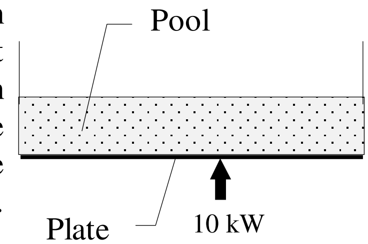
EN-634 NUCLEAR REACTOR THERMAL-HYDRAULICS
Assignment-7

1. Consider a circular plate being designed to dissipate 10 kW. One of the suggestion given by an engineer is to build a pool over the plate and fill it with water, so that the boiling water can become an effective heat transfer medium. It has been decided to use a factor of safety of 1.5 to avoid burnout of the plate. (a) Calculate the minimum diameter of the plate that can dissipate the heat safely. (b) Estimate the surface temperature of the plate. Assume that the pool is at 1 bar-absolute. You may make suitable assumptions and use appropriate empirical correlations. Justify everything you do suitably.



   Physical properties at 1 bar (a) are,
   $\mu_l = 283 \text{ X } 10^{-6}$ Ns/m^2, $\mu_g = 12 \text{ X } 10^{-6}$ Ns/m^2
   $v_f = 1.043 \text{ X } 10^{-3}$ m^3/kg, $v_g = 1.673$ m^3/kg
   $h_f = 419.1$ kJ/kg, $h_g = 2676.0$ kJ/kg
   $c_{pf} = 4.218$ kJ/kg-K
   $\sigma = 58.78 \text{ X } 10^{-3}$ N/m

2. Consider a fuel element of a PHWR whose pellet outer diameter (OD) is 14.2 mm, clad OD of 15.2 mm and 0.38 mm thick. The core length is 5 m long and can be assumed to be made of (19 X 306) rods of full length. The coolant flow rate is 3355 kg/s and it enters the core at 249 ^{o}C. The thermal power to coolant is 756 MW (th). Assuming Lyon's equation for the property of UO_2 (as supplied in the code), Clad Conductivity to be 16 W/m-K, C_p of D_2O is 5.79 kJ/kg-K, overall gap conductance to be 8520 W/m^2-K and h = 59620 W/m^2-K. and the axial power distribution is cosine, calculate the bulk coolant, fuel centre-line and clad outside temperatures at the centre of an average power channel, using the code supplied.3. Now modify the code to find the maximum fuel centre-line temperature and maximum clad surface temperature. Also specify their locations. (note that you have to add a routine to solve for the fluid temperature using the energy equation. Ou may assume c_p is constant and take its value at the average temperature of the coolant in the core.

3. Consider the data given on BWR in Kazimi and Todreas (pages 5, 13 and 31) and perform the following(for computations, do a node sensitivity analysis and comment accordingly):
   (a) Assuming that the power distribution is cosine, write down the expression for the power profile for the hot channel.
   (b) Write down a computer program that will discretise the channel into N nodes and perform the energy balance for each node to give the bulk coolant temperature variation along the length of the hot channel. Also calculate the pressure drop for every node so that the core pressure drop can be computed.
   (c) Use the computer code on the conduction analysis supplied to you to compute the temperature of the clad surface and fuel centreline temperature. Use the expression given in Kazimi and Todreas (K&T) for UO_2 thermal conductivity (page 301). The clad thermal conductivity may be assumed to be constant at a value of 15 W/m-K. Note that the point of incipience of boiling, subcooled boiling heat transfer coefficient, point of saturated boiling and saturated boiling heat transfer coefficient has to be determined by suitable procedure (refer notes on boiling supplied).

(d) Using the Biasi correlation and Bowring Correlation (K&T-pages 563-65), compute the axial variation of DNBR along the length of the hot channel.

(e) Repeat (d) using W-3 correlation. Compare this with that given by Biasi and Bowring correlation. Comment suitably.

4. Consider the data given on BWR in Kazimi and Todreas (pages 5, 13 and 31). Work out the fluid volume using vessel and fuel dimensions. Further, for BWR, you may assume that the initial free surface of steam is at a height half way between the vessel top and core top (use your judgments wherever needed and clearly mention the approximations). Also, assume the level of hot leg. Now do a depressurisation calculations for a break size of 20 cm^2. You may use bubble rise model. The bubble rise velocity may be assumed to be a constant at 20 cm/s.
5. Consider an experimental wet-well of a suppression pool containment as shown in the figure. The wet-well, having a total volume of 30 m^3, may be assumed to be thermally insulated. Initially it contains 1 m^3 of water. The initial state of the wet well is 35^{o}C, 100 kPa (total pressure), 100 % relative humidity. During a simulated LOCA, 55 kg of steam water mixture enters at an average state equivalent of 700 kPa, x=0.5. Find the final temperature and pressure of the wet-well after the incident.