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Applicability of a Ni-9%P+(a:C-H)DLC multilayer coating to improve the tribological behaviour of AISI 316L screws with internal channels produced by Powder Bed Fusion-Laser Beam

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The reduced production times and costs and lower environmental impact of the Powder Bed Fusion-Laser Beam (PBF-LB) technology compared to conventional technologies for producing complex-shaped parts are generating keen interest in the industrial sector. Thanks to its peculiar microstructure, the PBF-LB AISI 316L stainless steel has higher pitting corrosion resistance and mechanical strength than conventional AISI 316L stainless steel; however, it is also characterized by low wear resistance and high friction coefficient, especially in severe environmental conditions.

From this perspective, the Ni-9%P+(*a*:C-H)DLC multilayer coating represents a promising solution: the deposition conditions have no negative effects on the metastable microstructure of the PBF-LB AISI 316L alloy, and the Ni-9%P interlayer is able to uniformly cover the complex surface and surface defects of the substrate, ensuring good adhesion, continuity and load support to the (*a*:C-H)DLC topcoat, characterized by high wear resistance and low friction. Furthermore, barreling the substrate would ensure uniform functional properties through a controlled surface finish over the entire surface.

The effectiveness of the entire post-process cycle is evaluated through a complete microstructural and micromechanical characterization on functionalized PBF-LB AISI 316L screws. Optical profilometry and cross-section observations using FEG-SEM/EDS and ion milling were used to analyze the surface roughness and the quality of the multilayer coating, substrate and interfaces. The adhesion of the Ni-9%P layer on the substrate was evaluated by Rockwell indentation ("Mercedes test") and the practical adhesion of the (a:C-H)DLC on the Ni-9%P interlayer was tested by progressive load scratch testing. Instrumented indentation was used to measure the hardness of both layers (Ni-9%P and (a:C-H)DLC) on the micro/nanoscale.

The results allowed to define the guidelines for the design and production of high-performance coated PBF-LB AISI 316L screws, in order to create innovative components with sustainable materials and processes, capable of supporting the ecological transition in the automotive sector.

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