SAND2019-8708C

Improved Structural Performance Models for Qualification of Metal AM Components

John Emery, Kyle Johnson, Cory Medina, Mircea Grigoriu, Jay Carroll, and Joseph Bishop

Metal additive manufacturing (AM) provides manufacturing benefits that include automation and flexibility, enabling fabrication of geometries that otherwise require jointed connections. Presently, AM parts can exhibit a host of material defects that can compromise structural reliability. Sandia has been developing models and modeling methodology to predict residual stresses and performance, considering uncertainties, with intent to prove/qualify AM components. Experimentally, we have been advancing the state of knowledge with novel measurements and experiments, including micro-computed tomography (uCT), electron backscatter diffraction (EBSD) imaging, and novel mechanical properties characterization techniques.

We outline a proposed hierarchical approach that first uses engineering-scale, lower-fidelity models to identify hotspots where later concurrently coupled models containing explicitly-represented materials defects are employed to refine performance predictions. The talk will share preliminary results from efforts to implement this approach, which may include the following types of results. The engineering-scale models use uCT data characterizing materials defects to locally-seeded void-volume fractions in a damage mechanics plasticity model. Substantive residual stresses exist in AM, sometimes above the base material yield strength, and are likely to play an important role in structural reliability. Our approach considers their effects in the engineering-scale models. The fine-scale models develop subvolumes of AM materials, explicitly meshing the geometry of statistically informed porosity, and couple them to the engineering scale with multi-point constraints. Preliminary predictions of reliability are compared, and computational efficiency is discussed. Two additive systems are considered, SS316 and AlSi10Mg, and their similarities and differences are discussed.

Acknowledgment: Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.