Mechanical Engineering Thesis Defense

Condensation Heat Transfer on Actuated Thermally Enhanced Hydrophobic Tubes

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Abstract

Dehumidifiers are ubiquitous and essential household appliances in many parts of the world. They are used extensively in tropical and sub-tropical environments to lower humidity in living spaces, where high ambient humidity can lead to numerous negative health effects from mild physical discomfort to more serious ailments such as mold build up in structures and dangerous sicknesses in humans. Most common dehumidifiers are based on conventional mechanical refrigeration cycles, where the effects of condensation heat transfer play a critical role in their effectiveness. In these devices, humid ambient air flows over a cold evaporator, which lowers the temperature of the humid ambient air below its dew point temperature and therefore decreases its water content by causing liquid water condensation on the evaporator surface. The rate at which humidity can be extracted from the ambient air is governed in part by how quickly the evaporator can shed the condensed droplets. Recent advances in soft, stretchable, thermally enhanced (through the addition of liquid metals) silicone tubing offer the potential to use these stretchable tubes in place of conventional copper pipe for applications such as dehumidification. Copper is a common material choice for dehumidifier evaporator tubing owing to its ubiquity and its high thermal conductivity, but it has several thermal downsides. Specifically, copper tubes remain static and typically rely on gravity alone to remove water droplets when they reach a sufficient mass. Additionally, copper's naturally hydrophilic surface promotes film-wise condensation, which is substantially less effective than dropwise condensation. In contrast to copper, thermally enhanced soft stretchable tubes have naturally hydrophobic surfaces that promote the more efficient dropwise condensation mode and a soft surface that offers higher nucleation density. However, soft surfaces also increase droplet pinning, which inhibits their departure. This work experimentally explores the effects of periodic axial stretching and retraction of soft tubing internally cooled with water on droplet condensation dynamics on its exterior surface. Results are discussed in terms of overall system thermal performance and real-time condensation imaging. An overall null result is discovered, and recommendations for future experiments are made.

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Zoom Link: https://asu.zoom.us/j/85767083980