Problems [Ch. 4]

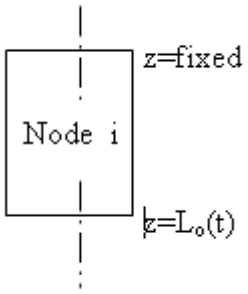
1. Derive that, in the two-phase region,
   1) $G = [\rho_f - \Delta\rho C_o\langle\alpha\rangle]\langle j\rangle - \Delta\rho V_{gj}\langle\alpha\rangle$, where $\Delta\rho = \rho_g - \rho_f$
   2) $j = u_{fo}[1 + x(v_g/v_f - 1)]$, where u_{fo} is the inlet velocity to an evaporating Tube

2. Derive the cross-section averaged void propagation equation from the vapor continuity equation. Describe the exact definitions for C_o and V_{gj}.

3. Solve the following Problem (2-1) in Collier's book.

4. In a vertical tube(D=1cm, L=2.5) heated uniformly at 100kw, the saturated water flows in with G=0.12kg/s under p = 70 bar. Derive the frictional pressure drop through the tube with a homogeneous and separate flow model.

5. Derive the nodal one-dimensional two-phase conservation equations for mass, energy and momentum.
   Assume the upper boundary of the node is fixed, but the lower one is moving [e.g. the boiling boundary, $L_o(t)$].
   Note : Relate the node-average parameters to the arithmetic average of the corresponding node inlet and outlet parameters.



6. Plot the void fraction versus quality for the bulk boiling of water in a 1" I.D. tube at 1000 psia and $G = 1 \times 10^6$ $lb_m/hr\text{-}ft^2$, using the Zuber-Findley model (use $C_o = 1.1$, $k_3 = 1.53$).

7. For a rectangular subchannel of 14ft long, plot the total static pressure drop along the heated length as a function of mass flux(i.e. ,plot Δp vs G). (neglect subcooled boiling region) Show the various pressure drop component.
   coolant pressure 1000 psia
   pitch to diameter of fuel rod 0.5 / 0.7 in
   power density(q') 7.0 KW/ft
   inlet coolant temperaqture 520 °F
8. For the case of ideal annular flow (i.e. annular flow with no liquid entrainment, no void in liquid film and smooth surface interface) in a pipe. Derive values fro the drift-flux parameters, C_o and V_{gj}. How do these parameters change for the cases of counter-current flow?

9. Show that an j can be expressed in term of the inlet velocity to an evaporating tube, u_{fo}, the mass quality, x, and the phase specific volumes, v_g and v_f, as follows;

$$j = u_{fo}[1+ x(v_g/v_f -1)]$$

10. Consider a rectangular subchannel having the pitch of 0.7 in. in a reactor of pressure of 1000 psia. The length and outer diameter of fuel rod is 14 ft and 0.5 in, respectively. The rod produces axialiy uniform heat of 17kw/ft. When the coolant flows at the inlet with 520 F and 6ft/sec, calculate the axial steady-state void fraction profile with following models.

    1) the profile fit model

    2) the mechanistic model with HEM

    3) the mechanistic model with $C_o = 1.2$, $V_{gj} = 0.4\ m/sec$

11. In Problem10, calculate the pressure drop in the subchannel when the inlet coolant flow varies from 1 to 20 ft/sec.

    Use ① HEM

    ② $K_{inlet} = 14.$, $K_{exit} = 0.01$