

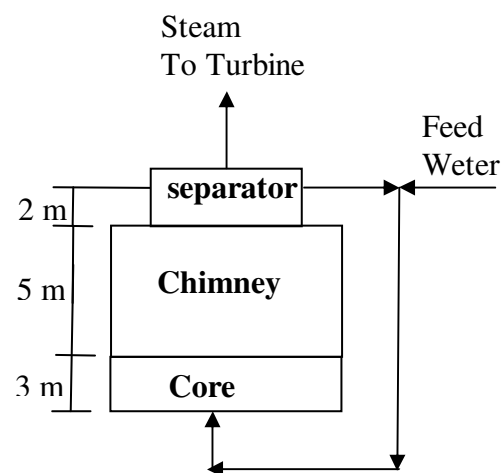
EN-634 NUCLEAR REACTOR THERMAL-HYDRAULICS

Assignment-7

1. 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 °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/m²-K and $h = 59620$ W/m²-K. and the axial power distribution is cosine, calculate the bulk coolant, fuel centre-line and clad outside temperatures at (a) the centre of an average power channel, (b) at the exit of the channel. You can use the code supplied for conduction analysis with suitable modification.

2. Consider a natural circulation boiling water reactor designed to operate on natural circulation in the vessel. to remove the heat from the core shown in the figure 2. Assume that the separator completely separates steam and water with no pressure loss. The chimney region may be assumed to have the same geometry as the core region. Estimate the maximum allowable core thermal power such that the core exit quality is less than 15%. The Darcy friction factor for single phase may be taken as 0.02. The design parameters of the system is as given below.

System pressure = 7.0 Mpa, Flow area = $9.55 \times 10^{-3} \text{ m}^2$,
 Length of the core = 4 m, Length of the chimney region = 2 m,
 Hydraulic diameter of the core passage = 0.013 m,
 Hydraulic diameter of the Chimney passage = 0.1 m,
 condensate vessel inlet sub-cooling = 135 °C, Separator effective length = 2 m. For simplicity heat flux may be assumed uniform. State all assumptions and proceed systematically.



3. Decay heat is to be removed from a three loop 1000 MWt sodium cooled fast reactor by natural convection. At full power, the coolant pump heads are 100 m of sodium and the total coolant flow is 20×10^6 kg/hr. The design requirement is that at 2% full power level, the natural convection must prevent the coolant temperature rise in the core from exceeding the value at full power level. Assuming that the core inlet temperature and the hydraulic resistance coefficients remain constant and that the flow is upward in the core, calculate the distance that the heat exchanger must be elevated above the core. Proceed to solve the problem systematically. State all the assumptions used to make the problem solvable. Assume that all the frictional drop is only in the core and heat exchanger
 Data: $\beta = 2.9 \times 10^{-4} / \text{K}$, $c_p = 1.256 \text{ kJ/kg-K}$, $\rho = 865 \text{ kg/m}^3$

4. A four loop PWR operates at 150 bars. The core pressure drop is 3.1 bars at the rated flow of 55×10^6 kg/hr. The pump rated head is 84 m of water at the flow conditions. The characteristic of pumps may be assumed to be $\frac{H}{H_R} = 1 - 0.2 \left(\frac{\dot{m}}{\dot{m}_R} \right)^2$. If one of the loop fails, estimate the fractional reduction in core flow, assuming, (a) the loop has a check valve, (b) the loop does not have a check valve. The density of coolant may be taken as 800 kg/m^3 .
5. A PWR has two identical loops. The hydraulic parameters for the system are $(L/A)_{\text{core}} = 1.5 \text{ m}^{-1}$, $(L/A)_{\text{loop}} = 30 \text{ m}^{-1}$. The $\Delta p_{\text{core}} = \Delta p_{\text{loop}} = 3.5$ bar, the core flow rate = 3.1×10^6 kg/hr, density of coolant = 1000 kg/m^3 . At zero time, power is lost to the pumps. Neglecting natural convection, estimate the time for the flow rate to be reduced to one half its initial value, (a) if pump inertia is neglected \ and \ (b) if the pump have half times of 30 s.
6. Consider a helium cooled gas reactor whose primary system volume is 1400 m^3 . The initial condition of the coolant is 60 bar and 450°C and the reactor was operating at a steady thermal power of 3000 MW(th.) for several months. If this reactor suffers a loss of coolant accident due to the development of a break whose area is 20 cm^2 , compute the variation of system pressure and temperature with time till the pressure drops to 2 bar, if, (a) the thermal power generated from the core may be assumed to be equal to the decay power level given by Way and Wigner formulation, (b) the depressurisation may be assumed to be isothermal and (c) the depressurisation may be assumed to be adiabatic. (It is better to solve it using a computer program and validate it using the expression derived in the class for the parts (b) and (c). For helium, the adiabatic index may be taken as 1.33.