HYDROGEN-ASSISTED FRACTURE OF ADDITIVELY MANUFACTURED TYPE 304L AUSTENITIC STAINLESS STEEL

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Additive manufacturing (AM) is a growing technology with potential benefit for manufacturing of components intended for extreme environments. The microstructures and mechanical properties of AM materials are distinct from conventional high-performance wrought product due to the localized solidification phenomena that are intrinsic to AM processes. The unique characteristics of these materials will undoubtedly have important implications for materials performance in extreme environments. In this study, we examine hydrogen-assisted fracture of type 304L austenitic stainless steel produced by powder-bed fusion (PBF) and direct-energy deposition (DED). Thermal precharging is used to produce a uniform hydrogen concentration within tensile and fracture test specimens for characterization of hydrogen-assisted fracture. High-quality structures were generated on several PBF platforms and test specimens were extracted to show that uniform and reproducible tensile properties could be produced across these platforms, both in the machined condition and in the hydrogen condition. In addition to a combination of high strength and high ductility in the AM materials, the influence of internal hydrogen on both PBF and DED materials is consistent with wrought materials. Fracture mechanics testing of the AM materials show exceptional performance with internal hydrogen, consistent with the characteristics of hydrogen-assisted fracture in welded 304L. In a few cases, substantial defect populations were identified in as-printed parts, and these defects exacerbated the effects of hydrogen. This observation highlights the importance of robust quality assurance metrics for AM components intended for extreme environments. Fractography and microstructural characterization are also used to assess similarities and differences in microstructure-property relationships of PBF, DED and wrought materials in hydrogen environments.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and 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-NA-0003525