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Tribological investigation of carbon fiber-epoxy composite reinforced by metallic filler layer

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This work aims to develop a carbon fiber/epoxy composite reinforced by metal fillers (Copper/Stainless steel) in order to improve the tribological properties. For this, a tribological study has been conducted using a ball-on-disc configuration. The surface of the material has been modified by deposing a layer of metal powder during manufacturing. For a better understanding of the wear mechanisms, the worn surface characteristics have been examined using a scanning electron microscope (SEM). The coefficient of friction and the wear rate under different normal loads have been determined for the filled and unfilled composite. The results obtained revealed an increase of the wear rate with the increase of the applied load. Metallic filled carbon–epoxy showed better wear resistance and friction behaviour under different loads. In fact, microhardness measurement showed that the surface hardness has been greatly influenced by the metal filler. The overall results illustrate the impact of metal powders in the modification of polymer matrix composites surfaces. This method is promising to improve the tribological properties.

Keywords: Polymer matrix composites, Metallic fillers, Wear, Coefficient of friction.

1 Introduction

Polymer matrix composites (PMC) are being extensively used in a variety of fields, from aerospace and aircraft to industrial components due to their high specific strength and stiffness compared to metals[1]. In addition, considering a wide variety of matrix, reinforcement materials and the simplicity of the manufacturing process, the usage of this class of materials continues to grow at an impressive rate[2]. Among the family of technical thermosetting polymers, the epoxy matrix is widely used due to attractive mechanical and chemical properties[3]. Moreover, carbon fibers, through their mechanical properties, are frequently used as reinforcement in the high-performance composite; while, fibers glass are used as general reinforcement due to quality- price ratio[4, 5]. Under these latter considerations, more and more metal parts are being replaced by PMCs all over the world. Initial applications were focused on structural and semi-structural aircraft components. For many technical applications, wear and friction are critical issues when polymer matrix composites are used under vibrating contact condition. However, these materials present some drawbacks, related in particular to their surface properties, such as tribological behaviour and low wear resistance. Tribological research includes the application of friction principles, wear, and lubrication[6]. Surface's interactions in micro-components are becoming increasingly important for the development of new products for modern industry[7]. It is admitted that the friction and wear are phenomena often leading to efficiency loss and a decrease in the lifetime of mechanical systems[8].

In a review of the literature concerning abrasive wear of polymers, H.H Parikh *et al.*[9] have identified the effect of material parameters and various operating parameters on the tribological behavior of PMC. They conclude that the on wear rate and friction coefficient of the composites depend on the materials selected polymeric matrix and reinforcement, fiber volume fraction, fiber orientation, fiber length, surface treatments, and manufacturing process. Also, the operating parameters greatly affect the tribological behavior of PMC, and the most influenced parameters are load, sliding distance, sliding velocity, and temperature[9]. In fact, B. Suresha *et al.*[8, 10] have concluded that carbon/epoxy composite has higher specific wear resistance than fiber glass/epoxy composite, due to

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