Department of Systems Engineering
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# Prediction of part quality in metal additive manufacturing

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## Abstract

Laser powder bed fusion (LPBF) additive manufacturing can fabricate metallic parts with complex geometric shapes directly from digital models, which is superior to traditional manufacturing techniques. However, there are still many challenges to control the quality of the final products in LPBF. Process-induced defects such as keyhole porosity, undesired surface roughness, lack-of-fusion porosity, residual stress, distortion, and balling phenomenon will significantly deteriorate the mechanical properties of the final products. Therefore, it is necessary to understand the formation mechanisms of these defects and develop accurate computational methods for rapid prediction of the defects.

In this study, physics-based analytical models are developed to predict the temperature distribution, molten pool geometric characteristics, process window, distortion, and formation of defects (porosity, surface roughness, and balling) under different combinations of process conditions in LPBF. The effects of boundary heat transfer (influence of part geometry), process conditions-dependent laser power absorption, powder size distribution and packing pattern, complex scan strategy, powder material properties and powder bed preheating are all considered in the modeling process. The proposed analytical models do not rely on any finite element-based numerical calculations, which ensures their high computational efficiency. To validate the proposed models, the predicted results are compared with experimental measurements of Ti6Al4V, Inconel 718, and 316L stainless steel under various process conditions and display very good agreement. Thus, the proposed analytical models can help the researchers understand the physics in LPBF process and guide the optimization of process conditions to fabricate defects-free products.


## About the Speaker

Dr. Wenjia Wang is a tenure-track Assistant Professor in the Department of Applied Engineering Technology in the College of Science and Technology at NC A&T State University. He received a Ph.D. degree in Mechanical Engineering from Georgia Institute of Technology (Atlanta, GA) in August 2022. He received a M.S. degree in Theoretical and Applied Mechanics from Northwestern University (Evanston, IL) in 2018, and a B.E. degree in Composite Materials and Engineering from Harbin Institute of Technology (China) in 2017. His research interests are centered on the study of additive manufacturing (AM) processes of metals and composites, based on computational mechanics and experimental characterization. He has collaborated with the Boeing Company and Ford Motor Company in developing efficient computational models to simulate the melting and solidification processes of different AM techniques. His research work has resulted in fourteen publications in top-ranked journals in the field of advanced manufacturing.

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