Accepted Manuscript

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PII: S0142-1123(18)30005-7
DOI: https://doi.org/10.1016/j.ijfatigue.2018.01.006
Reference: JIJF 4535

To appear in: *International Journal of Fatigue*

Received Date: 20 October 2017
Revised Date: 3 January 2018
Accepted Date: 6 January 2018

Effects of processing on microstructure evolution and fatigue crack growth mechanisms in cold-spray 6061 aluminum alloy

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Research highlights

- The FCG behaviour of cold-spray processed 6061 aluminum is examined
- Prior powder particle boundaries are critical in the FCG response at high ΔK values
- Design maps relating loading conditions to microstructural-scale damage are shown
- A microstructure-based model is developed to predict FCG rates in upper FCG regions
- Discussion on fatigue-critical applications of cold-spray materials is provided

Abstract

Owing to their fine microstructures, cold-spray processed alloys possess appealing static mechanical properties, similar to their wrought counterparts, making them potential candidates for structural applications. In spite of their great potential, the lack of knowledge of their cyclic behavior, especially the fatigue crack growth response, limits their use in high-integrity applications. Thus, further advanced characterization of cold-spray processed materials is needed. In this study, fatigue crack growth microstructural mechanisms were established for bulk cold-spray processed 6061 aluminum alloy tested in laboratory air at room temperature. The effects of the material's characteristic microstructure, stress ratio (R=0.1, 0.5, and 0.7), and post-fabrication heat treatment (annealing and T6) on the fatigue crack growth behavior were systematically investigated. It was found that the initial powder particle characteristics play an important role in the crack's propagation through the cold-spray 6061 microstructures, and particle boundaries are critical in the materials' response, especially at high driving force. To aid the material-process design, two crack tip driving force parameter maps that relate loading