CFD Simulations for Laser Welding

Mark Keating[1]

1- Flow Science UK Ltd

Corresponding author: mark.keating@flow3d.co.uk

Laser technologies have advanced a lot in the past few years, and laser manufacturers are now able to offer high powered lasers with pulsing capabilities at different wavelengths. The integration of lasers with robotic automation systems, controllers, and process sensors have expanded their use in various manufacturing industries, enabling laser welded joints with low heat inputs and smaller heat affected zones. However, defects such as solidification cracking, porosity, and spatter can arise due to insufficient knowledge in process control. Modelling tools can be beneficial in mitigating some of these challenges, paving the way for widespread adoption of laser welding.

Laser-material interaction is complex, and to accurately model it requires implementing the physics that is relevant at these temporal and spatial scales. The laser heat source deposits energy at the surface, melting the substrate and creating a pool of molten metal. Computational fluid dynamics (CFD) simulations are a useful tool for analyzing melt pool dynamics to optimize process parameters in laser welding processes. CFD models, which are based on a rigorous solution of the conservation equations can provide further insights into fluid convection in the melt pool, porosity formation, temperature gradients, cooling rates and microstructure predictions. With experimental studies capturing melt pool temperatures and dimensions, it is possible to validate the numerical models that incorporate physics such as viscous flows, heat transfer, recoil pressure, phase change, and solidification. In this presentation, case studies from industry and academia highlighting the successful use of CFD models in understanding the influence of process parameters such as laser power, beam shape and scan speeds on laser welding, brazing, soldering and cladding process stability are discussed. Additionally, information from these CFD models can be used to accurately model additional aspects like residual stresses and thermal distortions in the welded joint.