SLIDING WEAR OF A RRA TREATED HIGH STRENGTH ALUMINUM ALLOY

Sanjay K N[1], Dr. Aprameyan S[2], Suresh K R[3], Santhosh A N[4],
1 Assistant Professor, Department of Mechanical Engineering, C Byregowda Institute of Technology, Kolar -563101
2. Professor & Head, Department of Mechanical Engineering, C Byregowda institute of Technology, Kolar-563101
3. Assistant Professor, Dept. of Mechanical Engineering, Nitte Meenakshi Institute of Technology, Bangalore -64
E mail Address: kn.sanjay62@gmail.com

Abstract – *Age hardenable aluminum alloys belonging to the Al-Zn-Mg family have proved useful as structural materials primarily because of their unique combination of low density, high strength and good corrosion resistance. In the present study an attempt is made to investigate the effect of RRA heat treatment on the wear resistance of AA 7049 high strength aluminum alloy. In the present paper AA 7049 aluminum alloy has been subjected to heat treatment processes of T6 temper, T73 temper and RRA at different conditions. A systematic experimentation has been conducted to evaluate hardness and wear characteristics at various heat treated conditions. Based on the result it has been observed that, hardness is higher for the temperature range of 180^{0}C to 200^{0}C for all the retrogression time durations when compared to T6 temper. When compared to T73 temper hardness is higher for all the retrogression temperatures and time durations except for the temperature of 220^{0}C and 240^{0}C for more than 20 minutes duration.*

Key Words: Age Hardening, Retrogression and Re-aging, Corrosion, Wear, Hardness.

1. INTRODUCTION

Aluminum and its alloys are attractive engineering materials for many applications in chemical, aeronautical, automotive, food and aerospace industries, because of their low density in combination with good mechanical properties and good resistance to degradation in some corrosive environments [1]. However, they often suffer severe damage under the synergistic attack of wear and corrosion in some aggressive media, regardless of their good corrosion resistance [2]. Since poor tribological performance limits the use of aluminum and its alloys in wear related application, many efforts including modification of bulk and surface properties have been made to improve their wear and corrosion wear resistance. High strength aluminum alloys when heat treated with T6 condition have high mechanical properties. However, they are prone to stress corrosion cracking. High strength aluminum alloys when treated with T73 condition have resistance to stress corrosion cracking. However, decrease in mechanical properties.

A two-step heat treatment known as Retrogression and Re-ageing (RRA), has been shown to give high corrosion resistance in 7xxx aluminum alloys equivalent to the T73 temper, together with the T6 strength levels. The concept of retrogression and re-ageing was first developed by Cina in 1974[14], which consist of two steps,

- Retrogression of the 7xxx-T6 material at an intermediate temperature between the ageing temperature and the solutioning temperature.
- Re-ageing of the retrogressed alloy at 120^{0}C for 24 hrs.

In this present investigation the effect of Retrogression and Re-ageing on properties such as the hardness, wear resistance on the aeronautical grade extruded AA 7049 high strength aluminum alloy has been studied. The effect of RRA treatment is compared with T6 temper and T73 temper conditions.

1.1 EXPERIMENTS

Heat treatments were carried out at three different conditions namely, T6 temper, T73 temper and different retrogression & re-ageing tempers. The T6 temper heat treatment consists of solutionizing the samples at 470^{0}C for duration of 120 minutes, followed by quenching in water at room temperature. Further, these quenched samples were subjected to ageing process, which comprises of heating the test samples to 120^{0}C in a muffle furnace, holding the same test sample for duration of 24 hours and then removal of test sample from the furnace and allowed to cool to room temperature in air. The T73 temper heat treatment mainly comprises of solutionizing and 3 steps of ageing processes. The solutionizing is a process (similar to T6 temper) where in the test samples were heated to 470^{0}C in a solutionizing furnace, hold the

same test samples for duration (soaking duration) of 120 minutes in the furnace and then subsequently water quenched. Further, the solution treated samples were left for natural ageing (room temperature) for a period of 48 hours. Then the samples were subjected to two steps of artificial ageing. The first step of ageing was carried out at a temperature of 120^{0}C for duration of 24 hours in an ageing furnace (muffle furnace) and the test samples were air cooled to room temperature. The second step of ageing was carried out at a temperature of 160^{0}C for duration of 14 hours in an ageing furnace and air cooling to room temperature.

Prior to retrogression and re-ageing treatment (RRA), all the test specimen were first subjected to T6 temper heat treatment. The RRA heat treatment (T77 temper) schedule comprises of retrogression and re-ageing processes. The retrogression is a process, wherein test specimens already heat treated to T6 temper, are directly introduced into the furnace maintained at temperatures ranging from 180^{0}C to 240^{0}C in a step of 20^{0}C for a time duration varying from 2,5,10,15,30,45 & 60 minutes in a solutionizing furnace. All the specimens were water quenched after retrogression treatment and subsequently subjected to re-ageing process at 120^{0}C for duration of 24 hours. After ageing treatment the samples were air cooled to room temperature. Solution treatment was carried out in an electrical resistance furnace type with natural air circulation. This furnace consists of refractory brick lining to maintain the temperature at stable condition.

Hardness has been measured by hardness tester on Brinell Hardness Scale. INDENTEC Hardness testing machine was used to measure the hardness on Brinell hardness scale. Specimens were machined to the dimensions of 15mm diameter and 15mm thickness.

Experiments are conducted in the Pin-on-disc type Friction and Wear monitor with data acquisition system, which is used to evaluate the wear behaviour of the developed alloy, against hardened ground steel disc having hardness 65 HRC and surface roughness (Ra) 0.5 µm. The disc rotates with the help of a D.C. motor; having speed range 0-800 rpm with wear track diameter 40 mm-80 mm, which could yield sliding speed 0 to 10 m/sec. Load is to be applied on pin (specimen) by dead weight through pulley string arrangement. The test specimen diameter is of 6mm and length 40mm. The tests were carried out with a sliding speed of 400 rpm with a wear track diameter of 40 mm for load of 1 kilogram for sliding time of 30 minute.

Fig. 1 Photograph showing real test specimen utilized for wear test

2. RESULTS & DISCUSSION

The hardness for T6 temper was 182 BHN and for T73 temper was 167 BHN. From chart 1, the following observations are evident. In the temperature range of 180^{0}C to 200^{0}C, it is seen that the hardness value achieved is above T6 temper for all retrogression time duration employed in this investigation. At higher retrogression temperature range of 200^{0}C-240^{0}C, it has been seen that peak hardness occurs at 10 minutes retrogression time. The maximum hardness of 196 BHN is observed in the RRA 180-30 and RRA 220-10 regime. There is appreciable drop in hardness at higher retrogression temperatures and higher time durations. Hardness for all the RRA tempers is higher compared to T73, except for samples retrogressed at 220^{0}C & 240^{0}C for more than 20 minutes duration.

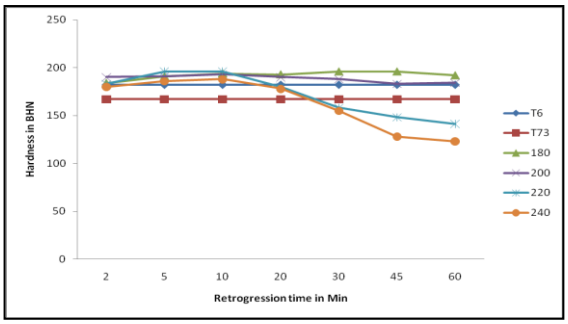

Chart -1: The variation of Hardness with Retrogression time

2.1 Effect of heat treatment of Wear rate

The wear rate data evaluated at 400 rpm for duration of 30 minutes at a load of 1 kilogram have been presented. The same response of the material retrogressed at 180^{0}C, 200^{0}C, 220^{0}C and 240^{0}C, for different retrogression time durations followed by re-ageing have been illustrated in charts 3 to 5.

The wear rate for the test samples heat treated to T6 temper and T73 temper have been superimposed in these charts for the sake of comparison.

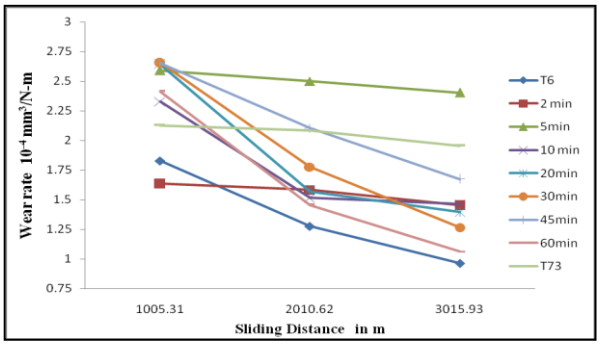

Chart 2: Variation of wear rate of AA7049 aluminum alloy subjected to retrogression at 180^{0}C for various time durations, followed by re-aging.

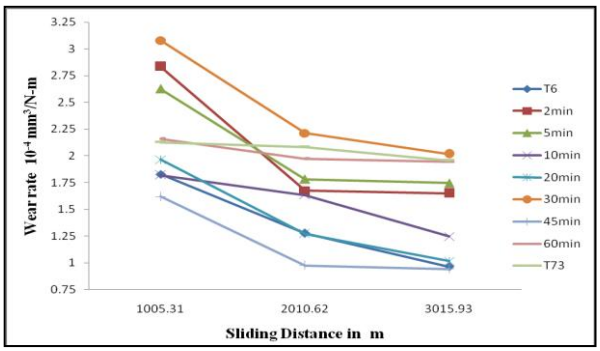

Chart 3: Variation of wear rate of AA7049 aluminum alloy subjected to retrogression at 200^{0}C for various time durations, followed by re-aging.

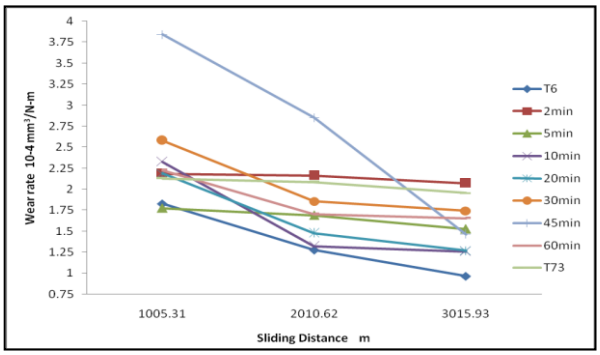

Chart 4: Variation of wear rate of AA7049 aluminum alloy subjected to retrogression at 220^{0}C for various time durations, followed by re-aging.

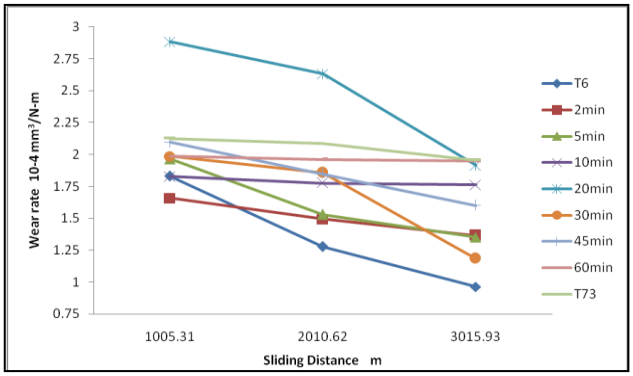

Chart 5: Variation of wear rate of AA7049 aluminum alloy subjected to retrogression at 240^{0}C for various time durations, followed by re-aging.

From the chart 2 the following observations are evident. For the temperature of 180^{0}C it is has been seen that the resistance to wear is less than the T6 temper for all the retrogression time From Figure 1 it can be seen that the wear decreases gradually as the sliding distance increases and also the wear rate decreases gradually for increase in retrogression time. When compared to the T73 temper condition it is seen that there is more resistance to wear.

From the chart 3 the following observations are evident. For the temperature of 200^{0}C it is has been seen that the wear rate decreases gradually for all the time lengths. It can also be observed that the resistance to wear for the retrogression time of 45 minute is more when compared to T6 temper condition. And also has more improvement in wear resistance when compared to T73 temper condition except for retrogressed time duration of 30 minute.

From the chart 4 the following observations are evident. For the temperature of 220^{0}C it is has been seen that the resistance to wear is less than the T6 temper for all the retrogression time and can be seen that the wear rate decreases gradually as the sliding distance increases and also decreases gradually for increase in retrogression time. When compared to the T73 temper condition it is seen that there is more resistance to wear for all time lengths except for 45 minutes retrogressed time.

From the chart 5 the following observations are evident. It is has been seen that the resistance to wear is less than the T6 temper for all the retrogression time and the wear rate decreases gradually as the sliding distance increases and also the wear rate decreases gradually for increase in

retrogression time. When compared to the T73 temper condition it is seen that there is more resistance to wear.

3. CONCLUSIONS

Based on the results obtained by carrying out heat treatment on high strength aluminum alloy confirming to AA 7049 alloy specification and systematic experimentation the following conclusions are drawn.

1. The effect of RRA heat treatment on hardness in terms of BHN has achieved the values above the T6 temper for retrogression temperature of 180^{0}C and 200^{0}C for all retrogression time durations. The higher hardness is observed for retrogression temperature range of 200^{0}C to 240^{0}C for retrogression time of 10 minutes. And also there is appreciable drop in hardness at higher retrogression temperature and higher time lengths
2. The hardness is higher for all the RRA treated samples compared to T73 temper, except for samples retrogressed at 220^{0}C and 240^{0}C for more than 20 minutes duration.
3. The effect of RRA on wear rate reveals that there is a gradual decrease in wear rate as the sliding distance and the applied load increases. It is found that for a retrogression temperature of 200^{0}C and the retrogression time of 10 & 45 minutes there is improvement in wear resistance when compared to T6 temper condition.
4. The improvement in wear resistance can be found for all the retrogression temperature and time durations when compared to T73 temper condition except for retrogression time of 30 minutes and above.

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