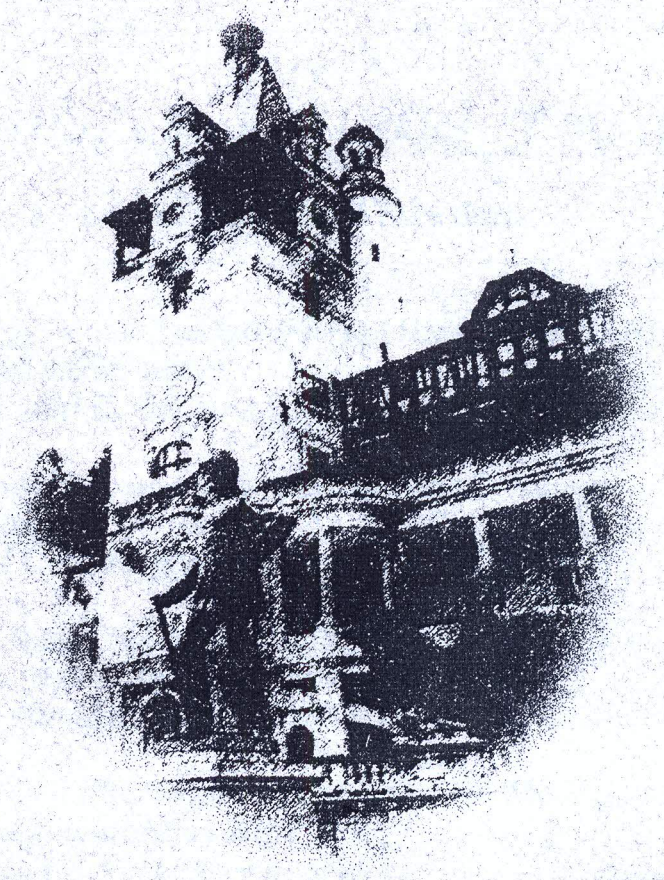
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WEAR BEHAVİOUR OF SOLUTİON-TREATED AND AGE HARDENED 2014AL ALLOY AT ELEVATED TEMPERATURE

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ABSTRACT

The 2014 Al (ETIAL-21) alloy was dry sliding against 100Cr6 bearing steel on pin-on-ring sliding wear testing machine. Experiments were performed at elevated temperatures between 50 ^{0}C-200 ^{0}C for a load of 60 N, a speed of 1 ms^{-1} and a test time of 15 min. Also, the effects of speed have been investigated on wear characteristics. It was found that weight loss at elevated temperatures was decreased slightly with increasing oxidation on worn surface. However, the rates of surface roughness and friction coefficient were decreased.

KEYWORDS: Sliding wear, elevated temperature.

1. INTRODUCTION

There has been an increased use of aluminum alloy in tribological systems in recent years due to excellent resistance to corrosion, superior fatigue resistance, good thermal conductivity. Wan et.al. / 1 / investigated the effect of the oil on the wear behaviour of aluminum. They found that base stock without any additives is a good lubricant for aluminum. D.Odabaş et.al. studied changes in the reciprocating and continous abrasive wear of solution-treated age-hardened 2014 Al alloy / 2 /. They found that the values of the average roughness of the worn surfaces for the reciprocating wear higher than those for the continous wear. This is because the values of the wear loss and abrasive wear coefficient for continous wear were higher than those for the reciprocating wear. Tribological properties of Al-Cu-SiC composite pins against 4Cr13, T1 steel and Si_3N_4 ceramic blocks have

been investigated in a pin-on-block reciprocal friction testing machine / 3 /. Li et.al. / 4 / studied dry sliding wear on as-cast and heat treated Al metal matrix composites. In situ prepicitation was found to occur in the subsurface during the sliding wear of the as-cast Al composites. The nature of the wear process changes with alloy composition and experimental conditions / 5 /. Sliding wear of alumina is strongly dependent on the nature and severity of contact, test temperature, environment and geometrical configurations. Wear and wear transitions of alumina depend on operating parameters, environment and microstructure of materials / 6 /. In this study, the effects of elevated temperature on the sliding wear of 2014 Al alloy against 100Cr6 bearing steel have been investigated using pin-on-ring methods.

2.EXPERIMENTAL DETAILS

2.1.MATERIAL AND ITS PREPERATION

In this study, 2014 Al (ETIAL-21) alloy with higher Cu content was chosen as a test material. For this test material, chemical analysis (wt.%) was: Fe 0.26; Si 0.81; Cu 4.18; Mn 0.67; Mg 0.72; Zn 0.02 and Ti 0.019 / 7 /. This alloy is used for heavy-duty forgings, aircraft fittings and truck frames in general. 2014 Al alloy was fabricated by casting in a metal mold at Seydişehir Aluminum Co.in Konya, Turkey. After casting, the homogenization heat treatment was applied to the alloy at 500 ^{0}C for 2 h and the hot-pressed billets with a 45 mm in diameter were extruded at 450 ^{0}C into rods with a 16 mm in diameter with an extruded ratio 3:1. After the rods were left for cooling at the room temperature, they were straightened by a 3% plastic deformation. The specimens were prepared from rods for wear tests. The specimens to be used for the wear tests were blocks 11.5x14x19 mm in size.

Before the wear test, the specimens were solution treated in a muffle furnace and then quenched in cold water (at 15 ^{0}C). Later, the ageing treatment was carried out at 185 ^{0}C for 8 h in the furnace.

2.2.APARATUS AND EXPERIMENTAL PRODECURE

PLINT universal friction and sliding wear test machine was used in this study. A new specimen holder was made according to our object. The heater and thermostat were mounted into the specimen holder. The ring with 30 mm in diameter was driven by an electric motor. The speed of the ring and temperature of the specimen are adjusted using of A.C. Control Unite. Before and after testing, the pin and ring were cleaned using acetone and dried in hot air. The pins

and rings were weighed in an electric balance with a sensivity of 0.1 mg. Friction coefficient was calculated using the graphics of the friction forces which were drawn by means of X-Y recorder. Sliding wear tests were carried out on 2014 Al alloy varrying temperatures and speeds. The worn surfaces of the pin and ring were characterised by optical microscopy, profilometer, SEM and ED-X.

Before the wear tests, the contact surfaces of pins were polished with 1000 grit size SiC paper. The initial average roughness of pins and rings were Ra= 0.49 μm and 0.50 μm, subsequently. Ring material was used 100Cr6 for a counterpart.

3.RESULT AND DISCUSSION

3.1.THE SOLUTION-HEAT TREATMENT AND MICROSTRUCTURE

Solution treatment of the 2014Al alloy was carried out at temperature of 475 ^{0}C for 1 h in a muffle furnace. Mean average value of brinell hardness was 132 HB. In the ageing, fine particles of $CuAl_2$ formed and precipitated in solution as shown in figure 1. As shown figure 1, the structure consisted mainly of dark, insoluble particles of a complex compound of Fe, Mn, Si, Al and a few particles of $CuAl_2$ (white) in a matrix of α solid solutions.



Fig.1. Microstructure of solution-treated 2014 Al alloy after ageing treatment (solution-treatment duration = 1h, etched in Keller's reagent). Solution-treating temperature of 470 ^{0}C. Mag. X500

3.2.WEAR CHARACTERISTICS

3.2.1.THE EFFECTS OF ELEVATED TEMPERATURE

The variations of weight loss in milligrams of the 2014 Al-pin-sliding wear against 100Cr6 bearing steel between 50 ^{0}C -200 ^{0}C are shown in figure 2.a for a speed of 1 ms^{-1}, a load of 60 N and a sliding distance of 900 m. With increasing temperature, the weight losses of pins decreased slightly from 50 ^{0}C to 200 ^{0}C. But, the weight losses of rings were increased from 0.0 to 1.90 mg. At 50 ^{0}C, the weight loss of pin is maximum. While temperature was increased, the crack on the worn surface was observed verticaly against sliding direction by optical microscopy as shown in figure 3. Those cracks could be occurred sudden cooling.

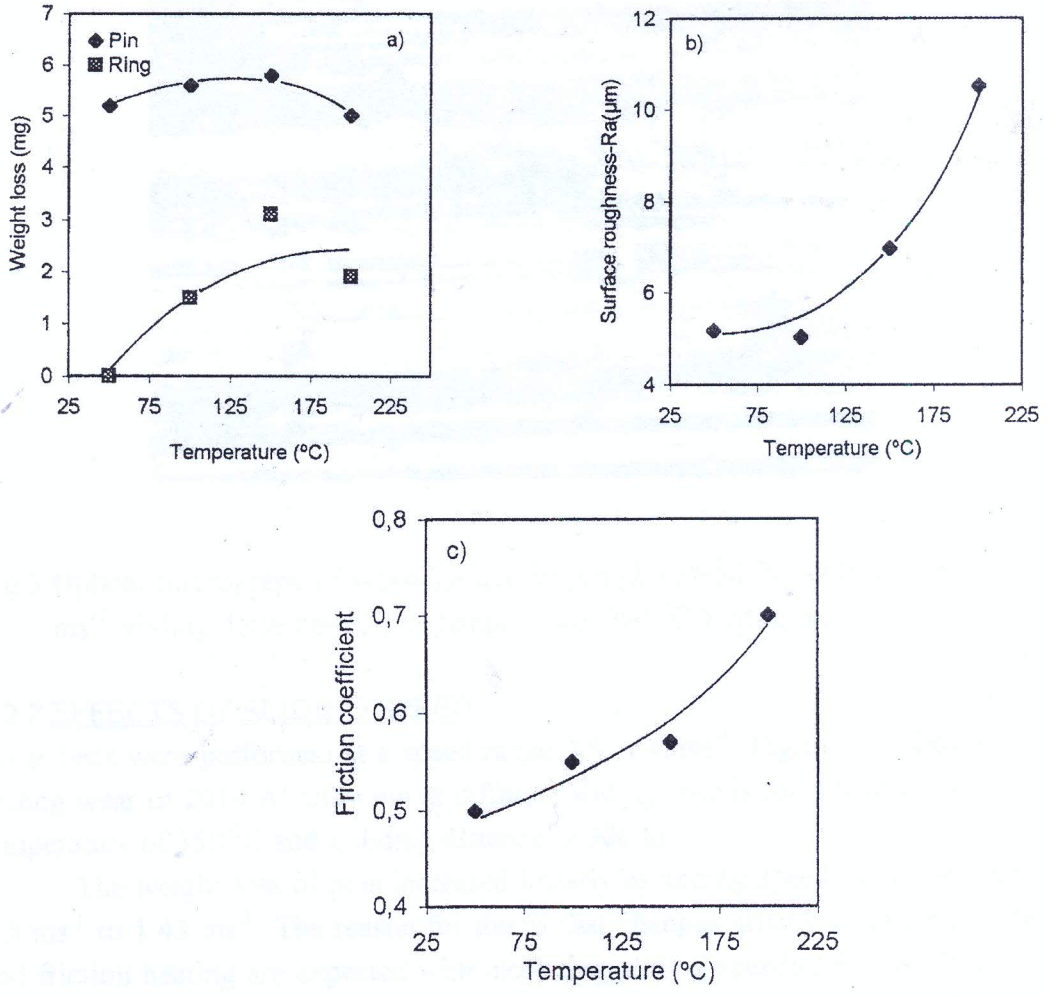


Fig.2.The effects of elevated temperatures on the wear characteristic of 2014 Al alloy. a) Weight loss, b) Surface roughness and c) Friction coefficient.

Profilometer was used to describe the surface roughness. The surface profiles of the worn surfaces of pins are shown in figure 2.b. Increasing tempeature led to abrupt surface roughness increase, e.g. at increased temperature of 100 ^{0}C. It was found that the surface roughness was smooth at low temperature. With increasing temperatures over 100 ^{0}C, worn surface became rougher.

Figure 2.c. shows the dynamic friction coefficient as a function of temperature corresponding to figure 3. It can be seen from this figure that the friction coefficient was increased with an increase in the temperature from 0.50 to 0.70.



Fig.3.Optical micrograps of worn surface of pin (Load=60 N, sliding speed = 1 ms^{-1}, sliding distance=900 m, temperature=200 ^{0}C). Mag. x100

3.2.2.EFFECTS OF SLIDING SPEED

Wear tests were performed at a speed range 0.5 -1.43ms^{-1}. Figure 4.a. shows the sliding wear of 2014 Al alloy pin at different sliding speeds for a load of 60 N, a temperature of 150 ^{0}C and a sliding distance of 900 m.

The weight loss of pins increased linearly as sliding speed increased from 0.5 ms^{-1} to 1.43 ms^{-1}. The reason for this is that changes arising from strain rate and friction heating are expected with increasing sliding speeds / 8 /. While wear of pins increased, wear of rings was decreased slightly. At 0.5 ms^{-1} and 1.43 ms^{-1}, weight losses of pin and ring were exactly different. Particularly, weight loss of

pin is higher than ring for a speed of 1.43 ms^{-1}. At the same speed, the weight loss of ring was increased for 0.8 mg. As shown in figure 5, ED-X analysis has proved that some metals from ring have been transferred to pin for a speed of 0.75 ms^{-1} and a time of 20 min.

Present investigations are suggested that adhesion and ploughing dominated for a speed 1.43 ms^{-1} as shown in figure 4. As hown in figure 4.b., surface roughness is highly big. Figure 4.c. shows that the friction coefficient was high for first two speeds. But, after a speed of 1 ms^{-1}, friction coefficient is increased slightly. With increasing surface roughness, surface contact area between pin and ring is decreased. Hence, friction coefficient was decreased.

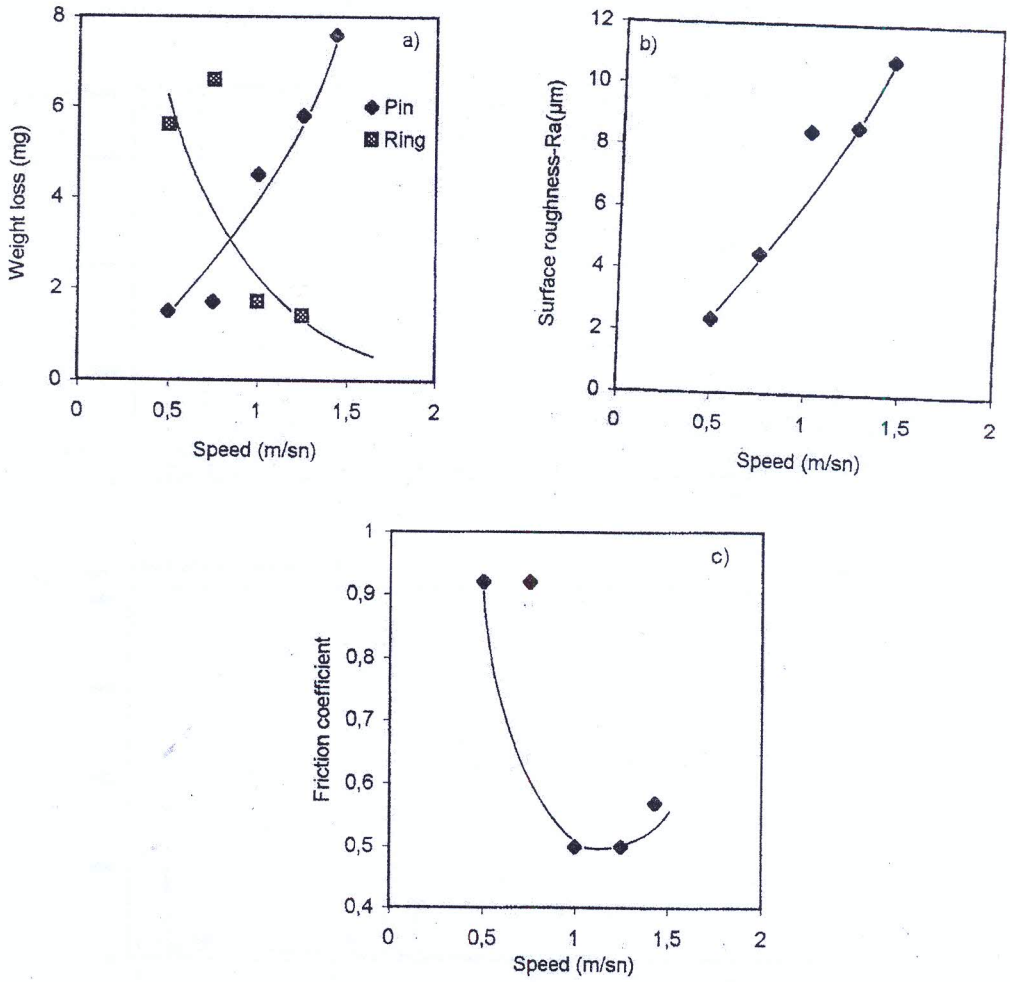


Fig.4.The effects of sliding speed on the wear characteristic of 2014 Al alloy. a) Weight loss, b) Surface roghness and c) Friction coefficient.

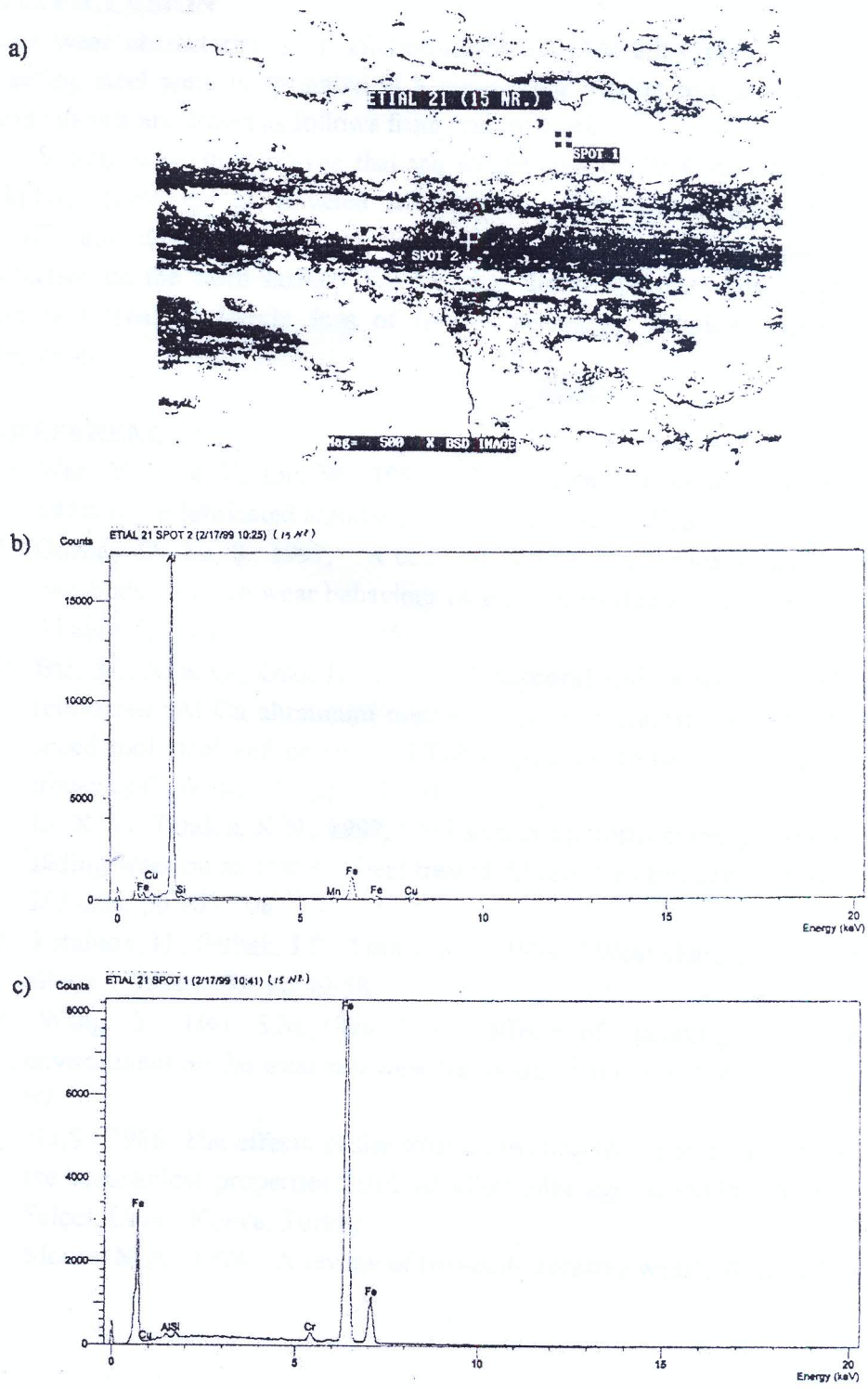


Fig.5.Worn surface of 2014 Al. a) BS image, b) and c) ED-X analyses.

4.CONCLUSION

The wear characteristics of solution-treated 2014Al alloy pins against 100Cr6 bearing steel were investigated in a pin-on-ring friction testing machine. Some conclusions are drawn as follows from present work.

Sliding wear test showed that the weight loss of 2014 Al alloy pin can be slightly decreased at elevated temperatures. Surface roughness and friction coefficient increased. The cracks were observed vertically against sliding direction on the worn surface. For varrying sliding speeds, while weight loss of pin is increased, weight loss of ring is decreased. Friction coefficient was decreased.

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