

EN-634 Nuclear Reactor Thermal Hydraulics and Safety
Assignment-7

1. Starting from the definition of χ^2 , show that

$$\chi^2 = \left(\frac{1-x}{x} \right)^{2-n} \left(\frac{\mu_l}{\mu_g} \right)^n \frac{\rho_g}{\rho_l}$$

Further, using the definitions of ϕ_{lo}^2 and ϕ_{ls}^2 , show that

$$\phi_{lo}^2 = \phi_{ls}^2 (1-x)^{2-n}$$

2. Starting from Chisholm's postulate that slip, s can be approximated as

$$s = \left[1 + x \left(\frac{v_g}{v_l} - 1 \right) \right]^{1/2}, \text{ show that this equivalent to } s = \left[1 - \beta \left(1 - \frac{v_l}{v_g} \right) \right]^{-(1/2)}. \text{ Further, starting from}$$

the basic definitions, show that $\frac{\beta}{\alpha} = \beta + s(1-\beta)$ and finally arrive at the closure

$$\text{equation } \frac{\beta}{\alpha} = \beta + \frac{(1-\beta)}{\left[1 - \beta \left(1 - \frac{v_l}{v_g} \right) \right]^{(1/2)}}$$

3. Consider an experimental loop in which sub-cooled liquid (by 10°C) at 75 bar is pumped into the test section at a rate of 60 kg/min. The hydraulic diameter and the flow cross sectional area of the test section is 6 mm and 22 cm². If the test section, which is oriented vertically, is 6 m long and is heated with a linear heat rate of 10 kW/m, estimate the accelerational, frictional and gravitational pressure drop using (a) homogeneous model (b) slip flow model with Drift correlation for void closure ($C_o = 1.2$, $U_{wd} = 3$ m/s) and Chisholm's C coefficient method for frictional closure (c) Chisholm's model for slip closure and his B coefficient method for frictional closure. Note that it is easier to write a computer programme to perform the integration. Keep the friction factor, two-phase multiplier and void fraction correlation, etc., as functions. First bench mark it with homogeneous model computed by hand. Now do the necessary modifications in the functions and run for other cases. Use Excel sheet to compute properties

4. Consider a simple problem to illustrate the development of empirical relations for a hypothetical One dimensional model.. The problem is a bit lengthy but very illustrative (I guess). Consider flow of air-liquid between two horizontal parallel plates separated by a distance D , with air flowing on top of the liquid (stratified flow). The flow may be assumed to be fully developed and laminar. In such a case, the exact axial momentum equation for liquid and gas can be

simplified to give $\frac{dp_g}{dx} = \mu_g \frac{d^2 u_g}{dy^2}$, $\frac{dp_l}{dx} = \mu_l \frac{d^2 u_l}{dy^2}$. In the above formulation, u_g and u_l are

functions of y alone and p is only a function of x . Note that x is along the plates and y is normal to the plates. Since dp/dx is only a function of x and $\mu_l \frac{d^2 u_l}{dy^2}$ is only a function of y , each of

them will be a constant (denoted as dp/dx). Thus u_g and u_l can be shown to be of the form $u_i = (dp/dx) y^2/2 + a_{1i} y + a_{2i}$. The values of the four constants are obtained using four conditions,

viz., the velocities at wall shall be 0 and the velocity and the shear stress at the interface ($y = y_{\text{interface}}$) shall be continuous. Thus we can find the velocity profiles in terms of two unknowns, viz., dp/dx and $y_{\text{interface}}$. These can be evaluated by integrating the velocity profiles and equating them to the respective phase volumetric flow rates per unit width, viz., Q_g and Q_l . This completes the formulation. Now having carried out the algebra, try to express β/α in the drift flux form.

5. Study Bankoff's model for the explanation of the value of C_A . Carry out the model for flow between two parallel plates separated from each other by a distance D . Compute the value of C_A for $m = n$ with values ranging from 1-7 in steps of 1. When will the value of C_A be equal to 1?
6. Get an Excel sheet prepared using Taitel and Dukler model discussed in class to generate the variation of h_l/D as a function of χ for horizontal ducts. Compare your result with the following figure. (Instead of iterating, it will be easy to assume h_l/D and compute χ , which is straightforward. This can be easily done in Excel)

