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Effect of rotational speed on dimensional wear coefficients of solution treated Al-Mg-Si and Al-Zn alloys tested in abrasion condition

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ABSTRACT - In our study, the effect of disk rotational speed on abrasive wear coefficients of solution treated Al-Mg-Si and Al-Zn alloys was evaluated. The abrasion tests were done at rotational speeds of 50-200RPM. A constant load of 10 N was applied. The grit size of abrasive sheet (emery paper) was 100µm.The tests were conducted on 60mm and 120mm Track diameters. The volume loss and dimensional wear coefficients were calculated and plotted with respect to rotational speeds. In the present set of experiments, as the rotational speed increases, the volume loss increased for both the alloys, wear coefficients slightly increased for Al-Mg-Si alloy and wear coefficients slightly decreased for Al-Zn alloy.

1. INTRODUCTION

The wear of alloys and composite materials have been studied especially in sliding and abrasion conditions since decades. It was noted that the abrasive wear was a most frequent wear mechanism along with sliding action in automobile engines, as it would ultimately affect the efficiency in process of combustion [1-4]. Many investigative studies ranging from material development to generation of wear mechanisms were done at different test conditions in the process of improving the wear properties [1-6].

Recently, Kaushik et al. [5, 6] reported on the types of independent and dependent variables in the abrasive wear process. The discussion on the interaction between pin surface and abrasive grit during wear was noticed. The parameters would affect the wear phenomenon positively or negatively depending on their combination adopted. It was further noted that limited attempts were made in the effect of rotational speed in the abrasive wear process. Hereby, an attempt has been made in this study to understand the effect of rotational speed on abrasive wear characteristics of solution treated alloys.

2. METHODOLOGY

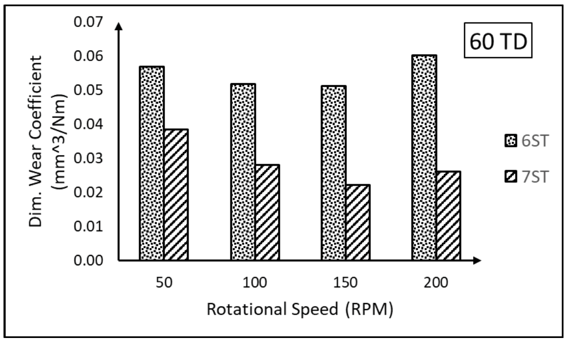
The 10mm diameter cylindrical rods of Al 6061 alloy (Al-Mg-Si alloy) and Al 7075 alloy (Al-Zn alloy) having densities of 2.70 and 2.81 g/cc respectively were chosen for the present study. The rods were machined to cylindrical pin samples of 27mm length and 8mm diameter. These obtained samples were subjected to solution treatment as per ASTM standards. The solution treatment procedure consisted of pin sample heat treatment followed by quenching in water at room temperature. The adopted heat treatment temperature for Al 6061 alloy was 530℃, 3 hours and for Al 7075 alloy was 490℃, 3 hours. After water quenching, the samples were polished to ~1µ surface finish prior to abrasive wear testing. The Vickers hardness of 6ST and 7ST samples were measured to be 97 and 173 HV respectively at 100g indentation load.

The abrasion wear tests of samples were conducted on the modified pin-on-disk machine at 10 N applied load, 50-200 RPM rotational speeds (RS), track diameter (TD) of 60 mm & 120 mm and time duration of one minute. The samples were made to slide against P150 SiC emery paper (of grit size ~100 µm) bonded on the disk for each wear test. The volume loss and dimensional wear coefficient i.e. specific wear rate was calculated from weight loss (initial and final weight of sample during wear test) obtained. The results were represented in graphs which was discussed briefly in the next section.

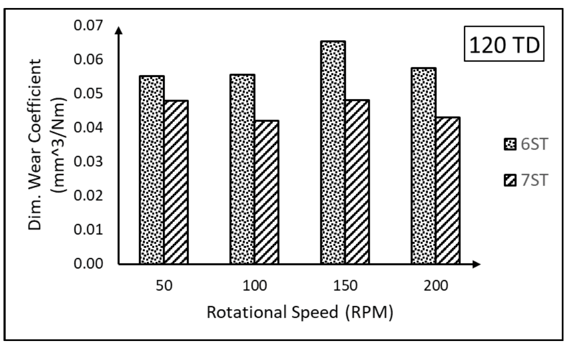
3. RESULTS AND DISCUSSION

The influence of disk rotational speed on obtained volume loss and wear coefficient results of solution treated aluminum alloys were briefly reported in this section. Figures 1(a) and (b) indicate the dimensional wear coefficients of samples tested at 60 mm and 120 mm TD respectively. A change is the wear coefficient at different rotational speeds is shown. For 6ST alloy the wear coefficient vs rpm graph was observed to be parabolic in nature. At same 150 rpm rotational speed minima of 0.051 mm^3/Nm was seen at 60 mm TD and maxima of 0.065 was seen at 120 mm TD. Similar results were obtained for 7ST alloy with minima of 0.022 mm^3/Nm and maxima of 0.048 mm^3/Nm at the same test conditions. This could be attributed to the dissimilar changes in rate of grit particles becoming blunt and distance abraded by the particles. However further investigation needs to be done on the surface of the emery sheets used. It was observed that the 6ST samples underwent more wear than 7ST samples at same test conditions. This behavior can be consolidated due to the higher hardness of 7ST alloy. This observed trend was in line with Archard's wear equation [8].

Figures 2(a) and (b) are the worn surface images of the samples tested at 120 mm TD and 50 rpm. It was noted that continuous parallel groves formed over the pin surface in the direction of sliding during abrasive wear process. The wear tracks formed due to abrasion indicate the plastic flow of the material. At initial stages of the wear the grit particles penetrate deeper into the pin material. The digging phenomenon cases the formation of grooves on the pin surface. The progression of wear depends on the formation, propagation and depth of the groves formed during the process. The presence of peaks and valleys lead to a highly non-uniform pin surface due to which localized friction forces arise. Due to the deterioration of abrasive particles during wear process their cutting efficiency decreases. Hereby, it is noted that the initial few seconds of interaction of pin surface with the fresh grit paper decides the cutting efficiency of the abraders. As time progresses the sliding of the pin on the emery paper releases the wear debris which tend to stay between the valleys of pin surface and emery paper. The abrasive grits on the emery paper would act as micron sized cutting tool and the orientation of the cutting edges decides the material removal during wear process [6,7].



(a)



(b)

Figure 1 Variation of dimensional wear coefficients of Al 6061 and Al 7075 alloys at various rotational speeds and track diameters of (a) 60 mm and (b) 120 mm.

4. SUMMARY

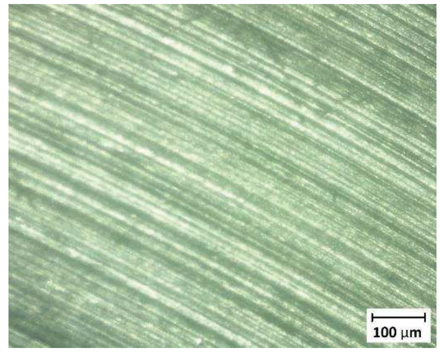
(a) The abrasive wear tests were performed to understand the influence of the rotational speeds on the wear coefficients.

(b) The wear coefficients of 6ST alloy were higher than those of 7ST alloy samples at all test conditions. This is due to higher hardness of 7ST alloy than 6ST alloy.

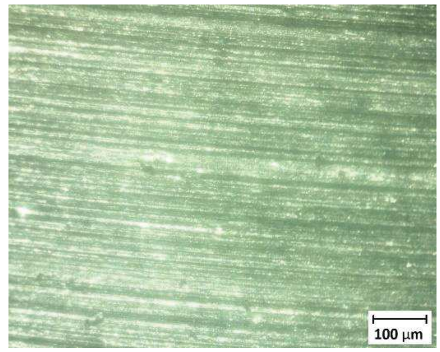
(c) With increase in rotational speeds, the dimensional wear coefficients slightly increased for Al 6061 alloy and slightly decreased for Al 7075 alloy.

(d) The change in wear behavior was observed at 150 RPM at both track diameters.

(e) The cutting and digging efficiency of the abrasive grit depends on the orientation of the grit particles over emery paper surface.



(a)



(b)

Figure 2 Worn surface images of (a) 6ST (b) 7ST samples tested at 120mm TD and 50 rpm rotational speed.

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