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Fatigue behavior of AA7075-T6 aluminum alloy coated with a WC–10Co–4Cr cermet by HVOF thermal spray

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ABSTRACT

Rotating bending fatigue experiments, both in air and in a 3% NaCl solution, have been carried out in order to study the fatigue behavior of a 7075-T6 aluminum alloy coated with a WC–10Co–4Cr cermet by high velocity oxygen fuel (HVOF) thermal spray, without any grit blasting prior to the coating deposition. The results indicate that the presence of the coating gives rise to a significant increase in the fatigue strength of the substrate and therefore, that from the fatigue behavior point of view this coating could be a feasible replacement of electrolytic hard chromium plating in aircraft applications. Such an increase in fatigue and corrosion-fatigue strength is believed to be associated with the intrinsic microstructural characteristics, corrosion resistance and mechanical properties of the coating, its compressive residual stresses and the possible compressive residual stress field induced in the substrate during coating deposition. The fractographic analysis of the specimens indicates that the final fatigue fracture could be due either to the joint action of a large number of cracks, which propagate from the substrate–coating interface, or to a single dominant fatigue crack, depending on the maximum alternating stress applied to the coated system. It is shown that the lack of grit blasting prior to HVOF deposition does not seem to compromise the functionality of the coated system, while it avoids the introduction of further sharp stress concentrators for the nucleation of fatigue cracks.

1. Introduction

The significant development experienced in the past few years by the aircraft and aerospace industries has been intimately associated with the improvements in airframe design and the forming processes employed in the manufacture of many different parts and components that constitute these complex structures [1]. Such advances in aircraft and aerospace engineering have also been possible due to the availability of a wide range of alloys with higher mechanical properties, particularly in relation to fatigue, crack propagation and stress corrosion cracking resistance [2].

Among these aeronautical materials, aluminum alloys of the 7000 series, supplied in different forms, have been extensively used for the manufacture of different critical aircraft components subjected to complex stress states, which include upper wing surfaces, internal ribs, spars, frames, landing gear and dynamic helicopter components, among others. The improvement in the mechanical properties of these materials has been possible due to the development and optimization of different thermo-mechanical processes [2].

However, in spite of their excellent bulk mechanical properties, in general, aluminum alloys of the 7000 series have poor surface properties, particularly in relation to applications that require wear and corrosion resistance. This disadvantage has led to the extensive use of hexavalent-chromium-based conversion coatings (HCCC), such as electrolytic hard chromium (EHC) plating and chromic acid anodizing (CAA), in order to improve their surface properties [3–7]. Nevertheless, it is well known that these treatments utilize chemicals that contain hexavalent chromium (Cr^{6+} ions), which is a carcinogenic substance subjected to a strong health and environmental international regulation [8–11].

EHC plating not only gives rise to a significant decrease in the fatigue properties of both ferrous and non-ferrous substrates, which represents a critical aspect for the aeronautic and aircraft industries. Also, it has an unreliable performance, delaminates in service and promotes hydrogen embrittlement in ferrous alloys [12,13].

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