Tribological characterization of carbon nanotubes containing silicon nitride composites under isooctane lubrication

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Nowadays, the automobile industry is progressively imposing the use of gasoline direct injection systems to enhance the fuel efficiency and to reduce, at the same time, the harmful emissions to the atmosphere. The new demanding operating conditions linked to the high injection pressures (above 50 MPa), accompanied by the insufficient lubricating response of the gasoline, promote the extensive friction and wear of the metallic sliding components, which requires the development of new components with improved tribological performances [1]. Advanced ceramic materials can be excellent candidates to overcome those difficulties and, in this way, the good tribological performance of silicon nitride (Si_3N_4) ceramics [2] can be potentially enhanced by the addition of carbon-based lubricants, such as carbon nanotubes (CNTs). Therefore, the aim of this work is to analyze the tribological behaviour of Si_3N_4/CNTs nanocomposites under isooctane lubrication, used in this study as substitute of gasoline.

Homogeneous Si_3N_4 nanocomposites with multi-walled carbon nanotubes (MWCNTs) contents up to 8.6 vol.% were fully densified, avoiding the nanotubes degradation, using the spark plasma sintering technique [3]. The tribological characterization was carried out in a reciprocating ball-on-flat tribotester under isooctane lubrication, mated against commercial Si_3N_4 balls. The sliding tests were conducted with a stroke length of 2.5 mm, a frequency of 20 Hz, a sliding distance of 360 m, and a normal applied load ranging from 50 to 200 N. Friction and wear responses were recorded as a function of the MWCNTs content and applied load. Worn surfaces of the specimens were characterized by scanning electron microscopy and micro-Raman spectroscopy.

The nanocomposites presented an excellent tribological performance compared to the monolithic material. In effect, the friction coefficient decreased up to 40% for the maximum contact load (200 N). Besides, the linear wear decreased with the addition of MWCNTs for all the range of loads, and especially for 50 N, where the maximum reduction of 80% in this parameter was achieved. Moreover, the linear wear for the balls kept constant with the applied load when mated against 8.6vol% MWCNTs nanocomposites, decreasing in ~ 70% the linear wear as compared to the monolithic counterbody. This improved tribological behaviour of these nanocomposites is partly explained by the lubricating effect of the carbon nanotubes, which at the same time retained the properties of the ceramic matrix.

References

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