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ON DESIGN OPTIMIZATION OF HEAT SINKS WITH CURVATURE CONSIDERATIONS FOR ADDITIVE MANUFACTURING

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Abstract: As recent power modules and semiconductor devices demand the utmost performance in small and light-weight structures, the design and the manufacturing of heat sinks that offer maximal cooling performance has become a challenge due to continuously evolving miniaturization and smaller cooling areas. In line of the above, and for practical realizations, heat sinks having the ability to operate in limited volume, as well as having simple geometry are highly desirable due to existing limitations in cooling area and machining processes. In this paper, we propose a methodology to design heat sinks that aim at minimizing temperature and pressure loss based on curvature considerations, as well as design of experiments and response surfaces. Exhaustive simulations and sensitivity analyses based on Finite Element Method have shown the improved cooling performance in terms of thermal resistance when compared to the conventional heat sinks with straight fins. Also, our proposed approach maximizes the contact area between the refrigerant and the heat sink, and increases the refrigerant flow velocity when compared to the conventional heat sink. Furthermore, the unique point of our proposed approach lies not only in the simplicity of the geometry of the heat sink, but also in the higher cooling performance, which is key to realize enhanced cooling mechanisms by existing metal-based 3D printers. We believe our approach offers the building blocks to enable the design and realization of heat sinks with manufacturable geometry and utmost cooling performance. As such, our proposed approach has the potential to capitalize on the benefits of metal-based 3D printing technologies, enabling the possibility to realize challenging geometries.