

Homework 7

Presentation by Group 7 on Thursday 7th November

Problem 1: Rohsenow's correlation

Rohsenow's correlation is commonly written in the following form (Eq. 7.30 in Van Carey):

$$\frac{q''}{\mu_l h_{lv}} \left[\frac{\sigma}{g(\rho_l - \rho_v)} \right]^{\frac{1}{2}} = \left(\frac{1}{C_{sf}} \right)^{\frac{1}{r}} Pr_l^{-\frac{s}{r}} \left[\frac{c_{pl}[T_w - T_{sat}(P_l)]}{h_{lv}} \right]^{\frac{1}{r}}$$

Rohsenow recommended $r = 0.33$ and $s = 1$. C_{sf} is suggested to be 0.0132 for water on mechanically polished stainless steel. Setting $P_l = 1 \text{ atm}$, with other thermophysical properties of water (consider using Matlab XSteam function, CoolProp library or looking for correlations in literature), write your own code to generate the boiling curve (q'' vs $T_w - T_{sat}(P_l)$) for T_w between 110° and 130° .

Problem 2: Bubble departure

Consider a static vapor bubble resting on a surface, neglecting the influence of the flow caused by the bubble growth. Given the apparent contact angle θ , the liquid-vapor density difference $\Delta\rho$, and the surface tension σ derive an expression that describes the volume of the bubble V_B at equilibrium.

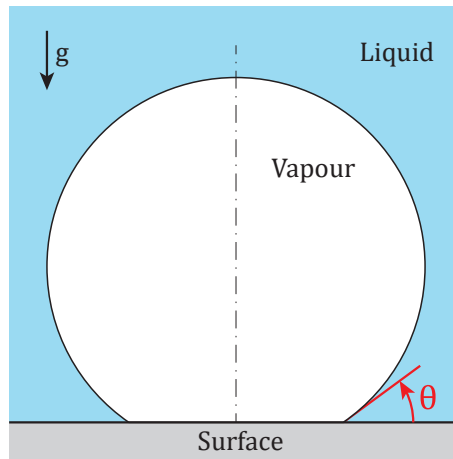


Figure 1: Schematic representation of a static vapor bubble on a surface.

Problem 3: Transient conduction in a semi-infinite solid

Consider a semi-infinite solid between $x = 0$ and $x = +\infty$ spanning half of the space, initially sitting at an isothermal state $T = T_i$ for all $x \geq 0$ and time $t < 0$. Please directly write down the solid temperature as a function of x and t ($t \geq 0$) for the following conditions, assuming you know all the necessary thermophysical properties of the solid. Comment on the timescale of the thermal response in each process assuming a certain characteristic length scale L_c representing the thermal penetration depth.

A) At time $t = 0$, set the solid surface temperature at $x = 0$ to $T_f \neq T_i$.

B) At time $t = 0$, expose the solid surface to a fluid of temperature $T_f \neq T_i$ and convective heat transfer coefficient h

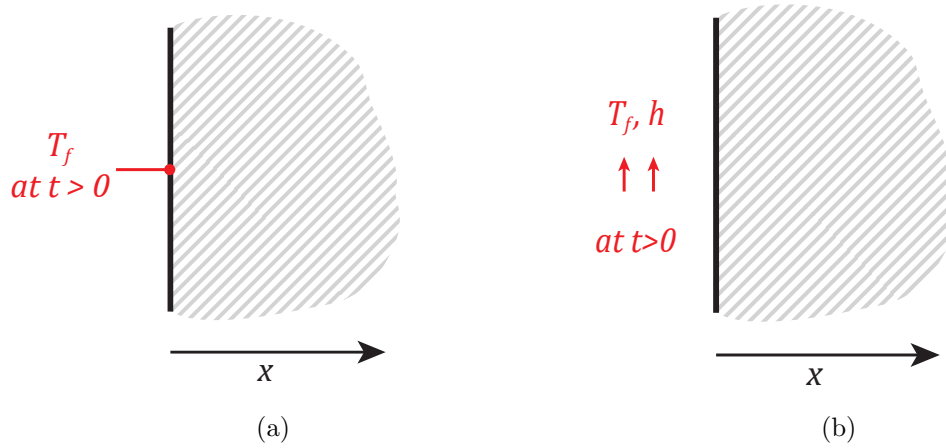


Figure 2: Scenario A, sudden shock at given temperature T_f at the surface (a). Scenario B, sudden shock at given fluid temperature and convective heat transfer coefficient h (b).