TRANSCOM 2025: 16th International Scientific Conference on Sustainable, Modern and Safe Transport

Wear-resistance of the DLC AF+ coating investigated by the Tip-on-Flat method

Martin Vicen[1],Otakar Bokůvka[1,2], Richard Joch[1], Pavol Belány[2], Peter Špuro[1], Ružica Nikolić[2]

1 University of Žilina, Žilina, Slovakia
2 Research Centre, University of Žilina, Žilina, Slovakia

INTRODUCTION

Diamond Like Carbon (DLC) coatings, properties – high hardness, low friction coefficients, high wear resistance, low mass loss, high corrosion resistance, high anti-seizure inertness, improved adhesion strength.

DLC coatings, find applications – in mechanical, civil, aerospace, biomedical and other various including tools or dies surface treatment – with the aim to increase the useful properties of components and construction.

The objective of this study was experimentally by Tip-on-Flat method verify the wear resistance of the DLC AF+ coating, deposited on the high – grade, low – alloy steel..... recommend coating as surface protection?

MATERIALS, METHODS & IMPLEMENTATION

The high-grade, low-alloyed steel was used as a substrate, on which the DLC AF+ coating was applied. The verification of the chemical composition was performed by the spark optical emission spectroscopy on a SPECTROMAXx device. The substrate, plates (25 x 80 x 5 mm), were heat treated by quenching and tempering. The microstructure was studied by an Axio Observer Zd1.m light microscope and by TESCAN LYRA3 electron microscope. Hardness was determined by the Rockwell hardness test (HRC). The deposition of the DLC AF+ coating on the substrate was executed by the PAPVD process particularly the DC magnetron sputtering. After the coating deposition, the EDX analysis was performed. The thickness of the coatings was measured by calottes method. Measurements of the mechanical properties, hardness H_{IT} and elastic modulus E_{IT}, were carried out by an Anton Paar NHT Nanoindentation Tester, with the standard Berkovich diamond tip. The dry coefficient of friction (COF) of the DLC AF+ coating was experimentally determined on a linear sliding tribometer (sliding speed v = 0.017 $m.s^{-1}$, sliding diamond tip with radius r = 0.3 mm).

RESULTS

The mechanical properties of DLC AF+ coating (about of thickness h = 2.74 μm) were – hardness H_{IT} = 11.8 ± 1.8 GPa and modulus of elasticity E_{IT} = 115 ± 9 GPa. The coefficient of friction of the DLC AF+ coating in steady state was ≈ 0.072 (-) (Fig. 1). In Fig. 2 are shown the tribological trace profiles of the DLC AF+ coating at F_N = 5 N. From the recording can be seen that the depth of the tribological traces had a maximum of approximately 1.0 μm. In Fig. 3 are shown abrasion wear traces of the DLC AF+ coating after different testing times. The analysis shows only partial cracking of the DLC AF+ coating. Due to the high contact pressure, no penetration of the diamond tip through the coating was observed.

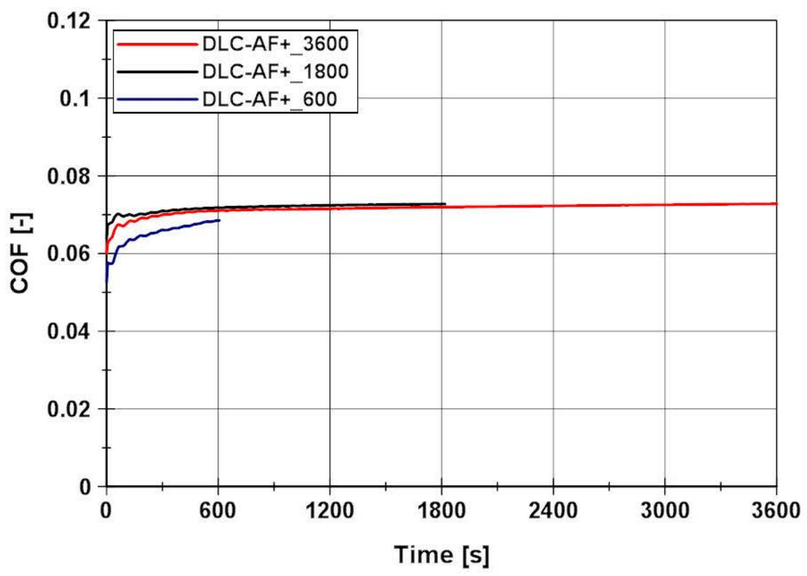

Fig. 1 COF vs. time of the DLC AF+ coating, dry friction; F_N = 5 N

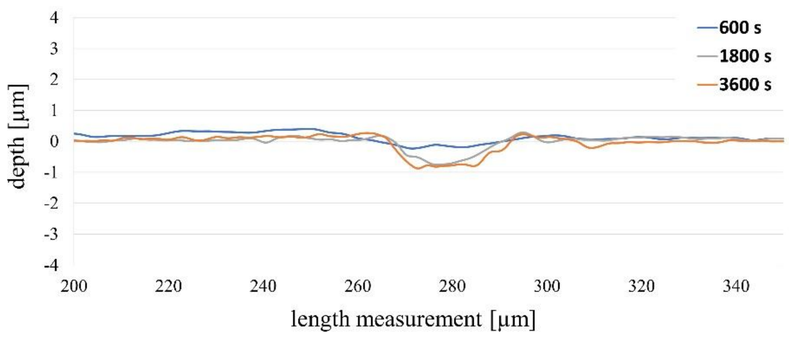

Fig. 2 Comparison of tribological traces profiles of DLC AF+ coating after 600 s, 1800 s and 3600 s testing time; F_N = 5 N

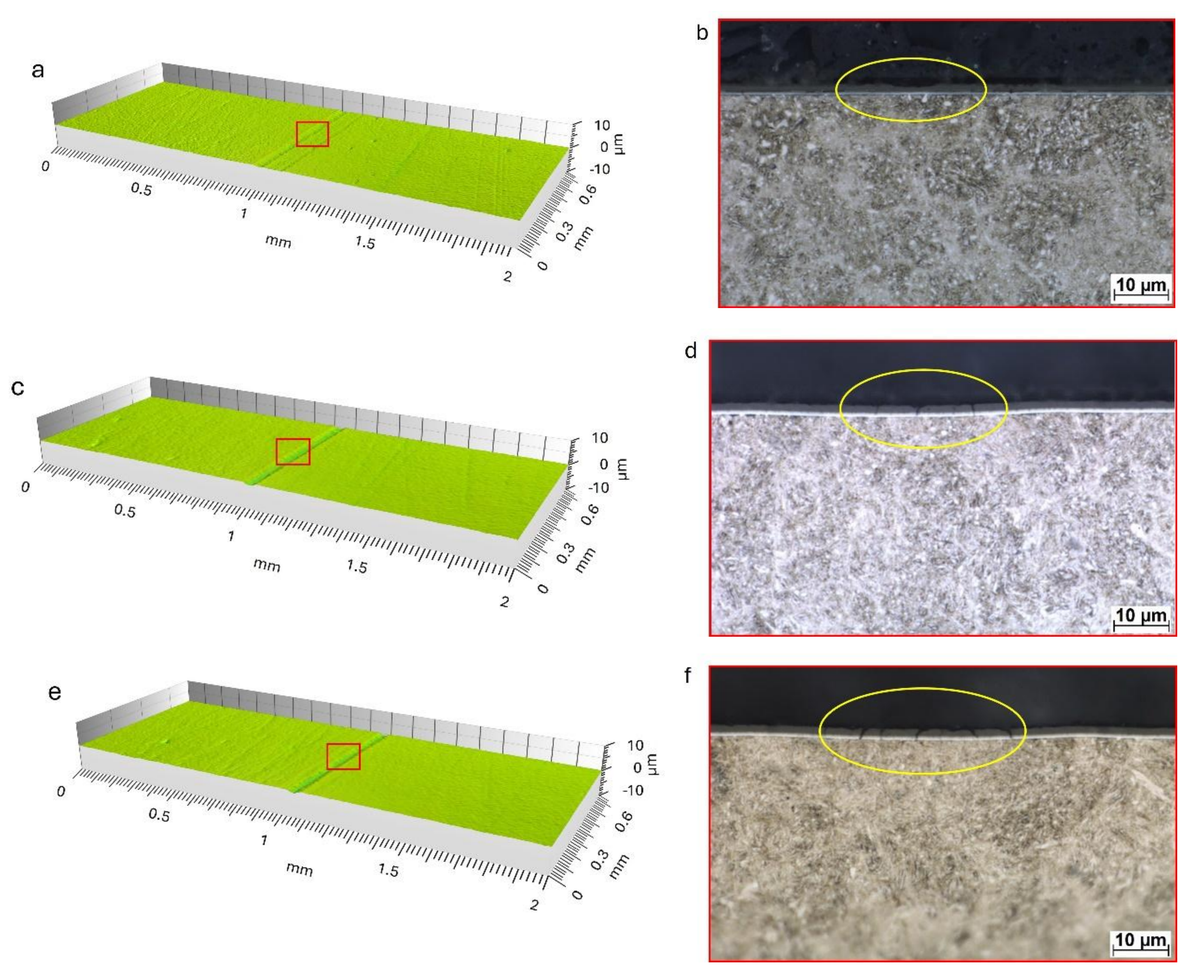

Fig. 3 Abrasion wear traces of DLC AF+ coating after different testing times, (a, b) 600 s; (c, d) 1800 s; (e, f) 3600 s; F_N = 5 N

CONCLUSION & IMPLEMENTATION PATH

With regard to the obtained experimental results the following conclusions can be drawn:

- The dry coefficient of friction (COF) of the DLC AF+ coating, deposited on the high-grade, low-alloy steel, investigated by the Tip-on-Flat tribometer was approximately 0.072 (-).
- No penetration of the deposited coating was noticed.
- The DLC AF+ coating possesses a very good wear resistance and it can be recommended as a surface protection of steels.

ACKNOWLEDGEMENTS

The research, results of which are presented in this paper, was funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09103-03-V03-0036” and by project KEGA no. 009ŽU-4/2023.