SEMINAR SERIES

FATIGUE AND FRACTURE BEHAVIOR IN METAL ADDITIVE MANUFACTURING

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Nik Hrabe is a titanium metallurgist with extensive experience in metal additive manufacturing research (PhD University of Washington 2004-2010, NIST-NRC postdoc 2011-2012, NIST staff 2015-present) as well as industrial experience using additive manufacturing in the medical device industry (3D Systems 2013-2015).

What is Additive Manufacturing (AM)? How is industry currently using AM? What is needed to enable use of AM for fatigue and fracture (F&F) critical applications? This high-level talk will introduce metal additive manufacturing and present the findings from a recent NIST/ASTM workshop on fatigue and fracture in metal AM. Background behind the AM F&F needs identified during the workshop will be presented, and some recent work will be discussed in more detail. In this work, the effects of residual stress and internal defects (pores and voids) on fatigue properties of EBM Ti–6Al–4V material in as-built, stress-relieved, and hot isostatic pressed (HIPed) conditions were evaluated. Conventional techniques were used to measure the chemical composition and quantify microstructures, and neutron scattering was utilized to measure residual stresses. Post-processing did not alter chemical composition. Compared to the as-built condition, microstructure was unchanged for stress-relieved material and coarser for HIPed material. No significant residual stresses were measured for any of the three conditions. This indicates build platform and layer preheating lead to sufficient process temperatures to achieve full stress relief in-situ. The high-cycle (R=0.1) fatigue strengths at 10^7 cycles measured for the as-built and stress-relieved conditions were statistically similar and were measured to be 200–250 MPa. A significantly higher fatigue strength at 10^7 cycles of 550–600 MPa was measured for the HIPed condition. The increase in fatigue endurance limit was attributed to a reduction in internal porosity and void content.

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