AN INTEGRATED TRANSIENT AND STEADY-STATE ADHESIVE WEAR MODEL

1. INTRODUCTION

Wear coefficient is an important wear parameter. However, its value is often determined from wear tests which are conducted without taking into account both their transient wear and steady-state wear. This has resulted in wear coefficient values varying greatly from one case to another when they are determined by different investigators, making meaningful comparison difficult. Research work done recently has found that more consistent steady-state wear coefficient values would be obtainable with the application of an integrated transient and steady-state adhesive wear model. Figure 1 shows that a wear volume versus distance curve can be divided into two regimes, the transient wear regime and the steady-state wear regime. The volume (or weight) loss is initially curvilinear and the rate of volume loss per unit sliding distance decreases until at P where it joins with the straight line PQ. The amount of volume loss in the regime given by OP is the transient wear and PQ is the steady-state wear. The standard method to calculate the wear coefficient is to make use of the total volume loss and the total sliding distance covered. Hence the standard wear coefficient value obtained from a volume loss versus distance curve is a function of the sliding distance. Due to the higher initial running-in wear rates, it has a higher value initially and will reach a steady-state value as shown in Fig.3. This practice would therefore give a higher steady-state wear coefficient value since the higher wear rate from the transient wear is included in its computation. Furthermore, it is sometimes difficult to decide whether the steady-state wear has actually reached in an experiment.

2. THE INTEGRATED ADHESIVE WEAR MODEL

In the integrated wear model, the original Archard equation was modified to enable the net steady-state wear coefficient to be determined more precisely, by excluding both the transient wear volume and transient sliding distance in its computation. Two different equations are used in the integrated wear model: an exponential equation to model the transient wear (Eq.1); while a revised Archard equation to model the steady-state wear (Eq.2). The transient distance ($L_t$) is determined by Eq.3; and the original Archard equation is shown in Eq.4.

\[
V_t = A[1 - \exp^{-BL_t}] 
\]

\[
V_S = K_N \frac{PL_S}{3H} 
\]

\[
L_t = -\frac{\ln[V_S/ABL_S]}{B} 
\]

\[
V = K_S \frac{PL}{3H} 
\]

where $V_t$ is the transient wear volume, $L_t$ is the transient distance, $A$ and $B$ are experimental constants, $V_S$ is the steady-state wear volume, $K_S$ is the standard wear coefficient, $P$ is the applied load, $H$ is the hardness of the softer material, $L_S$ is the steady-state sliding distance, $K_N$ is the net steady-state wear coefficient, while $V$ and $L$ are respectively the total wear volume and total sliding distance used in the original Archard equation.
3. EXPERIMENTAL TECHNIQUE

Wear tests for MMC-A, MMC-B and MMC-C, with 10%, 15% and 20% of alumina particles respectively, were carried out at distances from 250m to 12000m by using both the standard stationary pin-on-disc test and the moving-pin technique. The moving technique was again used in the current study as the aluminum alloy matrix composites containing alumina could be abrasive to cause a rapid wear of the disc which was made of Assab tool steel (equivalent to AISI-01) and hardened to 60HRC. The disc had a surface finish of 0.3µm (Rₐ). A constant load of 7.5kgf and a linear velocity of 4.58m/s were used. Weight loss data were collected, and the constants A and B were determined by using a standard commercial software. The standard wear coefficients of the specimens were calculated by using Eq.4 for both the transient wear and the steady-state wear. The proposed Eq.3 and Eq.2 were used to calculate the transient distance values and the net steady-state wear coefficient values respectively.

4. RESULTS

Figures 2, 3 and 4 show respectively the wear volume versus distance curves, the standard wear coefficient versus distance curves; and the net-steady-state wear coefficient versus sliding distance for the three materials. It is clear from Fig.2 that the wear volume versus distance curve can be divided into the transient and the steady-state wear regimes. By comparing Fig.3 with Fig.4, it is obvious that the standard coefficient values vary considerably while more consistent values were obtained with the net steady-state wear coefficients. It is also interesting to note that with the integrated adhesive wear model, a relationship between the transient wear volume and the steady-state wear coefficient can be established.

RELATED PUBLICATIONS:


The Proposed Adhesive Wear Model

\[ V_q = V_t + V_s \]

\[ L_q = L_t + L_s \]

Wear Volume Loss vs Distance

Figure 1. The integrated adhesive wear model.

Figure 2. Wear volume loss versus distance curves
Figure 3. Standard wear coefficient ($K_s$) versus distance curves

Figure 4. Net steady-state wear coefficient ($K_N$) versus distance curves.

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