CFD modelling advances in additive manufacturing

Pareekshith Allu[1]

1- Flow Science Inc., 683 Harkle Road, Santa Fe, New Mexico 87501, USA

Corresponding author: paree.allu@flow3d.com

Laser processing technology has contributed to the success of metal additive manufacturing (AM) processes such as laser powder bed fusion and direct metal deposition. Although AM has been generating significant interest, challenges remain towards a more widespread adoption of this technology. These challenges include defects such as porosity and spatially non-uniform micro-structures that occur because of insufficient knowledge in process control. Computational fluid dynamics (CFD) modelling can help understand the effects of process parameters such as laser power, beam shapes and scan paths on the underlying physical phenomena such as laser-powder interaction, melt pool dynamics, phase change and solidification. With experimental studies successfully capturing melt pool temperatures and weld bead dimensions, it is possible to calibrate numerical models to the experimental data. These numerical models, which are based on a rigorous solution of the conservation equations, can provide further insights into fluid convection in the melt pool, temperature gradients, solidification rates and microstructure predictions.
In this presentation, case studies from industry and academia highlighting the successful use of CFD and numerical models in understanding powder bed fusion and direct energy deposition processes are discussed in detail. It is shown how process parameter optimization is used to control porosity formation, balling defects and microstructure evolution for several alloys. Furthermore, these high fidelity, multiphysics CFD models provide a framework to better understand AM processes at the particle and melt pool scales. Ultimately, this information can be used to accurately model additional aspects of AM processes such as thermal and residual stresses and distortions at the part scale.