Wear Behavior of Magnesium Alloys AZ31B and its Composites

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1. Abstract

In this paper, wear characteristics of magnesium alloy, AZ31B, and its nano-composites, AZ31B/nano-Al2O3, processed by disintegrated melt deposition technique, are investigated. The experiments were carried out using a pin-on-disk configuration against a steel disk counterface under different sliding speeds of 1, 3, 5, 7 and 10m/s for 10N normal load, and 1, 3 and 5m/s for 30N normal load. The worn samples and wear debris were then examined under a field emission scanning electron microscopy equipped with an energy dispersive spectrometer to reveal its wear features. The wear test results show that the wear rates of the composites are gradually reduced over the sliding speed range for both normal loads. The composite wear rates are higher than that of the alloy at low speeds and lower when sliding speed further increased. The coefficient of friction results of both the alloy and composites are in the range of 0.25 to 0.45 and reaches minimums at 5m/s under 10N and 3m/s under 30N load. Microstructural characterization results classified different dominant mechanisms at different sliding speeds, namely, abrasion, delamination, oxidation, adhesion and thermal softening and melting.

2. Summary

2.1 Wear rates

Fig. 1 shows the volumetric wear rates of AZ31B and its composites at different sliding speeds and loads. It's apparently seen a trend that the wear rates of both AZ31B and composites were gradually reduced to minimums at a critical speed (~5m/s and 10N or 3m/s and 30N). Subsequently, at above these critical speeds, the wear rate of AZ31B went back to climb up while the wear rates of composites were still modestly decreased. In addition, the increment in normal load led to higher wear rates and a lower critical speed where the wear rates were minimums.

2.2 Wear mechanisms

Worn pin surfaces and wear debris were examined using FESEM equipped with EDS to identify wear characteristics. The analyses revealed the following five wear mechanisms in operation, either in dominance or in tandem with others: abrasion; delamination; oxidation; adhesion; and thermal softening and melting. Moderate differences are observed in both the extent and type of wear mechanisms present between the monolithic alloy and the reinforced composites for each corresponding test condition. To better summarize the wear mechanisms of AZ31B and its composites, a wear map between normal loads versus sliding speeds is constructed and shown in Fig. 2. Transitions from one mechanism to another are gradual, and the boundaries delineated are only estimations. The following general trends can be observed:

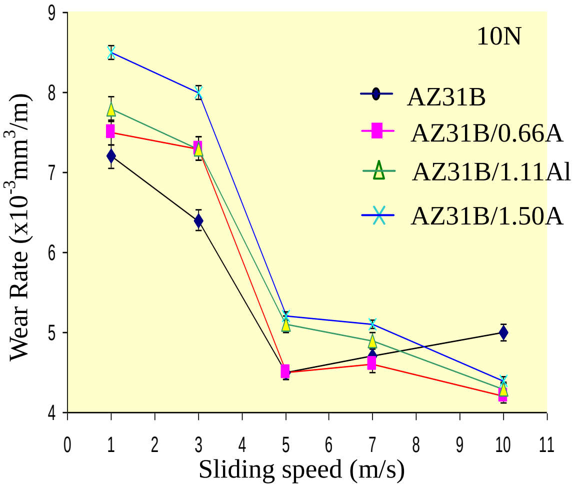

Fig. 1: Volumetric wear rate of AZ31B and its composites at different sliding speeds and loads.

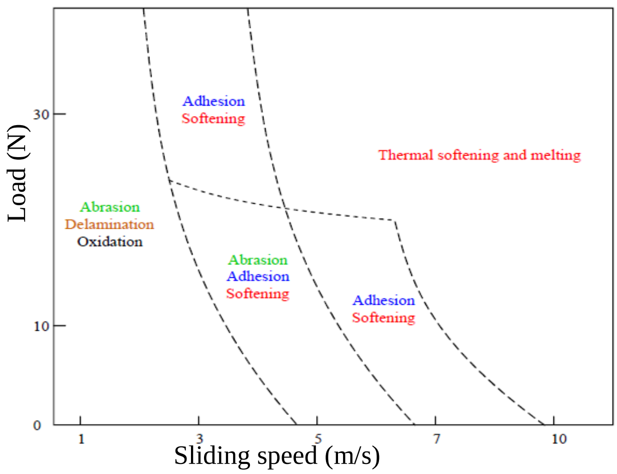

Fig. 2: Simplified wear mechanism map depicting wear behavior of AZ31B and its composites.

3. References:

[1] Stachowiak GW and Batchelor AW. Engineering Tribology, 3rd Edition, Elsevier Butterworth-Heinemann; 2005.

[2] Lim CYH, Leo DK, Ang JJS, Gupta M. Wear of magnesium composites reinforced with nano-sized alumina particulates. Wear 2005; 259:620–625.