Friction properties of hard anodizing and micro-arc oxidation coatings obtained on an aluminum alloy 5086 – WTC 2021, Lyon

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Mechanical properties of aluminum make it particularly sensitive to abrasive wear. Many applications are lost, and many parts are changed prematurely. Resistance to abrasive wear and service life of parts can be increased by surface treatment. Hard anodizing (HA) and micro-arc oxidation (MAO) are both coatings for their high mechanical properties. These were prepared on an aluminum alloy 5086. Coatings microstructure, phase compositions, and mechanical properties were studied before and after a linearly reciprocating ball-on-flat sliding wear test. Material removal mechanisms during abrasive wear were investigated. Structure-property correlations were also used to propose tribological circuits.

Keywords : tribology, sliding wear, third body, micro-arc oxidation, hard anodization

1. Introduction

Twenty percent of the planet's total energy consumption is wasted through friction. The use of innovative solutions would reduce the energy wasted by friction and wear around the world by 40 % in 15 years [1]. Aluminum is the most heavily non-ferrous metal consumed in the world. Its low density gives it capital importance to reduce global system mass and energy consumption. Its low hardness makes it particularly sensitive to abrasion wear. However, surface treatment can improve wear behavior. This study aims to compare hard anodizing (HA) and micro-arc oxidation (MAO) surface treatment. These two coatings processes are known to improve the surface's mechanical properties [2, 3]. MAO is a reach compliant process that produces hard coatings. It is composed of an inner dense layer and an outer friable layer.

2. Methods

Several analysis techniques have been used better to understand HA and MAO coatings properties and nature. Morphology, chemical composition, and mechanical properties of these coating have been studied. A tribological test is designed, and the effect of friction on wear and coating integrity is studied.
HA and rough MAO surface states are observed by SEM as well as by optical profilometer.
Coatings microstructure and phase compositions were analyzed using scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), and X-ray diffraction (XRD).
Hardness and elastic modulus are evaluated within the different coatings by nanoindentation. Atomic force microscopy (AFM) has also made it possible to distinguish variations in mechanical properties close to the interface.
Coatings tribological performance was evaluated using a linearly reciprocating ball-on-flat sliding wear test. Balls used were of 100C6 steel.

3. Discussion

XRD diffractograms show that MAO is predominantly made up of the crystalline alumina phase. EDX observations confirm that silicon provided by the electrolyte is mainly found in the friable layer. Mechanical properties measured in the coating are very close to those of crystalline alumina. It has also been pointed out that these properties evolve within the layer. Furthermore, they are more important near the substrate. The mechanical properties of the friable Si-rich layer are lower than those in the dense layer. Tribological wear is studied with optical profilometry and SEM/EDX. A deposit of iron-rich material from the ball is also visible in the friction marks. Friction promotes the formation of a third body favoring speeds accommodations within the tribological contact. Friction coefficient obtained on the MAO coating ($\mu = 0.8$) is lower than that on the HA ($\mu = 1.0$). Average energy dissipated by MAO during the tribological test is also lower than that dissipated by the HA. The rough MAO's friable layer also helps dissipate less energy during the first 10 seconds of sliding. Coatings mechanical properties were also measured after tribological tests by nanoindentation. All the information collected makes it possible to construct various tribological circuits describing friction.

4. References

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