

Progress in Plasma Electrolytic Surface Treatments for Wear and Corrosion Protection of Lightweight Metals

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An overview is provided to both fundamentals and applied aspects of novel Plasma Electrolytic Oxidation (PEO) processes used for wear and corrosion protection of Al, Ti and Mg alloys. PEO is a rapidly developing environmentally friendly technology, significant technical potential and economical benefits of which have already been recognised and appreciated by engineering community. The method relates to the group of electrochemical surface oxidation techniques and is featured by applied high anodic potentials that result in occurrence of a plasma discharge at the metal-electrolyte interface. Plasma-surface interactions accompany metal oxidation, affecting kinetics of the main electrochemical process, morphology and composition of the oxide film being formed. They also bring to the process significant nonlinearities that cause major problems in its understanding, optimisation and control.

Superior wear and corrosion resistances of PEO coatings demonstrated by numerous studies are normally attributed to their specific structure, in which a thick and dense inner layer can be formed comprising clusters of hard (nano)crystalline high-temperature oxide phases distributed in an amorphous/low temperature crystalline oxide matrix. However in certain situations, e.g. under severe impact erosion and erosion-corrosion conditions, the benefits of PEO coatings are not apparent. Limiting factors of the coating protective performance are associated with the matrix defects and imperfections, such as crack networks, crater-like features with central pinhole defects and sites of increased porosity, that are often a legacy of discharge thermal and hydrodynamic impacts on the coating surface. To refine coating morphology, application of pulsed current waveforms with relatively high frequency (10^2 - 10^3 Hz) are currently being considered. The methods of process optimisation based on application of frequency response analysis are discussed.