Process Mapping of Additively-Manufactured Metallic Wicks Using Bayesian Approach

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INTRODUCTION: Wick structures are porous media that provide spontaneous capillary action to maintain fluid circulation in advanced two-phase thermal management systems. However, the conventional manufacturing approaches such as furnace sintering involve various technical challenges to fabricate such geometrically-complex, optimal wick structures due to limited manufacturability and poor cost effectiveness. Metallic additive manufacturing is an ideal alternative, but the manufactured pore size using current selective-laser-melting approaches is much larger than desired pore size (< 100 micron), and this is not ideal for high heat flux two-phase thermal management system. Therefore, it is crucial to increase our understanding of efficient additively-manufactured wicks.

PURPOSE: We fabricate different types of metallic wick structures for pore sizes below 100 micron and employ a statistical method to develop a process map for efficient wick manufacturing.

METHODS: We use a powder bed fusion 3D printer (Lumex Advance 25) to fabricate wicks through partial sintering. To successfully manufacture wicks with substantial pores, we adjust the main printing parameters such as laser power, laser spot diameter, hatch spacing, and scan speed. Then we identify the printing parameters that led to successful wick manufacturing and develop a data set. This data set will eventually be used to develop a surrogate-based Bayesian optimization model to predict wick manufacturability for different materials and under different working conditions.

RESULTS: Our sequential approach will identify the training points that provide maximum information gain regarding the relationships between the process parameters and the possibility of manufacturing the 3D printed wick with certain accuracy.

CONCLUSION: Our study explores the possibility of a 3D printed wick with desirable thermophysical properties and provide deep insights into the optimal process parameters for the desired additively-manufactured wick structures.