22.313J, 2.59J, 10.536J THERMAL-HYDRAULICS IN POWER TECHNOLOGY

Homework Set 6

1. Calculation of the MDNBR in the PWR Hot Channel

Consider the PWR hot channel geometry and operating conditions from Homework Set 5.

   i)   Find the distribution of the DNBR in the channel. (*Hint:* use the Tong-68 correlation, and ignore grid spacer effects)
   ii) What is the location of the MDNBR?
   iii) If the inlet temperature is decreased, while all other operating conditions are kept constant, how does the DNBR distribution in the channel change? Provide a qualitative sketch of the new distribution.

2. Thermal Analysis of the BWR Fuel Assembly

A typical 8×8 BWR Fuel Assembly (FA) is shown in Figure 1. Only 62 (out of 64) positions are occupied by fuel pins, the other two positions are occupied by so-called "water rods", which generate no heat. The heated length of the fuel pins is 3.81 m. The FA operating conditions are as follows:

   Pressure: 6.4 MPa
   Inlet temperature: 270°C (corresponding to an inlet enthalpy of 1183.8 kJ/kg)
   Mass flux: 1,741 kg/m^{2}s
   Average linear power: 19 kW/m

Assuming a <u>cosine-shape</u> axial power profile, develop a numerical model to calculate the following parameters:

   i)   Mass flow rate.
   ii)   Axial distribution of the equilibrium quality.
   iii)   Axial location for the onset of saturated boiling.
   iv)   Axial distribution of the bulk temperature.
   v)   Axial distribution of the wall temperature. (*Hint:* use the Dittus-Boelter correlation for single-phase heat transfer, and the Chen correlation for two-phase heat transfer)
   vi)   Axial distribution of the critical quality at the operating power. (*Hint:* use the CISE-4 correlation)
   vii)   Critical Power Ratio (CPR) for the FA.

Assumptions:

   • Treat the FA as a round channel of equivalent diameter.
   • All fuel pins in the FA generate the same amount of power.

- Use the properties in Table 1. Neglect the dependence of the properties on temperature and pressure.
- In answering question 'v', assume that the onset of nucleate boiling occurs at $T_w=T_{sat}$, and also note that the Chen correlation reduces to the Dittus-Boelter correlation for $T_w<T_{sat}$.
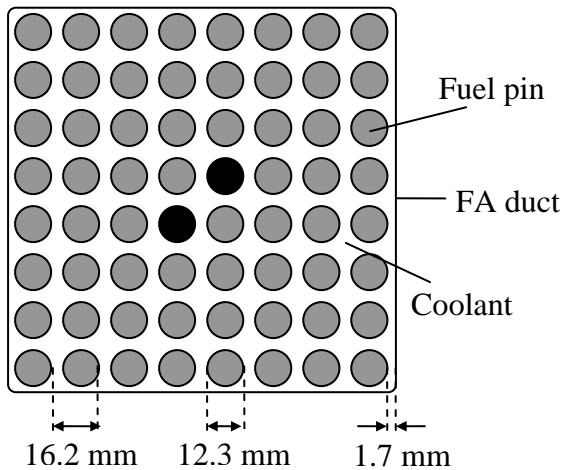- In using the Chen correlation, set x=0 for subcooled boiling and $x=x_e$ for saturated boiling.

Figure 1. Cross-section of the BWR FA.

Table 1. Saturation properties of water at 6.4 MPa

Parameter	Value
T_{sat}	279.8°C
ρ_f	751 kg/m^3
ρ_g	33 kg/m^3
h_f	1,236 kJ/kg
h_g	2,780 kJ/kg
$C_{p,f}$	5.3 kJ/(kg°C)
$C_{p,g}$	5.0 kJ/(kg°C)
μ_f	9.8×10^{-5} Pa·s
μ_g	1.9×10^{-5} Pa·s
k_f	0.574 W/(m°C)
k_g	0.061 W/(m°C)
σ	0.019 N/m