The Improved Condensation Heat Transfer Models on Homogeneous and Heterogeneous Surfaces

Jian Xie*, Cong Liang, Qingting She and Jinliang Xu

Beijing Key Laboratory of Multiphase Flow and Heat Transfer for Low Grade Energy Utilization, North China Electric Power University, Beijing, 102206, China.

*Corresponding Author: Jian Xie. Email: xiejian90@ncepu.edu.cn.

Abstract: Recently, micro/nano structured surfaces with various wettabilities have been developed to enhance condensation heat transfer. Here, two improved condensation heat transfer models were proposed to guide design of these surfaces. The first model deals with condensation on homogeneous wettability surface with nono-pillars. Compared with the classical model, the improved model behaves three features: (1) The linking from surface wettability to nano-pillars parameters is established; (2) The nano-porous thermal resistance under condensate droplets is considered; (3) The transition criteria of different droplet detachment modes including sliding, rolling and jumping is incorporated. The nano-pillars are found to have both positive and negative contributions to dropwise condensation. The increased nucleation sites number and decreased droplet detachment size are the positive contributions, while the decreased heat transfer rate of single droplet and the additional nano-porous thermal resistance are the negative contributions. Surface with dense nano-pillars is recommended to enhance condensation heat transfer due to the positive contribution suppressing the negative contribution. In contrast, long-term operation may break nano-pillars to induce heat transfer deterioration. The other model involves the hybrid dropwise/filmwise condensation on heterogeneous surface with hydrophobic and hydrophilic stripes. The condensate droplets on hydrophobic stripe are sucked by hydrophilic stripe. The droplet detachment sizes rises with increased distances between droplet location and hydrophilic/hydrophobic junction. Thus, increased hydrophobic stripe width W_{DWC} deteriorates the heat transfer on hydrophobic stripe. On the other hand, increased W_{DWC} enlarges area ratios of dropwise condensation to filmwise condensation. The two effects are competed to determine an optimal hydrophobic stripe width $W_{DWC,opt}$ to yield maximum overall heat transfer performance on heterogeneous surface. $W_{DWC,opt}$ is found to be majorly influenced by structural parameters instead of operational and wetting parameters. The predicted results were successfully verified by experiments. The improved models are potential to deepen the understanding of condensation on functional surfaces.

DOI:10.32604/icces.2019.05222