ME-446 Liquid-Gas Interfacial Heat and Mass Transfer

Homework 9

Presentation by Group 9 on Thursday 20th November

Problem 1: Capillary wicking

Read this paper where researchers characterized capillary flow in wicking materials combing experimental and theoretical effort. *It is suggested that two people work on this together.*

A Wettability Metric for Characterization of Capillary Flow on Textured Superhydrophilic Surfaces Taylor P. Allred, Justin A. Weibel, and Suresh V. Garimella Langmuir 2017 33 (32), 7847-7853 DOI: 10.1021/acs.langmuir.7b01522

A) Explain how the authors arrive at their expression for the volumetric wicking flow rate (Eq. 2 in the paper).

B) Explain how the authors relate their model to something experimentally measurable in their tube experiment.

Problem 2: Flow boiling heat transfer coefficient

Use Kandlikar's correlation (Eqs. 12.68-12.74 in Carey) to predict the local heat transfer coefficient for flow boiling of R-22 in a vertical tube at a pressure of $100\,kPa$ and vapor qualities between 0.2 and 0.6. The tube diameter is $0.9\,cm$, and the flow rate is such that the mass flux is $200\,kg/m^2s$, and a uniform heat flux of $10\,kW/m^2$ is applied to the tube wall.

Compare the results with the predictions of the Gungor and Winterton correlation (Eq. 12.60 in Carey) under the same conditions.

Use CoolProp (https://coolprop.org) to find the properties that you need. You can find an example of the usage of Coolprop in Matlab in the solution of HW7.

Problem 3: Onset of nucleate boiling

Liquid nitrogen flows upward in a vertical round tube with an inside diameter of $0.7\,cm$. The pressure along the tube is virtually constant at 360 kPa. The nitrogen enters subcooled at $80\,K$ and at a mass flux of $800\,kg/m^2s$. We apply a constant wall heat flux of $20\,kW/m^2$.

Assuming the flow of liquid becomes fully developed immediately at the entrance, estimate the location (distance downstream of the inlet) at which the onset of boiling occurs with the help of Eq. 12.14 in Carey.