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Comparison between nitrocarburizing and nitrogen/silicon addition in dlc film on tribological behavior of tool steel AISI M2

Danelon, M.R.(1); Almeida, L.S.(2); Manfrinato, M.D.(3); Rossino, L.S.(3);
(1) UFSCar Campus Sorocaba; (2) UFScar Campus Sorocaba; (3) Fatec Sorocaba;

DLC film is an amorphous carbon thin film that contains carbon hybridizations sp2 and sp3 related to graphite and diamond, respectively. This combination provides high hardness and low friction coefficient improving the wear resistance of the material. The doping of the DLC films with elements like N and Si can be an excellent alternative to change their properties and obtain different results, improving the adhesion or stability of these films at high temperatures. Thermochemical treatments are surface treatments that promote the diffusion of elements like nitrogen, carbon, and boron in the matrix of the material and produce a compound layer that improves the corrosion, wear, and fatigue resistance of the material. AISI M2 steel is utilized in machining and cutting tools, due to its high hardness. The objective of this work is to compare the tribological behavior of M2 steel treated with nitrocarburizing, DLC, N-DLC, Si-DLC film, and untreated material. Treatments were performed using a Pulsed-DC power supply and before treatments, an ablation treatment was performed with a gas mixture of 80%Ar/20%H2 for 1h. Films were deposited by the PECVD technique and after the ablation, an organosilicon film was deposited, to improve the DLC film adhesion, with a gas mixture of 70%HMDSO/30%Ar for 15min. Finally, DLC, N-DLC, and Si-DLC were deposited using a gas mixture of 90%CH4/10% with 30sccm of gas flow, and 70%CH4/30%N2 with 40sccm of gas flow, and 90%CH/8%Ar/2%HMDSO with 30sccm of gas flow, respectively. Treatments were performed with a temperature of 200ºC for 2h. Nitrocarburizing was performed with a gas mixture of 80%N2/15%H2/5%CH4 with a gas flow of 750sccm for 6h. Micro-abrasive wear tests by fixed ball were performed for 120,300,600,900,1200,1500, and 1800s. Craters were performed in the same spot, only varying the time. It was possible to observe that every treatment presented better wear resistance when compared to the base material. The best wear resistance was presented by sample Si-DLC. It's interesting to observe that films DLC and Si-DLC presented similar behavior when tested for 120,300, and 600 seconds but for higher sliding distances the Si-DLC film stands out, and this is justified by the low graphitization rate of the DLC film doped with silicon. Another behavior important to analyze is that nitrocarburizing presented worse wear resistance than DLC film for short sliding distances, but for longer sliding distances the thermochemical treatment also stands out over DLC film, and this can be explained by the depth hardness of nitrocarburizing treatment, which promotes a better wear resistance for longer sliding distances. N-DLC film presented the worst wear behavior when compared to other treatments, due to the reduction of sp3 hybridizations, which decreases the film hardness. Thus, it's possible to conclude that divergent treatments and doping DLC with different elements bring distinct tribological behaviors to AISI M2 steel.