10th International Conference on Composite Science and Technology
ICCST/10
A. L. Araújo, J. R. Correia, C. M. Mota Soares, et al. (Editors)

Abstract ID-22

ESTIMATING THE SPECIFIC WEAR RATE OF UNIDIRECTIONAL AND WOVEN CARBON FIBER/EPOXY COMPOSITES USING AN ENERGY-BASED MICROMECHANICS MODEL

Billy Cheng, Mark Kortschot

University of Toronto, Canada
billy.cheng@utoronto.ca, mark.kortschot@utoronto.ca

Keywords: woven carbon fibre composites, abrasive wear, fracture mechanics, modelling, micromechanics, energy dissipation, wear resistance, coefficient of friction

Summary: The specific wear rate of composite materials can be expressed as a ratio between friction coefficient and energy dissipated per unit wear volume: $\kappa = \mu / Ev$. In this study, a micromechanics model was developed to estimate the energy dissipated per unit wear volume of unidirectional carbon fiber/epoxy composites in the abrasive wear regime.
Wear testing was performed using unidirectional carbon fiber/epoxy composites, with fibers aligned parallel and antiparallel to the sliding direction. The results showed that fiber orientation had a significant impact on the energy dissipated per unit wear volume, and by extension, the specific wear rates of these composite materials.
From SEM observations, it was determined that the character of the fiber delamination leading to wear particles depended on the orientation of the fibers. In the case where the fibers were parallel to the sliding direction, cracks could only propagate along the fibers, which limited the wear particle volume. However, when the fibers were antiparallel to the sliding direction, cracks could propagate into the composites transverse and normal to the sliding direction, and this generated larger wear particles. Based on these observed wear mechanisms, an energy-based model was developed to estimate the amount of energy required to generate the wear particles for the two different fiber orientations.
To estimate the specific wear rate of woven carbon fiber/epoxy composites, it is proposed that a modified rule of mixtures equation can be used, with the specific wear rates of unidirectional carbon fiber composites as the input variables. A modified rule of mixtures equation was derived using theories adapted from the particle-reinforced metal-composites literature. The abrasive wear of woven composites with heterogeneous surfaces may be modeled in one of two ways. Either 1) the more wear resistant domains bear more load so that the wear rate of the two domains is equal, or, 2) the two domains wear independently and the load is distributed in proportion to the area fraction. It was found that under milder abrasive conditions, the first model was accurate in predicting the specific wear rates of plain and 5HS woven composites. Under more severe abrasive conditions, the second model seems to fit the data more accurately. Furthermore, the same principles were also applied to predict the friction coefficients of plain and 5HS woven carbon fiber composites, with good success.