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Tailoring Vapor-Liquid Condensation Phenomena: Challenges and Opportunities

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Abstract

Liquid-vapor condensation is a ubiquitous phase change process that is essential in both nature and industry. The enhancement of heat and mass transfer during condensation can provide substantial economic and environmental benefits to various applications, including power generation, thermal management, water management, refrigeration, and environmental conditioning. Previous studies showed that the coalescence-induced droplet jumping phenomena substantially enhanced the condensation heat transfer by facilitating droplet removal and surface refreshment. However, applying such condensers to real-world applications has been restricted by several challenges. First, their performance rapidly decreased at a high supersaturation level due to the flooding. Second, typical low surface energy coatings applied to such condensers showed limited thermal stability; therefore, the performance rapidly decreased in a hot steam environment. Finally, the droplet jumping condensers could not provide the enhanced heat transfer for low surface tension fluids such as alcohols and refrigerants. In this talk, we will summarize our efforts to overcome such challenges. We will explain the flooding mechanism and suggest anti-flooding condensers providing excellent heat transfer performance even at high supersaturation levels. Then we will discuss our approaches to obtaining excellent thermal stability and long-term stability. Later in the talk, we suggest other potential opportunities associated with tailoring condensation phenomena.