Multiphysics simulation of thermal phenomena in direct laser metal powder deposition

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Abstract
The direct laser metal deposition (DLMD) is a recently developed technique for manufacturing solid parts, layer by layer, directly from powder. The process uses a high power laser beam focused onto a metallic substrate to generate a molten pool to which a stream of powder is fed. This way, the material volume increases leading to the formation of a solid layer. The laser beam and powder nozzle are repeatedly scanned to accomplish a layered buildup of a solid part by additive manufacturing. The key process parameters are laser power, scan speed, laser beam diameter, and powder feed rate. The parameters influence the thermal phenomena during the growth process of the solid part as well as the metallurgical and mechanical properties. This paper presents on two dimensional multi-physics models to describe the physical mechanism of heat transfer, melting and solidification that take place during and post laser-powder interaction. The simulated transient temperature profile, the geometrical features of the generated structures and thermal cycles are presented. The transient temperature history is critically important for determining the thermal stress distribution and residual stress state in additively manufactured parts. The results obtained from the model generated by COMSOL Multiphysics software provide the basis for the selection of the process parameters in additive manufacturing.

Keywords: Laser additive manufacturing, multi-physics modelling, temperature fields