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Quantitative fractography and modelling of fatigue crack propagation in high strength AerMet®100 steel repaired with a laser cladding process

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Abstract:

Ultra-high strength steels employed in safety-critical applications, such as AerMet®100 used in aircraft landing gear structures, are managed on very conservative rejection criteria for small defects and repair options are limited. A novel repair technique using laser cladding has recently been developed. In the present paper we report a study of the fatigue endurance of AerMet®100 steel components repaired by the laser cladding process, and a fracture mechanics based model to predict the fatigue endurance of repaired components. Three different types of samples were tested; baseline AerMet®100 sample with a small electro-discharge machining notch to initiate a crack, as-clad repaired, and as-clad repaired followed by heat treatment to relieve residual stresses. The specimens were subjected to cyclic loading under a special sequence consisting of constant amplitude segments at two different stress-ratios (ratio of minimum to maximum cyclic stress). The test results showed that the crack propagation lives from a common initial depth of 0.25 mm for the as-clad samples were significantly longer than the baseline samples by a factor of three to four. The longer life is attributed to the beneficial compressive residual stresses resulting from the repair process. The model predictions are found to correlate well with the results of quantitative fractography measurements from samples tested under variable amplitude cyclic loads.

Keywords:

Laser cladding repair; crack growth; ultra-high strength steel; variable-amplitude loading; spectrum loading; crack closure; stress-intensity factor; Quantitative Fractography

1. Introduction

Ultra-high strength steel components, such as aircraft landing gear components made of AerMet®100, are complex and very expensive to manufacture and replace. Ultra-high strength steels typically account for 5-15% of the airframe structural weight [1, 2]. Safety

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