33.95%

The SEM microphotographs and EDS of Al-13Si alloys at sliding velocity 0.9424 m/sec.

CONCLUSION

1. The wear rate of the Al-13, 20 Si alloys the wear rate is decreases with increase in sliding velocity.
2. The wear rate of the Al-13, 20 Si alloys decreases with an increase in temperature.
3. The wear rate of the Al-13, 20 Si alloys decreases with an increase in temperature. This effect is due to the oxide film formation on sliding components, which is more rapid at high operating temperatures

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