UNIVERSITY OF ILLINOIS
DEPARTMENT OF NUCLEAR, PLASMA AND RADIOLOGICAL ENGINEERING
NPRE 449 – Nuclear Systems Engineering and Design

HW8: Simplified CP

In the CP, temperatures and pressure in the hot channel of a PWR and a BWR are calculated. In both cases the linear heat generation rate changes in z as:

$$q'(z) = q'_0 \cos(\pi z/H_e), \quad -H/2 \le z \le H/2$$

where H is the fuel height and H_e is the extrapolated height.

Assumptions:

- Steady-state
- No internal heat generation in the fluid
- Axial conduction is negligible
- Single phase properties are constant (based on inlet pressure and temperature)
- Saturation temperature, liquid saturation enthalpy, and vapor saturation enthalpy are functions of pressure. All other saturation properties are constant (based on inlet pressure)
- Changes in fuel and clad properties with temperature are negligible

PWR

Geometry:

- H = 4 m
- H_e = 4.3 m
- D_{rod} = 0.95 cm
- Pitch = 1.26 cm
- D_{Fuel} = 0.82 cm
- Gap thickness = 0.006 cm
- k_{gap}=0.25 W/m^{o}C
- k_fuel=3.6 W/m^{o}C;
- k_cladding=21.5 W/m^{o}C

Conditions:

- G = 4000 kg/m^{2}s
- q'_0 = 380 W/cm
- P (z=-H/2) = 15 MPa
- T_f (z=-H/2) = 277^{o}C

BWR

Geometry:

- H = 4.1 m
- H_e = 4.4 m
- D_{rod} = 1.227 cm
- Pitch = 1.62 cm
- D_{Fuel} = 1.04 cm
- Gap thickness = 0.010 cm
- k_{gap}=0.25 W/m^{o}C
- k_fuel=3.6 W/m^{o}C;
- k_cladding=21.5 W/m^{o}C

Conditions:

- G = 2350 kg/m^{2}s
- q'_0 = 605 W/cm
- P (z=-H/2) = 7.5 MPa
- T_f (z=-H/2) = 272^{o}C

1) For the PWR condition, assuming constant properties, derive the governing equations, calculate the parameters necessary, and provide following plots – provide copy of code with submission (NOTE: put z on the y-axis of the plot – like we have done for other reactor channel plots):
    a. Fuel Centerline temperature, clad surface temperature, liquid temperature and saturation temperature vs z
    b. Equilibrium quality vs z
    c. Pressure vs z