Dew-Point Evaporative Cooling for All Weather Application and PV Cooling: Thermodynamic and Entropy Generation Analysis

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論 文 内 容 の 要 旨

Thesis Summary

The growing global demand for energy-efficient cooling and heating solutions, driven by climate change and increasing energy consumption, necessitates innovative technologies to reduce environmental impact. This work presents a comprehensive investigation into dew-point evaporative cooling (DPEC) systems and their integration with advanced energy solutions, focusing on thermodynamic performance, system optimization, and potential applications.

The study commences with an entropy generation analysis of a counter-flow DPEC system, employing a dynamic mathematical model to evaluate mass and heat transfer processes. Results reveal that inlet air conditions, geometric parameters, and operational settings significantly influence entropy generation and system efficiency. For instance, higher inlet air temperatures enhance heat transfer but increase entropy generation, while optimized channel dimensions, such as smaller heights, improve wet-bulb efficiency.

Further, the research develops and evaluates an enhanced DPEC system for photovoltaic (PV) panel cooling. Simulations demonstrate that the addition of a second wet channel improves cooling performance, stabilizes PV surface temperatures, and elevates solar cell efficiency by up to 16.7%. However, the system's water consumption and dependency on ambient humidity necessitate further optimization and potential integration with pre-dehumidification systems.

Lastly, the study explores the hybridization of DPEC, PV, and desiccant units for winter heating applications. Results indicate the system's capability to provide air at 28°C and 45% relative humidity, aligning with thermal comfort standards. Dynamic modeling validates its efficiency in maintaining PV panel performance while delivering energy-efficient heating.

Overall, this research highlights the DPEC system's versatility, suggesting future efforts should emphasize experimental validation, economic feasibility studies, and innovative integrations to enhance its practical impact and align with sustainable development goals.