Evaluation of wettability and Anti-Erosion/Corrosion Properties of TiAlN-Si_3N_4 Nano-Composite and TiAlN/TiN Nano-Multilayer Thin Films in Molten Aluminum Alloy

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The durability of materials, including both metals and ceramics, exposed to molten aluminum alloy is an important concern in many engineering applications since molten aluminum is one of the most aggressive metals to a number of materials [1]. An important field example is Die Casting process in which the thermo-chemical interaction between liquid aluminum alloy and steel surface results in soldering and wear of die surface [2]. The Aim of this research is to investigate the influence of the TiAlN-Si_3N_4 Nanocomposite and Nanolayered TiAlN/TiN multilayer coatings on wettability and erosion/corrosion resistance of hot work tool steel. To obtain a duplex coating, nano films were applied by PVD vacuum cathodic arc evaporation (CAE) technique onto pre-nitrided pin samples made of H13 tool steel. The X-ray analysis was employed to assess nano-films constitutive phases and measuring both the average Si_3N_4 crystallite dimension and the lattice parameters. The SEM investigation and AFM approach were employed to indicate morphology and roughness of Nano-structural surface layers. Furthermore, specially developed release test, which is a surrogate to measure samples wettability and adhesion tendency, was done by measuring release force of coupons encompassed by solidified aluminum from the casting. An accelerated experimental approach was also conducted for testing erosion/corrosion resistance by dipping and rotating samples in A380 aluminum alloy melt over the various periods of time. EDS analyses in Back Scatter mode, proved tribo-chemical interaction between uncoated samples and $Fe_xAl_ySi_z$ intermetallic phase formation. While, Nano-structural coatings not only prevent atomic diffusion and intermetallic phase formation at the surface but also reduce wettability and adhesive force between the solidified aluminum and pin surface in different condition. SEM metallographic investigation of corroded and eroded surface showed some pitting effect. Due to its surface morphology, Nanocomposite coating provides less Weight Loss (WL) and percentage of Eroded Area (PEA) than both of Nano-multilayer coatings.

Keywords: Nano-Composite, Nano-Multilayer, Corrosion, wettability, TiAlN

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