DRY SLIDING WEAR BEHAVIOR OF AS CAST AL-30MG2SI-4FE ALLOY

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Abstract— In present work, dry sliding wear behavior was investigated on a pin on disc wear testing machine at constant sliding velocity 1-4m/s and normal load 10-50N. As the sliding velocity increases, the coefficient of friction decreases. Tribo surfaces were investigated by optical microscopy and reveals that the majority of wear is due two body abrasive mechanism. Wear behavior of material is a common phenomenon when two surfaces are into contact, the nature of the wear depends upon large number of variables like temperature, sliding velocity, nature of surface contacts, type of materials, applied loads and many more. In the present work an attempt is carried out to minimize the wear rate by using various compositions. Further, it was observed that at lower speeds and lower loads the wear rate accordingly decreases and increases by an increase in loading. At constant load of 10N the rough surface nature of contact was observed and resulted in more wear rate. It was also observed as the sliding velocity increases to 4m/s the wear rate decreases by 17% and due to surface contact time decreases.

Keywords—Al-30Mg_2Si-4Fealloy,Dry sliding, Microstructure, Wear Rate.

I. INTRODUCTION

In the recent years, the demand of automobile industries for design of newer light weight (high strength to weight ratio) material has been greatly increasing with high strength, excellent wear and corrosion resistance [1]. Al-Si alloy has created a lot of interest and has become a prime material for both automobile and aircraft components [2]-[5]. With the increase in the silicon content, the alloy gives excellent hardness, low density and also improves the wear resistance [3]-[4]. Research has emphasized that by adding the transition metals like Fe and Cu to Al-Si alloys showed a improvement in wear resistance. Also adding of iron in Al-Si alloys decreases mechanical and tribological properties due to the formation of long and brittle needle like β-Al_5FeSi intermetallics [5]-[6]. The dry sliding wear behavior of Al-Si alloys depends on distribution of Si particles in the Al matrix. In order to improve mechanical properties of this alloy, Mg and Fe are added as alloying elements. Cu and Fe are also the alloying elements considered to be more promising for producing Al-Si alloy with improved properties [1]-[2]. Amongst the most aluminium casting alloy, Aluminium-silicon alloys are most common alloys having an attractive characteristics such as high strength to weight ratio, good mechanical and thermal conductivity and corrosion resistance. Aluminium-silicon was found to have wide variety of application in cylinder blocks and heads, piston and engine parts, rocker arms, impellers etc [4]. Recently it has been shown that addition of Fe to this alloy showed Increase in hardness and also improved the wear resistance but with the increase in percentage of Fe content further increased the hardness but decreased the wear resistance of the alloy. A large reduction in density is thought to be great boon for automotive industries [4]-[5]. These leads to the formation of Mg_2Si an intermetallic compound which results in the improvement of mechanical properties. Al-Si alloys, the size and morphology of primary and eutectic silicon phases have vital importance in terms of mechanical properties. Al-Si-Fe alloys have been studied extensively to ensure reasonable mechanical or tribological properties [7]. For adhesive and abrasive wear processes it was shown that the material removed is directly proportional to sliding distance and the normal load and is inversely proportional to hardness[8]-[9]. Wear of a material is controlled by the material characteristics as well as operating parameters such as applied pressure, sliding speed, environment and type of sliding interaction[10]-[12].

II. EXPERIMENTAL PROCEDURE

2.1. Material and characterization

The alloy used in the present investigation is light weight heat treatable. Commercially available alloy was purchased from FENFE Metallurgical, Bangalore, India. Table 1 summarizes the chemical compositions of the selected alloy. The material was cut into these specimens with dimensions of 30mm length and 10mm diameter. The dimensions are maintained according to ASTM E8 standards. The alloy used in the present work is Al-30Mg_2Si-4Fe. The microstructure characterization of alloy was carried out by optical microscope.

Table 1: Chemical composition (wt %) of Al-30Mg_2Si-4Fe alloy

Alloy %	%Mg	%Si	%Fe	%Cu	% Al
Al-30Mg_2Si-4Fe	16.89	12.71	3.74	0.003	Bal

2.2. Wear testing

The dry sliding wear test of as cast alloy was carried out at room temperature on pin on disc wear testing machine (Model: TR-20, DUCOM). The specimens were of 30mm length and 10mm diameter with machining the surface of the specimens. The wear testing was conducted under various normal loads of 10, 30, 40 and 50N at various sliding velocities of 1, 2, 3 and 4m/s. All the specimens were weighed after each of the tests been conducted at various loads and at various sliding velocities. The wear rates of the alloy are calculated by measuring the difference in weight of the specimens measured before and after the tests. Further frictional force, wear rate, loss of material by volume, coefficient of friction etc were measured. The study of wear debris and worn out surfaces were done by SEM images. The following Fig. shows the pin on disc wear testing machine on which wear test of as cast Al-30Mg_2Si-4Fe alloy were conducted.

Fig. shows photograph of Pin-on-disc wear testing machine (TR-20)

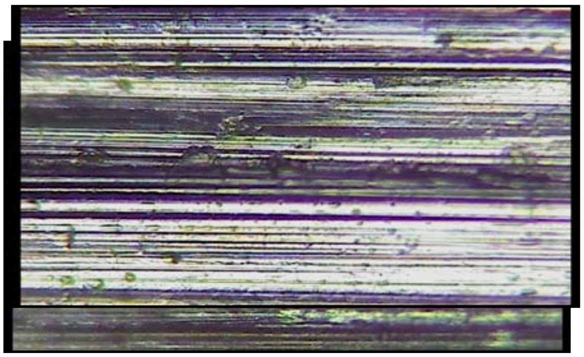
III. RESULTS AND DISCUSSION

The optical micrographs of Al-30Mg_2Si-4Fe alloy as cast samples before and after wear are shown in Fig. 1 (a-d)

As cast Al-Mg_2Si-4Fe alloy

The microphotograph of optical microscopy shows Mg and Si are distributed uniformly throughout the surface. Si represnts needle like structure and Mg appears like platelets and the black appears to be Fe. The Aluminium bieng the soft matrix and Mg and Si are hard particles which are distributed uniformly and resist the wear. This also reduces the heat generation and hence these alloy does not get over heated.The needle like structures reduces the contact surface area of bulk matrix and softens the alloy hence aluminium does not deform. Mg particulates are hard particles and thus increases the volume surface area,thus better the distribution of reinforced particles decreases the volume wear rate.

Fig.1a Optical microscopy image of 1m/s at sliding



velocity of 10N

Fig.1b Optical microscopy image of 2m/s at sliding velocity of 10N

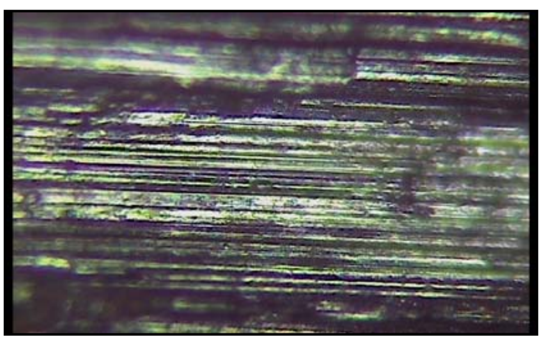
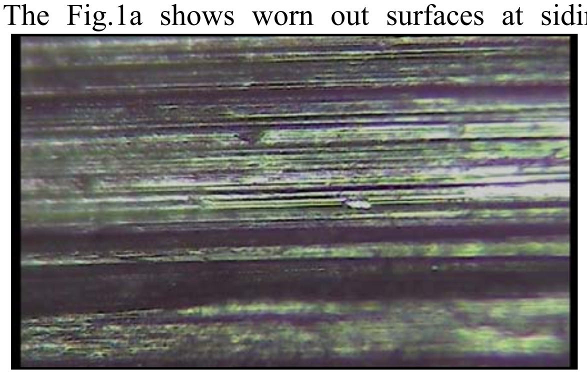


Fig.1c Optical microscopy image of 3m/s at sliding velocity of 10N

Fig.1d Optical microscopy image of 4m/s at sliding velocity of 10N

The Fig.1a shows worn out surfaces at siding



velocity of 1m/s at constant load of 10N. The wear of an alloy is demonstrated by the microphotograph which shows the 2 body abrasive wear mechanism. The plough lines indicate a continuous contours and Al matrix is deformed due to large ductility, however due to Mg, Si hard particles dispersions the wear rate is reduced and small contours indicate that the alloy is harder and act as a resistance to abrasion decreasing the wear rate. Figs. 2(a-d) show the wear rate (volume loss of the material) and (coefficient of friction) against varying load and speed of Al-30Mg_2Si-4Fe alloy.

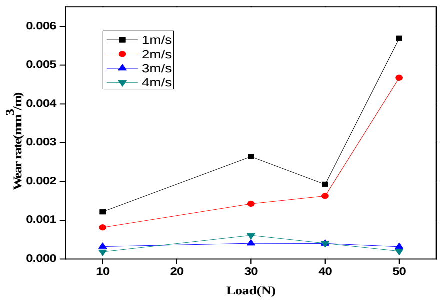


Fig 2a Wear rate v/s Load

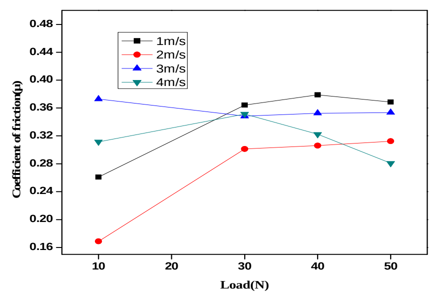


Fig.2b Coefficient of friction v/s Load

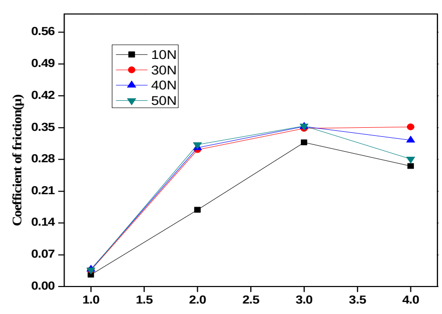
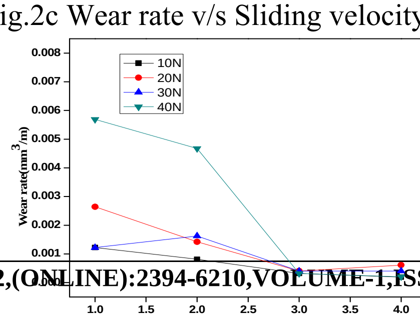
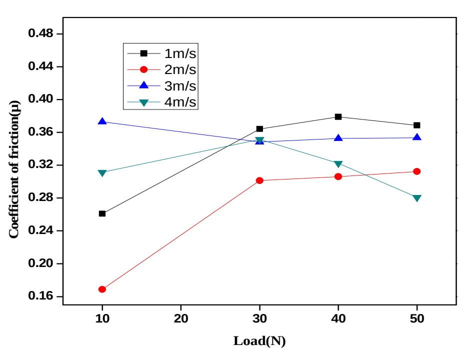


Fig.2c Wear rate v/s Sliding velocity



Fig, 2d Coefficient of friction v/s Sliding velocity

Fig. 2a shows volume loss of material at various loads by keeping sliding velocity constant. It is observed that wear rate increases as load increases but decreases as the sliding velocity decreases. Fig. 2b shows coefficient of friction at various loads by keeping sliding velocity constant. It is clear from the graph that the coefficient of friction increases with an increase in the load up to 30N and further a sudden decrease in the slope is observed from 30 to 50N. This sudden decrease occurs with a increases in the sliding velocity. Fig. 2c shows wear rate against sliding velocity with a constant load. In this graph the wear rate decreases as the sliding velocity increases up to 3m/s and further shows linearity from 3 to 4m/s. This might be due to the transition from abrasive to abrasion wear mechanism and finally Fig. 2d shows a graph coefficient of friction at various sliding velocity with constant load. This graph reveals that coefficient of friction increases at initial point of sliding velocity 2m/s and then gradually decreases at 4m/s but decreases with the increase in the constant load.



IV. CONCLUSION

1. An alloy with many elements will exhibit higher wear resistance then just one element.
2. At 40N wear rate gradually decreased and then sudden increase at 50N with the different constant sliding velocity.
3. Whereas coefficient of friction decreases with increase in load.
4. At varying speed there is increase in wear rate as speed increases with different constant load.
5. Coefficient of friction decreases with increase in speed, as contact surface time is less.

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