Enhanced tribological and tribocorrosion performance of cast Al-Si alloys using Plasma Electrolytic Oxidation technology

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In this work, the development of PEO coatings on different cast Al-Si alloys, throughout the employment of new alkaline electrolytes, have been successfully achieved. The influence of the substrate and the electrolyte compositions on the tribological and anti-tribocorrosion performance of the PEO coatings have been studied and compared with the results provided by the uncoated Al-Si reference alloy. Finally, the optimized PEO coatings have been developed on real cylinder liners. Tribological tests simulating the real contact between the piston ring and cylinder liner have shown very promising results for automotive applications.

Keywords: Tribology, Tribocorrosion, Cast Al-Si alloys, Coatings, Plasma Electrolytic Oxidation

1. Introduction

As the weight of a car is directly correlated with its polluting emissions, lightweighting is a priority in the present automotive industry. In this context, the replacement of conventional materials by new lighter materials is one of the greatest challenges, since it implies a decrease in fuel consumption and, consequently, a lower rate of CO_2 emissions. Cast aluminum-silicon (Al-Si) alloys are widely used in the automobile industry due to their outstanding properties, such as their low density and high strength-to-weight ratio. However, the application of these alloys is restricted due to their poor tribological resistance and limited anti-tribocorrosion (wear and corrosion) performance.

Plasma electrolytic oxidation (PEO) is an advanced surface technology for the development of protective coatings on light alloys, e.g. aluminum, titanium, or magnesium. The main advantages of PEO coatings are their high thickness, density, and hardness, as well as their notably improved tribological and tribocorrosion resistances [1].

2. Methods

2.1. Development of PEO processes

Cast eutectic and hypereutectic Al-Si alloys have been successfully employed as substrate materials for the development of PEO coatings, using two new electrolytes. The effect provided by the application of a top sol-gel layer on the PEO coatings was also analyzed. Finally, real automotive components were coated employing the above-mentioned newly developed electrolytes.

2.2. Characterization of PEO coatings

The PEO coatings obtained were characterized by means of thickness, roughness, and hardness measurements. SEM and EDS techniques were employed for the study of the surface and cross-sections morphologies and composition of the different coatings. The phase structure of the coatings was analyzed through XRD.

2.3. Tribological tests

The wear resistance of the PEO coatings was evaluated using a UMT-CETR3 tribometer with a ball-on-flat linear reciprocal configuration. The tribological tests of the PEO-coated real cylinder liners were performed in a SRV oscillation friction wear tribometer under piston ring/cylinder liner configuration.

Falex Multispecimen Test Machine, with unidirectional and rotatory movement, was also employed to test certain PEO coatings simulating the brake disc-pad contact.

2.4. Tribocorrosion tests

For the tribocorrosion experiments, a three-electrode cell was placed in the rotatory plate of an unidirectional MicroTest MT/10/SCM tribometer and connected to an Autolab Methrom PGSTAT30 potentiostat. The tests were performed under ball on disc configuration using an inert alumina ball.

3. Discussion

Two new aluminate-based electrolytes were formulated and successfully employed in the development of PEO coatings on Al-Si alloys. The chemical composition of the electrolytes determines several properties of the coatings obtained (hardness, thickness, porosity…), while the post-treatment applied influence some critical parameters of the tribological behavior, such as surface roughness or the coefficient of friction.

Compared with uncoated cast Al-Si alloys, PEO treatments not only enhance notably the tribological and tribocorrosion resistance, but also provide them with new functionalities, as aesthetic properties.

This study presents new insights in the obtention of multifunctional PEO coatings developed on cast Al-Si alloys, which have been found to be able to extend the service life of automotive tribological components.

4. References

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