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Microstructural evolution and its influence on the plastic deformation of Inconel 625 additively manufactured using arc-wire direct energy deposition method

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Arc-wire direct energy deposition (DED) is one of the metal additive manufacturing (AM) techniques which can produce large size components with high deposition rate. It enables design flexibility without any size limitation. In this process, the prevailing temperature gradient and the solidification rate of a melt pool together dictate the evolution of solidified grain morphologies. Typically, the arc-wire DED microstructures have shown grains with wide range of aspect ratios. It is widely recognized that directionally solidified (DS) microstructure exhibit exceptional high temperature mechanical properties. Nonetheless, comprehensive understanding on role of grain aspect ratio on the high temperature mechanical properties of AM superalloys is limited. Therefore, the present study aims at understanding the plastic deformation of Inconel 625 samples manufactured using gas metal arc welding based arc-wire DED process under controlled dip short-circuiting metal transfer mode.

Tensile specimens were extracted parallel to the build direction. Subsequently, quasi-static tensile tests were conducted in the temperature range of 25 – 900 ºC and at various strain rates. Besides, digital image correlation technique was used to study the flow localization and correlated with the microstructural evolution. Further, post deformation microstructural characterization was carried out using EBSD and TEM to understand the role of various microstructural constituents on the high temperature flow behavior of arc-wire DED Inconel 625 specimens.

Keywords: Inconel 625, Additive manufacturing, High temperature deformation, Arc-wire DED