Chapter 17
Reciprocating Wear Behaviour of Two Dimensionally Reinforced Carbon–Phenolic and Carbon–Epoxy Composites

Sourav Sarkar
Advanced System Laboratory, India

V.G. Sekaran
Advanced System Laboratory, India

E. Badisch
Austrian Center of Competence for Tribology, Austria

Manish Roy
Defence Metallurgical Research Laboratory, India

R. Mitra
Indian Institute of Technology, Kharagpur, India

ABSTRACT

A comparative study has been carried out on performance of two-dimensionally reinforced carbon/phenolic (C/P) and carbon/epoxy (C/E) composites, subjected to low amplitude reciprocating wear at different temperatures. The C/P composite has shown greater wear rate than the C/E composite, with the difference being modest at room temperature, and larger at 250 °C. The values of coefficient of friction, surface roughness, and depths of craters on worn surfaces have been measured, which along with surface morphologies examined by scanning electron microscope have been correlated to both amount of weight loss and mechanisms of damage by wear.

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1. INTRODUCTION

The tribological behaviour of the carbon fibre reinforced composites is believed to be influenced by the nature of matrix, microstructure and fibre architecture of the composites. Wear of components under oscillatory relative motion (either linear or torsional) with small amplitudes of displacement is termed as low amplitude reciprocating wear. Such short amplitude reciprocating sliding between contacting surfaces for a large number of cycles involves fatigue and is also termed as fretting wear. It has been shown that micro-movements involved in the process of reciprocating sliding motion are fundamentally associated with Hertzian contact subjected to a tangential force (Mindlin, 1949). One of the special characteristics of fretting is the prolonged retention of wear debris between the sliding surfaces, when amplitude of sliding is relatively small. It has been shown that such accumulation of debris can cause depressions on the surfaces by deformation (Colombie, Berthier, Floquet, Vincent, & Godet, 1984) due to the development of large contact stresses. Moreover, the temperature may affect the process of fretting in two ways: (12) corrosion and oxidation rates usually increase with temperature; and (ii) the mechanical properties of materials usually change with temperature.

Reinforced polymer based composites are frequently used to make components such as bearing's outer ring and housing, wire ropes, electrical switchgears, multiplayer leaf springs, palliatives, spline couplings, flanges, seals, riveted and pinned joints (Ohmae, Kobayashi, & Tsukizoe, 1974; Bill, 1985; Jocobs, Friedrich, & Schulte, 1991), where fretting wear is commonly observed. A survey of the literature (Chivers & Gordelier, 1984; Vishwanath & Rao, 1991; Sabota & Holy, 2000; Bijwe, Indumathi, & Ghosh, 2002; Bijwe, Indumathi, Satapathy, & Ghosh, 2002; Bijwe & Rattan, 2006; Xiang & Chuanjin, 2006; Rattan & Fahim, 2007; Shangguan & Cheng, 2007; Li & Cheng, 2008) suggests that research on the tribological behaviour of the continuous fibre reinforced composites has received significant attention. On account of their high strength and elastic modulus, corrosion resistance, good friction and wear properties and low thermal expansion, carbon fibres are widely used as fillers in advanced composite materials (Okabe & Takeda, 2002). However, limited information is available about the performance of carbon fibre reinforced composites with phenolic and epoxy matrices. In the present study, the response of two dimensionally (2D) reinforced carbon-fibre reinforced composites having different phenolic or epoxy matrices to reciprocating wear tests under two different test loads at either room temperature or 250 ^{o}C have been compared. These tests could not be carried out at higher temperatures such as 500 ^{o}C, because the rates of vaporization of phenolic and epoxy matrices have been found to be accelerated to an extent that damage by wear becomes less significant.

2. EXPERIMENTAL PROCEDURE

2.1. Processing of Materials

The carbon fibres used in preparation of the 2D C/P composite were PAN- type, and their properties are shown in Table 1. Composites having carbon fibres impregnated with phenolic resin were fabricated by stacking multiple plies in two directions (0^{o} and 90°). The specified constituents and physical properties of the phenolic resin used in this study are shown in Table 2. To remove moisture, the carbon cloth was passed through a preheating chamber with temperature of ~100 ^{o}C. After passage through the preheating chamber, the cloth was fully dipped in the resin and then passed through a roller, where the excess resin was removed from the carbon cloth. Subsequently, the cloth was passed through the prepegging machine operated at controlled temperatures. Then, the prepregs were stacked with a polythene sheet

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