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Paper Title: Solar-Powered Cooling Unit Based On Thermoelectric Cooler For Cooling And Dehumidification Applications

Abstract:

This study presents the investigation of the performance parameters of a small-scale thermoelectric cooling unit designed as an alternative to conventional cooling and dehumidification systems. Conventional systems based on Chlorofluorocarbons CFCs cause harmful effects to the environment, with a lot of moving parts that need more maintenance. The proposed system is compact and eco-friendly. The proposed system integrates three Peltier modules PMs, thermoelectric coolers (TEC), arranged thermally in parallel and electrically in series, which can be powered by direct current generated directly from photovoltaic panels, giving the system the ability to work in off-grid locations. This novel design permits the integration of the cooling and dehumidification unit with sweeping air-based desalination techniques for both water and space cooling generation. A detailed mathematical model based on electro-thermal and energy balance equations was developed to investigate the system performance, and an experimental prototype was tested under varying operating conditions, including different airflow rates (1 CFM and 2 CFM) and operating currents (0.5 A to 5 A). The experimental results validated the accuracy of the theoretical model, showing a strong correlation between predicted and actual performance. Findings indicate that increasing the operating current initially improves cooling performance, but excessive Joule heating reduces efficiency beyond 7 A. Similarly, airflow rate enhances heat dissipation, improving the coefficient of performance (COP) and dehumidification rate, which reach maximum value at 7 CFM, while achieving a cooling load of almost 100 Watts and 96 grams/hour of condensed water at operating conditions (7 A, 7 CFM, and 100% inlet air relative humidity with COP of 0.43). The study highlights the importance of optimizing airflow rate and operating current to balance cooling capacity and energy efficiency. These results provide valuable insights for improving thermoelectric cooling systems in small-scale applications such as air cooling and dehumidification, especially in sweeping air desalination techniques.

Keywords: *Solar Cooling; Thermoelectric; Air Dehumidification; Water Harvesting.*