TRIBOLOGICAL INVESTIGATION OF A LOW FRICTION, LOW WEAR POLYMER/POLYMER COMPOSITE

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INTRODUCTION

Wear resistant and low friction solid lubricants offer the design engineer attractive options for extreme environment lubrication, particularly in situations where the use of fluid lubricants are precluded. Past work with wear resistant PTFE nanocomposites made with sub 100nm particles of alumina showed that the nanoparticles decorate the PTFE surface during jet-milling process. Subsequent compression molding of these powders is believed to result in a compartmentalize PTFE composite. It is hypothesized that these reinforcing nanoparticles arrest crack propagation, although there is qualitative evidence that they weaken strength of the composite. The hypothesis for this investigation was to use small particles of PEEK as the filler, which can act to compartmentalize damage and form a structural filler network that would not require matrix/filler strength for mechanical integrity. The tribological properties of composite samples ranging from 0-100 weight percent PEEK filled PTFE were evaluated in this study.

EXPERIMENTAL SETUP

Hand mixed powders of appropriate proportions of approximately 3 µm PEEK and 20 µm PTFE were jet-milled and subsequently compression molded at 362°C into 19 mm diameter x 25mm long cylinders. Samples measuring 6.4 mm x 6.4 mm x 12.7 mm were machined out of the interior of the cylinders using a laboratory numerically controlled milling machine. A linear reciprocating tribometer was used to evaluate the tribological performance of this material on lapped AISI 304 stainless steel counterfaces with an average roughness of 161 nm Rq. Test conditions include a nominal contact pressure of 6.2 MPa, a reciprocation length of 25.4 mm and a sliding speed of 50.8 mm/s.

RESULTS

In general, the composite samples had lower coefficients of friction than unfilled PTFE and PEEK, which had friction coefficients of μ=0.135 and μ=0.363 respectively. Friction coefficient appears minimum at approximately 50 wt% PEEK filled PTFE.

Figure 1. Friction coefficient for the composite plotted as a function of PEEK filler weight percent. The normal load was 250 N and the sliding speed was 50.8 mm/s.

Figure 2. Wear rate for the composite plotted as a function of PEEK filler weight percent. The normal load was 250 N and the sliding speed was 50.8 mm/s.
with μ=0.111. The wear rates of the composites were much lower than the wear rates of unfilled PEEK and PTFE, which were K=6.0x10^{-4} mm³/(Nm) and K=1.9x10^{-6} mm³/(Nm) respectively. The 32 wt% PEEK filled PTFE sample had the best combination of tribological properties with a wear rate of K=2.0x10^{-9} mm³/(Nm) and a coefficient of friction of μ=0.116.

**DISCUSSION**

Nearly all of the composites had lower average friction coefficients than unfilled PTFE, which is in contrast to what might be expected from a linear rule of mixture. The mechanism for this reduction in friction coefficient is believed to originate from thin running films of PTFE that are drawn out over the PEEK enriched regions. These running films then slide against a transfer film that develops on the surface of the stainless steel counterface. Like friction, wear resistance also fails to follow any rule of mixture explanation. The best performing composite sample is 260,000 times more wear resistant than unfilled PTFE and 900 times more wear resistant than unfilled PEEK.

Characterization efforts for this PEEK and PTFE composite were not successful at revealing the microstructure. However, using agglomerated PTFE (the agglomerations could be millimeters in size) a modified 20 wt% PEEK sample was prepared. An optical micrograph shown in Figure 10 reveals this microstructure, where large continuous regions of PTFE are clearly visible and regions of PEEK with PTFE fibrils comprise approximately 70% of the surface. This composite performed well with a wear rate K=5x10^{-8} mm³/(Nm) and a friction coefficient equal to unfilled PTFE.

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**REFERENCES**
