Problems [Ch. 3]

1. Calculate the nucleate boiling heat transfer coefficient on the surface of S.S heating rod in the water at 1 atm, using Foster and Zuber correlation (Eq. 4.46 in Collier's Book).

2. calculate the critical power(Kw) with McBeth's low flow CHF correlation inside an electrically heated tube of 6 ft long and 0.5 in I.D at 1000 psia, where the water flows with 20 Btu/lbm and 0.5 x 10^6 lbm/hr-ft^2 of inlet subcooling and mass flux(G), repectively.

3. Compute the minimum time to needed heat up 100 kg of water from 20°C to 100 °C at atmospheric pressure. The water is contained in a well-insulated tank which is also stirred. The water is electrically heated with a high- power in the form of a horizontal cylinder 0.02m in diameter with a surface of 1m^2. The heater unit can be operated with its maximum power condition with switching off if the burnout flux is exceeded. Use at least two CHF correlations to get a good estimate of the minimum time.

4. Neglecting the partial nucleate boiling region, determine the wall superheat (T_w-T_{sat}) at which the boiling commences in a water system.
   Assume : T_{bulk} = T_{sat} - 100°, G = 3.0x10^6 lbm/hr-ft^2,
   p = 1000 psia, D_H = 0.5"
   How much lower is the wall superheat at the point of initial nucleation? Display both points on a boiling curve.

5. It is known that the flooding phenomena can cause the flow of water to be reversed in a tube in annular counter current flow and begin to flow upward at some critical gas upflow velocity given by

$$(j_g^*)^{1/2} + (j_l^*)^{1/2} = 0.725$$

   also the point of flow reversal for upward cocurrent annular flow (i.e for liquid film drainage) is given by j_g^* = 0.5.
   (a) Now let us consider the case of flow reversal where we want you to derive the superficial velocity below which an annular flow cocurrent upward changes to gas flow up and liquid film flow down. (Hint: use a momentum balance)
   (b) Can you cast this superficial velocity limit in terms of j_g^* ?
   (c) How would you attempt to do this for flooding ?

6. Compare the film boiling heat transfer coefficient from the Bailey and Berenson correlation, for water at 14.7 psia and 1000 psia. Assume the heater rod diameter of 0.5" and express H_{film} in units of Btu/hr-ft^2-°F.

7. A vertical tube in a high pressure water boiling channel has the following characteristics :

$p = 6.89 MPa$

$D = 10$ mm

$L = 3.66$ m

$T = 204$ °C

Using the Biasi and CISE-4 correlation, find the critical channel power for uniform heating at $G = 2000\ Kg/m^2s$.

8. At the same case of Prob. 7, but the axial heat flux profile of chopped cosine shape given as,

$q''(z) = 1.4 x q_{avg}'' x \cos\{k(z-L_H/2)\}$,   where $k = 0.45753\ ft^{-1}$

obtain CHF.

9. For $G=1.0x10^6$ lbm/hr-ft^2, <x> = 0.5 and p=1000psia, determine the two-phase heat transfer coefficient, $H_{2\phi}$, in a 1 inch diameter(I.D) heated pipe through which a steam/water mixture flows.

Assume we have ;

(a) fully developed nucleate boiling

(b) forced convection vaporization

How do these numbers compare?

Now evaluate $H_{2\phi}$ using Chen's correlation. Which boiling regime are we in?

10. Compare the film boiling heat transfer coefficient from the Bailey and Berenson correlation, for water at 14.7 psia and 1000 psia. Assume the heater rod diameter of 0.5" and express H_{film} in units of Btu/hr-ft^2-°F.

11. You want to determine the Leidenfrost temperature in a pool boiling experiment. You must make this measurement in a electrically heated experiment (i.e in a heat flux controlled experiment). Fortunately, you have identified a heating element that can withstand very high temperature without melting. How would you perform such an experiment ?