PhD Dissertation Defense Announcement
Mechanical and Aerospace Engineering Department
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Characterization of Fatigue Strength of Additively Manufactured Ti-6Al-4V with Recoater Blade Interference Flaws and Residual Stresses Towards an Enhanced Fatigue Substantiation Methodology for Aerospace Structures Applications

By

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Abstract

This research characterized the fatigue strength of additively manufactured (AM) Ti-6Al-4V, through fatigue and static tests conducted using specimens with and without recoater blade interference flaws (RBIF), and further enhanced the fatigue substantiation methodology for AM parts, by using combined fatigue strength knock-down-factors (KDF), as developed through this study. Qualification and certification (Q&C) of metallic AM parts, through acceptable methods for fatigue and damage tolerance (F&DT) substantiation, is an area where significant gaps still exist. While progress has been made in design as well as materials and process standardization, Q&C of additively manufactured metallic structural parts, especially those in civil aviation certification termed Principal Structural Elements (PSEs), failure of which is catastrophic, remains the holy grail in aerospace AM application. By characterizing the effects of the mechanically induced RBIF to metallic Laser Powder Bed Fusion (L-PBF) Ti-64-built parts, and further combining this fatigue strength reduction to include residual stresses, indicates a sufficiently conservative approach while continuing to minimize highlighted causes of RBIF which include: the type of recoater blade used, the aspect ratio of the parts built, optimal use of support structures in heat dissipation and distortion control, layout of the parts on the build plate, and blade interference control settings. Indeed, while RBIF was shown to occur to varying degrees commonly in most metallic AM builds, no specific studies have previously been undertaken to characterize its effect on the fatigue strength of Ti-6Al-4V. Further, the structural integrity assurance baked into the proposed fatigue methodology enhancement presented, where the use of this example Ti-6Al-4V Soderberg characterized with a fatigue KDF for RBIF in combination with the KDF for induced residual stress, will ensure that probabilities of combined worst case mechanical flaws and a heat treatment failures at a critical crack initiation site (CIS), can be considered extremely remote, and thus this is representative of a “worst-case” effect. Future validation studies propose building full-scale parts in aerospace applications to verify the adequacy of the fatigue margins in the analytical predictions using the enhanced methodology proposed, with combined RBIF and residual stress KDFs against full-scale test failure data.