Abstract

Light Emitting Diodes (or LEDs) experience a significant reduction in luminous output and lifespan due to inadequate thermal management. In modern designs, multiple LED chips are packed into a limited space, resulting in significant heat generation; therefore, thermal management becomes critical. The thesis aims to investigate radial heat sink designs with branching fins for cooling LED panels under natural convection, with the objective of enhancing thermal performance and minimizing material usage. Firstly, the effect of branching fins on the performance of radial heat sinks is studied. Branching designs promote the chimney effect and cause flow acceleration, which improves the thermal performance. Due to branching, the thermal resistance of branching arrays reduces by 13% at lower fin lengths. Later, interruptions are introduced into the branching fins, which prevent the growth of the thermal boundary layers due to multiple edge effects. The interrupted (or slotted) fin designs achieve a maximum 33% reduction in heat sink mass compared to branching plate fins, while providing comparable thermal performance. To further improve the performance of the heat sinks, the height of the interrupted branching fins is varied along the radius and is numerically studied. Multiple machine learning regression models are trained on the parametric data set from numerical modeling. The best-performing model among the multiple models is used as a surrogate model in the multi-objective optimization to identify the designs with lower thermal resistance and mass. The optimized branching heat sink with varying fin heights exhibits an 8.8% improvement in thermal performance compared to a uniform-height heat sink with equivalent surface area and mass. The thesis establishes design guidelines for branching radial heat sinks in LED cooling applications, defining geometric ranges in which the proposed configurations outperform existing designs. The combined numerical-surrogate modeling and multi-objective optimization framework developed in this work constitutes a robust and transferable methodology for a broad class of passive thermal management problems.

Keywords: Branching radial heat sink, natural convection, LED cooling, numerical modeling, surrogate modeling, machine learning, multi-objective optimization.