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On the friction and wear behavior of PTFE composite filled with rare earths treated carbon fibers under oil-lubricated condition

Shangguan Qian-qian [a], Cheng Xian-hua [a,b,*]

[a] School of Mechanical & Power Engineering, Shanghai Jiao Tong University, Shanghai 200030, PR China
[b] State Key Laboratory of Solid Lubrication, Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, Lanzhou 730000, PR China

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Abstract

Carbon fibers (CF) were surface treated with air-oxidation, air-oxidation followed by rare earths (RE) treatment and RE treatment, respectively. The friction and wear properties of the polytetrafluoroethylene (PTFE) composites filled with differently surface treated carbon fibers, sliding against GCr15 steel under oil lubrication, were investigated on a reciprocating ball-on-disk UMT-2MT tribometer. The worn surfaces of the PTFE composites were examined using a scanning electron microscopy (SEM). Experimental results revealed that surface treatment of carbon fibers reduced the wear of CF-reinforced PTFE composites. Among all the treatments to carbon fibers, RE treatment was the most effective and lowest friction and wear rate of CF-reinforced PTFE composite was exhibited, owing to the effective improvement of the interfacial adhesion between the carbon fibers and PTFE matrix.

Keywords: PTFE composite; Carbon fiber; Rare earths; Surface treatment; Friction and wear; Oil lubrication

1. Introduction

Polytetrafluoroethylene (PTFE) is a kind of perfect self-lubricating material due to its very low friction coefficient, good high-temperature stability and chemical stability. Yet, it cannot be used as anti-wear material alone because of its poor mechanical properties, bad thermal conductivity and high wear rate. Therefore, various reinforcement and modification of PTFE have been tried [1,2]. Carbon fibers (CF) made by pyrolysis from pitch and polymers are widely used as fillers in composite materials, particularly lightweight polymer–matrix composites, due to their higher stiffness, excellent electrical and thermal conductivity, and high resistance to fatigue and creep. Carbon fiber-reinforced PTFE composites are a class of advanced materials that are being used in applications requiring low friction and wear situations. The tribological properties of carbon fiber-reinforced PTFE composites have been studied by many investigators [3–5].

The properties of fiber and matrix make a critical contribution to the quality of a fiber-reinforced composite. In addition, the physical–chemical interaction at the fiber–matrix interface plays an important role in improving the mechanical properties of a fiber-reinforced composite [6]. Carbon fibers are chemically inert and it is difficult to arrange for them to interact with the resin [7]. Carbon fibers, when used without any surface treatment, produce composites with low interlaminar shear strength which, in turn, affects most of the other mechanical properties [8].

Surface treatment of carbon fiber (e.g. air-oxidation [9] or by using ozone [10], silane [11], glutaric dialdehyde [12], electron beam [13], aqueous ammonia [14], plasma [15] or acidic anode [16]) is useful for improving the fiber–matrix adhesion, interfacial shear strength, etc. However, the interfacial adhesion between carbon fiber and the matrix was not strong enough, which affected the friction and wear properties of the composites. Also, for the most part, an improvement of the coupling often causes a decrease in impact strength, and makes the composite more brittle [8].

Our previous work found that rare earths were superior to the silane coupling in promoting the interfacial adhesion and interfacial toughness between glass fibers and PTFE, and largely enhance the tensile properties and tribological properties of glass

* Corresponding author. Tel.: +86 21 62932404; fax: +86 21 62933772.
E-mail address: xhcheng@sjtu.edu.cn (C. Xian-hua).

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