HÖGSKOLAN VÄST

Process Understanding and Weldability of Laser-Powder Bed Fusion Manufactured Alloy 718

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Abstract

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Laser-powder bed fusion (L-PBF) is an additive manufacturing (AM) process that involves building components by fusing fine metal powders using laser. There is no universal set of process parameters that can yield optimum results for all the different materials, geometries, and L-PBF machines. The research performed at hand regarding the process parameters showed that laser power, scanning speed, laser exposure time, and laser point distance are the most influential process parameters to decrease the amount of lack of fusion. In contrast, gas porosities are unavoidable in the L-PBF material because they can occur either because of powder particles containing inherent gas pores from the powder atomisation process or entrapped shielding gas during the L-PBF process.

To fully utilise the L-PBF technique as a commercial production process, joining of small parts to build large-sized or complex shaped components, such as structural components for jet engines, can be a solution. The as-built microstructure of L-PBF-manufactured superalloy Alloy 718, which is the material in focus in the present research, has grains mostly oriented in the building direction of the part with a very fine cellular-dendritic structure within them. The microstructure of the alloy also contains NbC, TiN and low melting Laves phase in the interdendritic regions and along the grain boundaries. The specimens in this study were subjected to different heat treatments, such as hot isostatic pressing (HIP), solution heat treatment, and solution and ageing heat treatment, prior to welding, to study the effect of these heat treatments on the microstructure of the L-PBF-718 with regard to the susceptibility towards heat-affected zone (HAZ) liquation cracking during welding. Results showed that L-PBF-718 was susceptible to HAZ cracking during welding in all material conditions. L-PBF-718 subjected to HIP was more prone to HAZ cracking while welding and revealed a lower ductility behaviour in comparison to L-PBF-718 in the as-built condition and wrought Alloy 718. The welding direction with respect to the grain growth direction in L-PBF-718 was also found to have a significant influence on hot cracking susceptibility. The extent of HAZ cracking was observed to be smaller in samples welded parallel to the elongated grain orientation than in samples where the welding was performed perpendicular to it.