**A Surface Treatment Technique: Plasma Electrolytic Oxidation**

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In past decades, lightweight metals (aluminum, magnesium and titanium) and their alloys have attained great importance in various engineering and biomedical applications because of the many superior qualities they exhibit in contrast to conventionally used steel and other materials. Such qualities include a high strength-to-weight ratio, low densities, biocompatibility, biodegradability, and other physical and chemical characteristics. However, poor tribological properties, such as low wear and corrosion resistance, have severely restricted the usage of lightweight metals commercially (Li, Liang, Wang, 2013). Fortunately, scientists have developed many effective methods to resolve tribological deficiency. One of the most promising procedures is plasma electrolytic oxidation (PEO). PEO is a novel surface treatment technique that manipulates electrochemical reactions to produce a passivating oxide layer on the surface of the substrate (Dehnavi, 2014). This essay will be explaining the PEO equipment, the PEO process, and the structure and compositions of PEO coatings.

The equipment for PEO will differ from site to site, but plasma electrolytic oxidation is always performed in an electrochemical cell consisting of two electrodes sharing an electrolyte. A safety enclosure is mounted beside a high voltage power source. The sample to be coated serves as the anode and is immersed in the electrolyte in a cooled, insulated electrolyte tank which also serves as the cathode. The tank is positioned in the safety enclosure which is equipped with a window for extraction and viewing of substrate. The electrolyte is stirred with a mixer and cooled with water.

 The process for plasma electrolytic oxidation is essentially the modification of the anodization process by applying electric potentials greater than the dielectric breakdown field of the traditionally grown oxide. When the metal substrate is immersed in the electrolyte and electricity is introduced, an oxide film is generated on the surface of the substrate. As the voltage ascends, the oxide film thickens and grows. When the voltage reaches a critical value and exceeds the dielectric breakdown potential (this is defined as the voltage level that makes an insulated material electrically conductive), the micro-arc discharge phenomenon occurs (Li, Liang, Wang, 2013). This phenomenon takes the form of numerous sparks engulfing the substrate. The resulting plasma produced from the intense heat of the discharges perform substantial modification to the growing oxide film. The end result is a highly dense and extremely hard coating that provides exceptional protection against corrosion and wear, thus greatly enhancing the substrate's tribological properties. The modification of the oxide film involves many complex physical, chemical, electrochemical, and thermochemical reactions, and despite vigorous research, the exact coating formation mechanisms are not yet fully understood (Dehnavi, 2014; Li, Liang, Wang, 2013).

Plasma electrolytic oxidation coatings may have different compositions determined by the intrinsic and extrinsic parameters, but the structure is primarily constant. PEO coatings generally consist of a thin inner layer termed "the barrier layer", an intermediate layer of relatively low porosity termed "the functional layer", and a third porous outer layer. The thickness of the functional layer can vary, but typically it constitutes 70-80% of the coating. The term "functional layer" is appropriate for the intermediate layer because it provides the coating with the main thermal, dielectric, mechanical, and tribological functionality (Dehnavi, 2014). The functional layer's properties allow PEO to be employed in numerous aggressive environments being high temperature, electric, and corrosive. The porous outer layer can be utilized to bring ductility to the coating. Also paints and other coatings can be efficiently applied to the outer layer. The barrier layer provides adhesion to the substrate and contributes most to the corrosion resistance of PEO coatings. It provides the final protection against corrosive medium that can penetrate through the pores of the outer and functional layer (Dehnavi, 2014).

Although the usage of the three layers are distinct, they are all comprised of the same elements. Coating composition for PEO is chiefly determined by the substrate material, but electrolyte composition also has influence. PEO ceramic coatings are mainly composed of substrate metal oxides such as Al2O3, TiO2, and MgO for aluminum, titanium, and magnesium respectively. However, traces of more complex oxides can be found in correlation to electrolyte used (Li, Liang, Wang, 2013).

Plasma electrolytic oxidation is the perfect candidate possessing great potential for many industrial applications. These may include the automotive, aerospace, construction, electrical, biomedical, oil and gas processing, textile, and sports and leisure industries. This considerable range of applications is mainly due to the coating quality and properties PEO possess. High hardness, excellent tribological properties, high heat resistance, biocompatibility for implant integration, and dielectric attributes for insulation purposes; these are the desirable properties of PEO that are useful in every industry. Although more research should be conducted to further understand the micro-arc discharge phenomenon and the complex reactions involved, the coating quality and properties PEO possess are exceptional. Work should be done to commercialize PEO so its benefits can be felt in industries around the globe.