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Fatigue behavior of a structural steel coated with a WC–10Co–4Cr/Colmonoy 88 deposit by HVOF thermal spraying

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ABSTRACT

The fatigue behavior of a SAE 4340 steel, coated with a 50% WC–10Co–4Cr/50% Colmonoy 88 deposit, by high velocity oxygen fuel (HVOF) thermal spray, has been investigated. The change in the maximum alternating stress with the number of cycles to fracture has been described by means of the relationship advanced by Stromeyer. A fractographic analysis has been carried out on some representative fracture surfaces, by means of scanning electron microscopy (SEM) techniques. The mechanical properties of the coating were characterized by means of nanoindentation tests. The results indicate that the coating is highly heterogeneous. Its deposition gives rise to a decrease in the fatigue strength of the substrate of ~30%, in comparison with the uncoated substrate. The decrease in fatigue strength is due to the presence of stress concentrators at the substrate–coating interface, as well as the intrinsic characteristics of the coating.

1. Introduction

The aeronautic industry constitutes an important application field of thermal sprayed coatings, particularly as far as dynamic components for planes and helicopters are concerned. These structural elements include, transmission parts and rotor heads, internal cylinders for landing gear, shafts, hydraulic actuators, gas turbine engines components, etc. [1,2]. For these applications, structural aluminum alloys and steels with high strength, toughness and fatigue properties are commonly employed, whose resistance to sliding, and abrasive and fretting wear can be increased by means of adequate coatings.

However, such an improvement in the tribological properties could give rise to a significant decrease in the fatigue life of the coated components, such as it has been found in many different parts coated with electrolytic hard chromium (EHC) plating. Although such a coating gives rise to an improvement in the substrate wear resistance, it occurs at the expense of a decrease in the fatigue performance, in comparison to the uncoated parts [3–10]. Therefore, the qualification of a thermal spray coating employed as a feasible replacement of EHC requires the evaluation of the effect of such a coating on the fatigue properties of the substrate, particularly in critical components such as aircraft engines, for which high cycle fatigue represents the most important failure mechanism [11,12].

Thus, it is expected that the deposition of the coating does not give rise to any decrease in fatigue properties or, at least, if a fatigue debit is induced, it should not be greater than that produced by EHC [1,5,6]. In this sense, a number of investigations have shown that although WC–Co and WC–Ni coatings deposited by HVOF thermal spray give rise to a decrease in the fatigue properties of 4340 steel substrates, it is less than that produced by EHC [8,9,13–15].

In relation to Ni-base self-fluxing coatings deposited onto medium carbon structural steels, previous work has shown an increase in the fatigue strength of the coated system in comparison with that of the uncoated substrate, particularly when tests are conducted in a corrosive medium [16–21]. However, if the tests are conducted in the air, the decrease in fatigue strength could be greater than that produced by WC–Co coatings [22,23].

Flame post-heat treatments have also been employed to modify the microstructure of self-fluxing coatings and therefore, the fatigue properties of the coated systems. In this sense, Akebono et al. [24], conducted an investigation of such a treatment on a Ni-base alloy (Ni–13.7Cr–2.96B–4.40Si–2.67Fe–0.60C; wt.%), deposited onto an AISI 1036 steel substrate. The deposition was conducted by flame spray, employing a mixture of oxy-acetylene, a spraying distance of 200 mm and a coating thickness of 1.5 mm. Post-heat treatments were conducted in a vacuum for 0.5, 4 and 10 h, at a temperature of 1283 K. Rotating bending fatigue tests were carried out at room temperature at a frequency of 50 Hz, employing samples in which the

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