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Phase Separation in Phase Change Heat Transfer Devices

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Abstract

Phase change heat transfer has wide application in power generation, desalination and thermal management, in which the complicated mass, momentum and energy exchanges between liquid and vapor phases governs the transport phenomena. In this presentation, the phase separation principle for phase change heat transfer is introduced and discussed. For micro-evaporators, the separated pathways for liquid and vapor enhances the thermal performance and eliminates the flow instability. Using porous wall microchannels, high frequency "eye-blinking oscillation" is generated, causing switching of pressure between neighboring channels and resulting in ultra-stable heat transfer in micro-evaporators. For micro-condensers, lined pin fin array creates separated liquid and vapor passages. Conical alignment of pin fins provides expanded liquid pathway to adapt increased liquid flow rate, and the phase separation condenser avoids overflooding of pin fins and enables effective filmwise condensation with increased heat transfer coefficients at low pumping power. For heat pipes, the sintered porous mastoid process array separates the pathways of liquid suction and vapor venting of the evaporator surface. It allows the superhydrophilic evaporator to work in nucleate boiling mode and the superhydrophobic condenser to work in dropwise condensation mode, so that heat transfer coefficients increase with heat loads for both components, and the smart heat pipe is self-adaptive to external working conditions.