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TRIBOLOGICAL BEHAVIOUR IN DIVERSE TESTING ENVIRONMENTS OF A SELF-LUBRICANT W-S-C COATING DEPOSITED BY CFUBMS

Todor Vuchkov [ab*], Manuel Evaristo [b], Talha bin Yaqub [ab], Tomas Polcar [cd], Albano Cavaleiro[ab]
* Corresponding author: todor.vuchkov@ipn.pt
[a] IPN - LED & MAT - Instituto Pedro Nunes, Laboratory for Wear, Testing and Materials, Rua Pedro Nunes, 3030-199 Coimbra, Portugal
[b] SEG-CEMMPRE, Department of Mechanical Engineering, University of Coimbra, Rua Luís Reis Santos, 3030-788 Coimbra, Portugal
[c] Department of Control Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague, Technická 2, Prague 6, Czech Republic
[d] nCATS, University of Southampton, University Road, Southampton SO17 1BJ, UK

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ABSTRACT
Transition metal dichalcogenide based coatings alloyed with carbon show very promising tribological behavior, providing reduction of friction and wear in various testing environments (normal air, dry nitrogen, vacuum) [1,2].Coatings providing good tribological response presented in the literature were often deposited in a laboratory scale deposition units by RF magnetron sputtering [2]. In this study W-S-C coating was deposited by closed field unbalanced magnetron sputtering (CFUBMS) in a semi-industrial deposition unit (Teer UDP 650/4) equipped with 4 magnetrons. The coating had ~40 % at. of carbon with a S/W ratio of 1.47. Cross-sectional imaging was performed using field-emission scanning electron microscope (FESEM). The coating had dense and featureless morphology, with a thickness of ~2.3 µm including a ~400 nm Cr interlayer. The hardness of the coating was ~5.7 GPa. Tribological studies were performed at normal laboratory air (RH=30-40%) with 2 different loads, elevated temperatures (up to 400°C), vacuum ($p<10^{-3}$ Pa) and dry N_2 environments. Unidirectional pin on disk apparatus was used for performing the tests. The counterbodies were 100Cr6 bearing steel balls and the sliding speed was set at 0.1 m/s, unless otherwise noted. Tests performed at normal laboratory air with 5 N of load resulted in coefficient of friction (COF) of 0.15-0.2 with specific wear rates of $\sim 3\text{x}10^{-7}$ mm^3/Nm. Raman spectroscopy performed on the tribolayers formed on the bearing steel balls showing presence of graphitic carbon. Testing with 35 N of load resulted in reduction of COF (~0.06). Raman spectroscopy performed on the tribolayers showed presence of well oriented WS_2 on the sliding interface. Testing at elevated temperatures was marked with significant reduction of COF, with average values of ~0.01. Specific wear rates were an order of magnitude higher for the higher temperature tests compared to RT tests with values of $\sim 3\text{x}10^{-6}$ mm^3/Nm. Raman spectroscopy performed on both sliding partners showed well defined peaks related to WS_2, peaks that are not observed on the coating in the as deposited state. Vacuum tests were initially performed against 100Cr6 balls, and the friction was high, reaching values up to 0.7-0.8. Further tests were done with the ball being coated using the same coating. Friction was much lower during the first 1000 cycle (<0.01), with presence of friction spikes (COF=0.4) during the remaining time of the test (10000 cycles). Same testing conditions were used for testing under dry N_2 environment. COF response was much more stable (no presence of frictional spikes), with a slightly higher average value (0.02-0.03) compared to the vacuum tests if the friction spikes are not considered.

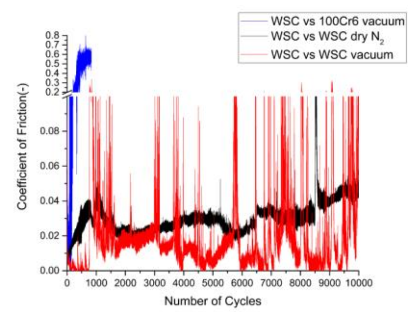

Figure 1 Tribological response in vacuum and dry N_2 environments

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