Abstract for ICMCTF 2023

Symposium E3. Tribology of Coatings and Surfaces for Industrial Applications

"Carbon based coatings deposited over AISI 4140 to improve wear resistance in machine components"

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Carbon based coatings or DLC are well known to have a low friction coefficient, chemical stability at room or low temperatures, high hardness and also corrosion resistance. Three different carbon-based coatings were deposited over plasma nitrided or non nitrided AISI 4140 mild steel to improve hardness and wear resistance so as tribological properties.

One of them is an amorphous hydrogenated thick Si doped DLC (a-C:H:Si) deposited by PACVD, in a Rübig facility in Austria using a DC pulsed discharge, with acetylene and HMDSO as carbon and silicon precursors, respectively. It will be compared with a Si-free DLC (a-C:H) deposited in the same conditions. The third one is a multilayer film with DLC as top coating deposited by the PVD PEMS technique in a Cemecon facility in Argentina. In this case, the anchor layer consists of CrN and the top layer is a chromium-dopped hydrogenated amorphous carbon (a-C:H:Cr).

Full characterization was carried out by SEM, Raman Spectroscopy and XRD. Mechanical properties were obtained with nanoindentation. Tribological behavior was study with Pin-on-Disk tests, evaluating wear loss and friction coefficient, and complementary SEM/EDS analysis on the wear track and on the counterpart. Adhesion was assessed with variable load Scratch Test and Rockwell C indentation method. Abrasion tests following ASTM G65 standard were also conducted.

All coatings contain hydrogen and a combination of sp^3-sp^2 bonding, with high disorder level caused mainly by the dopants. Low coefficients of friction were obtained with the films, between 0.1 and 0.3, being the lowest the Si-free thick DLC reaching 0.06. Regarding the wear rates with alumina as counterpart, only the Si-free DLC and the duplex nitrided steel plus a-C:H:Cr presented a low volume loss. Adhesion was also improved by the plasma nitriding pre-treatment in this coating, which provided a hardness gradient in the substrate to support the load applied. Meanwhile, Si doping improved DLC wear resistance in the case of abrasion tests.

As a conclusion, the thick and Si-free DLC coating has the lowest CoF and wear rate when deposited over mild steel. On the other hand, the thin PVD Cr doped DLC coating presented the best performance when deposited over nitrided steel. This also improved the adhesion comparing to the other two PACVD coatings. The Si-doped DLC failed in the PoD test because of the adhesion with the counterpart, but it presented a good wear resistance in abrasion. Tribological mechanisms, and applications of each type of coating will be discussed.