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

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論　文　名	Dew-Point Evaporative Cooling for All Weather Application and PV Cooling: Thermodynamic and Entropy Generation Analysis （全天候用途及び太陽光発電冷却のための露点蒸発冷却システム：熱力学およびエントロピー解析）
論文調査委員	主　査　九州大学　教　授　宮﨑　隆彦 副　査　九州大学　准教授　Kyaw　Thu 副　査　九州大学大学大学院工学研究院　准教授　濱本　芳徳

論　文　審　査　の　結　果　の　要　旨

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. The work presented 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 primary objective of the study was to address the research gaps in the field of DPEC systems. It aimed to enrich performance studies on DPEC from various perspectives, and to provide insights and strategies for system optimization. Furthermore, the potential applications of DPEC systems across different fields were explored. Grounded in the laws of thermodynamics, the study analyzed and characterized the heat and mass transfer behaviors within the system. The main findings of the thesis are summarized below.

- The study established a dynamic mathematical model based on the mass and heat transfer processes, and analyzed the counter-flow DPEC system by an entropy generation analysis. The results revealed that inlet air conditions, geometric parameters, and operational settings significantly influenced entropy generation and system efficiency. For instance, higher inlet air temperatures enhanced heat transfer but increased entropy generation, while optimized channel dimensions, such as smaller heights, improved wet-bulb efficiency.
- The simulation and analyses of an enhanced DPEC system for photovoltaic (PV) panel cooling were performed, and demonstrated that the addition of a second wet channel improved cooling performance, stabilized PV surface temperatures, and elevated solar cell efficiency by up to 16.7%. It was also found that the system's water consumption and dependency on ambient humidity necessitated further optimization and potential integration with pre-dehumidification systems.
- The hybridization of DPEC, PV, and desiccant units were also explored, and the system performance was investigated for winter heating applications. The results indicated the system's capability to provide air at 28°C and 45% relative humidity, aligning with thermal comfort standards. Dynamic modeling validated the efficiency in maintaining PV panel performance while delivering energy-efficient heating.

In conclusion, the study proposed a novel system with dew-point evaporative cooling, and showed a potential to enhance energy efficiency of photovoltaic power generation. The findings of the study have practical impact to achieve sustainable development goals and contribute greatly to the progress of thermal engineering. Therefore, the author of the thesis deserves to receive Doctor of Engineering.