Optimization-Centric Modeling and Thermal Performance Enhancement of a Flat-Plate Solar Collector Using the Grasshopper Optimization Algorithm

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Abstract

Enhancing the thermal performance of flat-plate solar collectors requires effective optimization of multiple interacting parameters. This study investigates the optimization of a flat-plate solar collector integrated with a semi-circular heat pipe and three absorber profiles (flat plate, V-groove plate, and V-trough plate) using the multi-objective Grasshopper Optimization Algorithm (MOGOA). The objective is to maximize heat output (HO) and thermal efficiency (TE) while minimizing thermal resistance (TR). The performance of MOGOA is compared with the Response Surface Method (RSM) to evaluate its effectiveness in handling complex parameter interactions. The results indicate that the V-groove absorber provides the best overall performance. Using MOGOA, the highest heat output was achieved to be 127.48 W and a highest thermal efficiency of 35.79 %, with a relatively low thermal resistance of 0.059 °C/W, demonstrating a balanced optimization of the objectives. In comparison, RSM produced the lowest thermal resistance (0.0133 °C/W) and the highest thermal efficiency (37.855 %), but without consistently maintaining high heat output. Overall, MOGOA provides a more balanced and robust optimization approach, contributing to improved design and performance of high-efficiency solar thermal collectors.

Keywords

Flat plate solar collector, Grasshopper optimizer.