Laser Shock Peening of Additively Manufactured Nickel-Based Superalloys

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Abstract : One significant roadblock for additively manufactured (AM) parts is the buildup of residual tensile stresses during the fabrication process. These residual stresses are formed due to the intense localized thermal gradients and high cooling rates that cause non-uniform material expansion/contraction and mismatched strain profiles during powder-bed fusion techniques, such as direct metal laser sintering (DMLS). The residual stresses adversely affect the fatigue life of the AM parts. Moreover, if the residual stresses become higher than the material's yield strength, they will lead to acute geometric distortion. These are limiting the applications and acceptance of AM components for safety-critical applications. Herein, we discuss laser shock peening method as an advanced technique for the manipulation of the residual stresses in AM parts. An X-ray diffraction technique is used for the measurements of the residual stresses before and after the laser shock peening process. Also, the hardness of the structures is measured using a nanoindentation technique. Maps of nanohardness and modulus are obtained from the nanoindentation, and a correlation is made between the residual stresses and the mechanical properties. The results indicate that laser shock peening is able to induce compressive residual stresses in the structure that mitigate the tensile residual stresses and increase the hardness of AM IN718, a superalloy, almost 20%. No significant changes were observed in the modulus after laser shock peening. The results strongly suggest that laser shock peening can be used as an advanced post-processing technique to optimize the service lives of critical components for various applications.

Keywords : additive manufacturing, Inconel 718, laser shock peening, residual stresses
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