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THERMAL EFFICIENCY EVALUATION OF A FLAT-PLATE SOLAR COLLECTOR UNDER STRONG WIND EXPOSURE

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Abstract

Large-scale environmental deterioration highlights the importance of green energy technologies, including flat-plate solar collectors (FPSC), which are valued for their thermal and operational advantages. This study evaluated the thermal efficiency of the FPSC under strong wind conditions to predict its energy performance during operation. The evaluation was based on the thermal properties of the collector materials and climatic factors. The thermal efficiency of the collector was assessed using the energy balance equation and the Sharples-Charlesworth equation, which calculates the heat transfer coefficient from the collector glazing surface to the environment. A case study of the FPSC Hevelius Wunder CLS 2108 model was conducted. The results indicate that wind significantly affects the conversion of solar energy to thermal energy. A high thermal efficiency of 69.8% was achieved under windless conditions. An increase in wind velocity from 0 to 8 m/s resulted in a fivefold increase in convective heat transfer from the glazing. Consequently, the useful heat generated by the collector decreased by 17% and 21% at total solar radiation intensities (TSRI) of 800 W/m² and 700 W/m², respectively. The thermal efficiency of the collector decreased by 18.2% and 27.3% at TSRI values of 800 W/m² and 700 W/m², respectively, highlighting the necessity of computing the thermal efficiency for each collector. The proposed evaluation method is crucial for conducting feasibility studies and comprehensive assessments of the operational efficiency of solar hot water systems utilizing FPSC.

Key words: flat-plate solar collector, heat transfer coefficient, total solar radiation intensity, thermal efficiency, wind velocity

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