Assignment 6

1. A small PWR plant operates at a power of 485 MW(th). The core is approximately 1.9 m in diameter and 2.3 m tall. It consists of 23,142 tubes of thickness 0.5 mm and inner diameter 7.5 mm on a square pitch of 10.5 mm. The tubes are filled with 3.4 w/o enriched UO_2. The core is cooled with water entering at 260 ^oC flowing at a rate of 15.4 X 10^6 kg/hr at 150 bar. Compute the,

(a) average temperature of water leaving the core.

(b) average power density in kW/litre, and

(c) maximum linear heat rate, surface heat flux and volumetric heat generation rate.

2. Design a 3000 MW(th) bare cylindrical PWR, whose height to diameter ratio is 1. The fuel to coolant volume ratio is to be maintained equal to 1 in a square lattice. The system pressure and core inlet temperature shall be 175 bars and 285^o C respectively. If the reactor has to work under the following three thermal constraints, viz., the

(i) maximum power density = 250 W/cc,

(ii) maximum clad surface heat flux = 125 W/cm^2 and,

(iii) maximum core outlet temperature = 325^o C,

Compute , the

(a) reactor dimensions and volume ,

(b) fuel element diameter and lattice pitch,

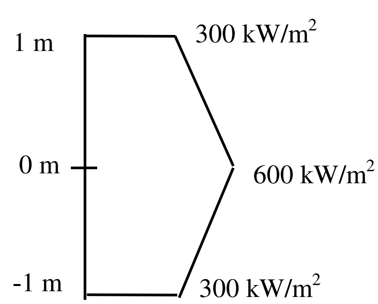
(c) number of fuel elements, and

(d) mass flow rate and average coolant velocity.

You may assume: c_p of coolant = 6 kJ/kg-K and overall peaking factor = 3.64

Note: The N square lattices, when properly arranged forms a circular core of diameter D

3. The heat flux at the surface of fuel rod in an experimental reactor varies as shown in the figure. The fuel rods are 1 cm in diameter and 2 m long. Water (C = 4.5 kJ/kg ^oC) enters at 65^o C and flows at the rate of 160 kg/hr per rod. The heat transfer coefficient is 6000 W/m^2-C. Calculate the temperature of coolant and fuel surface temperature at the middle and the exit of the channel.



4. A reactor is made up channels with fuel rods of 10 mm diameter. The associated coolant flow area is 1.5 cm^2. The coolant enters at 10 Mpa at a velocity of 3.6 m/s and 250 ^oC. The exit temperature of the coolant is 295 ^oC. The axial power profile in the channel may be assumed to vary as,

$q'' = q''_0 e^{\frac{\pi z}{H}} \sin(\frac{\pi z}{H})$,

where H represents the height of the core, which is 3.6 m, z=0 represents the bottom of the core and q''_0 is a constant. Compute the location of the maximum fuel surface temperature, given the following:

$\rho_f = 732.3$ kg/ m^3,

c_p of the coolant = 5.51 kJ/kg-K.

Convective heat transfer coefficient = 10 kW/m^2-K

$$\int e^{ax} \sin(bx)\ dx = \frac{e^{ax}}{a^2 + b^2}\left(a \ \ \sin(bx) - b \ \ \cos(bx)\right)$$

5 Consider a vertical fuel rod of 8 mm diameter wetted with a coolant mass flow of 0.5 kg/s. If the linear heat generation rate is as shown in the figure, and the coolant enters at 267 ^{o}C, compute the location at which the coolant will boil. You may assume that the saturated temperature of water at the fluid pressure is 285.8 ^{o}C, c_p = 5.444 kJ/kg-K. If the heat transfer coefficient at that location is 8000 W/m^2-K, compute the clad surface temperature.