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A novel insight into the design of perforated-finned heat sinks based on a hybrid procedure: Computational fluid dynamics, machine learning, multi-objective optimization, and multi-criteria decision-making

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Abstract

The optimal design of heat sinks presents a challenge for engineers. Using longitudinal perforations is an innovative technique employed in the design of parallel finned heat sinks that can be applied to various equipment. This technique leads to the simultaneous improvement of the heat transfer rate, pressure drop, and weight of heat sinks. The size (φ) and shape of the perforations alongside the Reynolds number are considered design variables. The results obtained from machine learning showed that the combinatorial algorithm is more reliable in modeling various objectives compared to the GMDH neural networks. The Pareto fronts generated by the NSGA-II algorithm indicated that >75% of the optimal points in the perforated-finned heat sinks (PFHSs) with square perforations had a $\varphi \geq 0.6$. The reason for this superiority is the geometric compatibility between the square perforations and rectangular fins. This compatibility enables the possibility of enlarging the perforations, resulting in improvements in essential parameters like heat dissipation, drag force, and overall heat sink volume. Various scenarios for weighting objectives in the multi-criteria decision-making (MCDM) process revealed that square-based PFHSs with Reynolds numbers around 39,900 in a wide range of perforation sizes could be applied as optimal design in real-world applications.