THE INFLUENCE OF ADDITIVE MANUFACTURING ON THE SUSCEPTIBILITY OF ALLOYS TO ENVIRONMENTAL INDUCED FRACTURE

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Additive manufacturing (AM or 3D Printing) consists of digital technologies for building 3D objects by incrementally adding small quantities of material at predetermined locations. These technologies enable the fabrication of complex shapes optimized for strength-to-mass ratio, air-fuel mixing, conformal cooling, or assembly, and are revolutionizing manufacturing. Unlike most traditional manufacturing methods where material is removed without altering microstructures, the processes of AM utilize materials processing to join the added material to the part. This influences the microstructures of the finished part; but more importantly, it means that the thermal-mechanical processing history of a part is optimized for fabrication, not properties. Laser powder bed fusion (LPBF) is a popular method for the fabrication of metal parts, but it is essentially the welding of thin layers of metal powder to a substrate followed by very rapid cooling. This processing route results in segregation and non-equilibrium phases in the microstructures of as-built parts. For this reason, parts made by this process are given post-build heat treatments to relieve stresses, and reduce build-flaws (HIP, hot isostatic pressing). However, the microstructure and stresses present in the “as-built” condition will influence the microstructures and properties that result from these heat treatments. This presentation will review our research into the unique microstructures, secondary phases, and stress states present in AM processed alloys (17-4PH, IN625, and IN718) and computer modeling of phase relations to optimize post-build heat treatments to improve fracture toughness and resistance to environmentally induced fracture. Then, it will discuss our on-going research into confirming the influence of these phases, microstructures, and post-build heat treatments, on the susceptibility of these alloys to environmentally induced cracking.