22.313 THERMAL HYDRAULICS IN NUCLEAR POWER TECHNOLOGY

Take Home Quiz

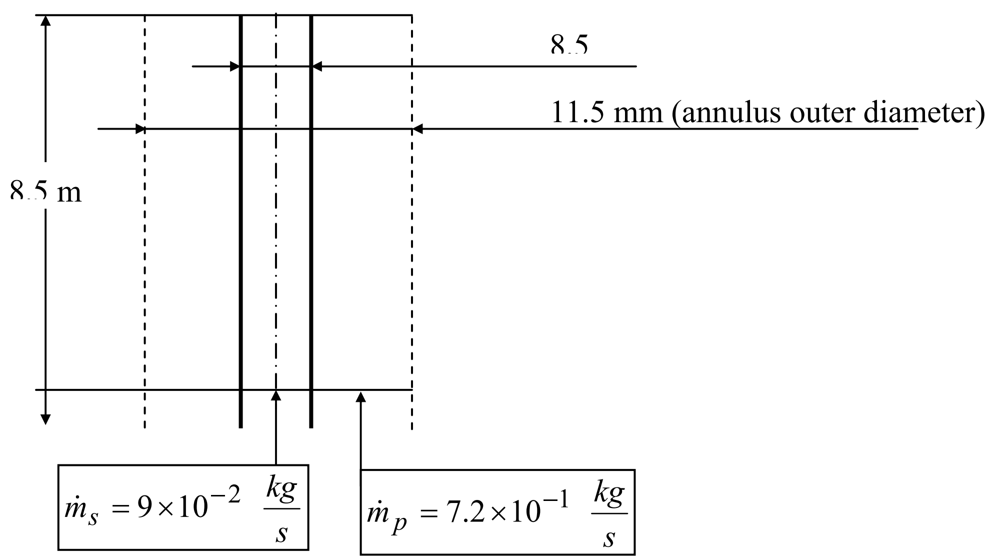
Due at 9:30AM on Day# 16

Do not consult anyone about this examination in preparing your solution.

Problem 1 (60%)

A once through steam generator of a new design has the high pressure primary flow in the shell side and the lower pressure secondary flow in the tubes. A single tube with its associated annular primary system flow region is pictured in Figure 1. Operating conditions and water steam properties to be used are given below.

Figure 1



The secondary flow becomes steam at 10 ^oC superheat at the outlet. The inlet and outlet temperature and enthalpy conditions are:

	Temperature	Enthalpy
Primary Inlet	330 ^oC	1980 kJ/kg
Secondary Inlet	230 ^oC	991.2 kJ/kg

The secondary coolant pressure is 7.5 MPa and the saturation temperature and related enthalpies are:

Saturation temperature	290.5 ^oC
Saturated liquid enthalpy	1292.7 kJ/kg
Saturated steam enthalpy	2766.9 kJ/kg
Heat of evaporation	1474.2 kJ/kg

Steam and water properties:

	v	c_p	σ x 10^3	μ x 10^6	ν x 10^6	k	Pr
	m^3/kg	kJ/kg/K	N/m	Ns/m^2	m^2/s	W/m/K	---
Water	1.368 x 10^{-3}	5.47	16.71	94.10	0.128	0.558	0.932
Steam	2.533 x 10^{-2}	7.09	---	19.21	0.491	0.066	1.61

Questions:

You are encouraged to prepare a numerical algorithm for the solution of this problem. but be sure also to write out the solution approach including all equations and correlations used as well.

a) Compute and make a plot of the following quantities considering thermal non-equilibrium and mechanical non-equilibrium (use the slip correlation of Smith provided below)

i) $T_{wall}(z)$

ii) $\alpha(z)$

Please show all computations and assumptions. You may assume that at 4 meters along the tube length the CHF condition occurs. (i.e. film dryout) Hence, calculate conditions in the SG tube only up to z = 4.0 meters.

b) If at film dryout it is assumed that the heat transfer coefficient on the secondary side goes to zero, what is the resulting tube wall temperature?

Smith 1969 Slip Correlation (eqn 3.12, Collier and Thome)

$$\frac{u_v}{u_\ell} = .4 + (1 - .4)\left[\frac{\rho_\ell/\rho_v + .4(1/x - 1)}{1 + .4(1/x - 1)}\right]^{1/2}$$

Acceptable Calculation Simplifications:

1. Neglect tube wall resistivity
2. Take primary side heat transfer coefficient to be constant
3. Neglect pressure losses

Calculational Aids

Matlab® data files and scripts will be made available to you that are free to use for the purposes of obtaining the additional water properties you may need for this problem. Additionally, a Matlab® script is provided the two-phase heat transfer coefficient from the Chen correlation for a given set of water properties. (Please see the TA if you need help in setting up these Matlab® functions.)

However you choose to solve this problem, be sure to provide a clear description of the correlations and flow models that you use.

Problem 2 (20%)

A bottle has a volume, V, of 1 liter and neck internal diameter, d, of 20mm. It is full of water and emptied by turning it upside down. Assume the bottle emptying is controlled by the entry of slug (plug) flow bubbles into the bottle. If these bubbles are inertia controlled, find the emptying time.

Problem 3 (20%)

1. Open yourself a bottle of beer. Explain the origin of the cloud you observe in the neck of the bottle.

Pour your beer into a transparent glass. As you relax, observe the beer and answer the following additional questions.

2. Identify the types of locations of sites from bubbles are originating.
3. By what mechanism are bubbles being continually created from these given sites?
4. For any given site bubbles depart at a given frequency and rise in a column.
    a) Predict the rise velocity of any given bubble and compare it with your observation.
    b) Also predict and compare the observed bubble diameter change.
5. Sprinkle some salt into the beer and explain the behavior you observe.