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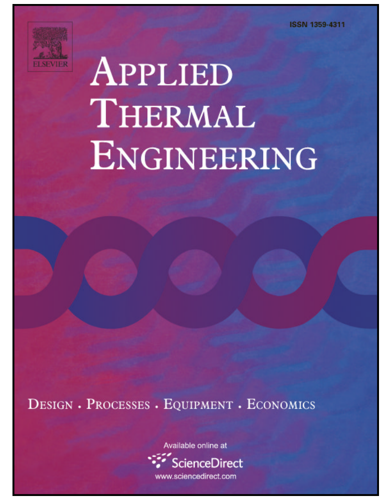

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System-Level Analysis of a Novel Air-Cooled Condenser using Spray Freezing of Phase Change Materials

Ben Xu, Swanand Bhagwat, Hongxin Xu, Arif Rokoni, Matthew McCarthy, Ying Sun*
Department of Mechanical Engineering and Mechanics, Drexel University,
Philadelphia, PA 19104, USA

Highlights

- System-level analysis of a novel air-cooled condenser using phase change materials.
- Improved air-side heat transfer by 5× and anchored steam condensation temperature.
- Provided up to 10.8 MW net power production gain compared to the baseline ACC.
- Multiscale modeling two-phase slurry flow of phase change materials over tube banks.

Abstract

A comprehensive system-level analysis is performed for a novel air-cooled condenser based on spray freezing of phase change materials (PCMs). This novel air-cooled condenser uses PCMs to decouple the process of steam condensation and heat rejection to air in order to significantly improve air-side heat transfer and reduce steam condensation temperature as compared to conventional air-cooled condensers (ACCs). Melting of solid PCM particles in a two-phase PCM slurry flow anchors the steam condensation temperature close to the PCM melting point regardless of the change in ambient air temperature. Spray freezing of millimeter-sized liquid PCM droplets increases the air-side heat transfer coefficient by five times compared to the finned-tubed ACCs. A multiscale model, which directly captures the melting and settling of PCM particles at the microscopic level and accounts for phase change through energy source terms at the macroscopic level, has been developed to simulate the PCM slurry flow over heated tube bundles. Using this multiscale model, the effects of particle volume fraction, Reynolds number, and particle to steam tube diameter ratio on the averaged wall Nusselt number of the steam tubes are investigated. It is found that the averaged wall Nusselt number for a PCM slurry flow of 20% solid fraction achieves a 38% enhancement over the PCM single-phase flow of

*Corresponding author. Tel.:+1-215-895-1373; fax: +1-215-895-1478; Email: ysun@coe.drexel.edu.