22.39 HW#2

Fall 2005 Problem Statement

Consider an epithermal reactor like the IRIS TIGHT described in the paper handed out in class.[1] The designer wishes to have an eight-year, single batch (n=1) core achieving a burnup of 70 MWd/kg_{HM}. The enrichment is 14 w/o ^{235}U. The expected forced outage time (T_{FO}) is 58.4 days and the expected refueling outage time (T_{RO}) is 20 days, both on a per cycle basis. The reactor is to be used for base load electricity production, so the amount of time that it will be capable of operating but not called upon to do so (T_I) is expected to be 0 days. The unit capability factor (T_c) is 97%.

Some core parameters, simplifying assumptions and thermal properties of core materials are shown below:

d_{fs} = 7.759 mm
d_{ci} = 7.914 mm
d_{co} = 9.000 mm

Note that the gap thickness is 1% of the pellet diameter and that the clad thickness is 7% of the pellet diameter.

Coolant temperatures
T_{in} = 292°C
T_{out} = 330°C

$\dot{Q}_{core}$ = 1661 MW_{th}

Active core height = 4.27 m

Rods arranged in a triangular lattice with;
P/d = 1.156 (here "d" refers to the clad outer diameter d_{co})

Assume the axial power distribution has a cosine shape and that the neutronic extrapolation distance is 0.10 m.

The number of flow channels in the core is 70,000, which is about twice the number of fueled rods.

[1] Saccheri., J, N.E. Todreas, and M.J. Driscoll, "A Tight Lattice, Epithermal Core Design for the Integral PWR", Proceedings of ICAPP '04, June 13-17, 2004, Pittsburgh, PA, USA.

Use the following thermal properties:

- fuel conductivity = 2.163 W/m K
- clad conductivity = 13.85 W/m K
- water conductivity = 0.5 W/m K
- gap conductance = 5700 W/m^2 K
- water viscosity = 8.69 x 10^{-5} kg/m s
- water heat capacity = 6270 J/kg K
- water density = 740 kg/m^3

As with Problem Set 1, you may calculate one value of the heat transfer coefficient and apply it to the entire active core.

Hint: DO NOT use Xu's formula (Equation 14 in the class notes) as it was developed for thermal reactors, whereas the IRIS TIGHT is an epithermal reactor.

You are asked to calculate the following:

- The core average specific power (q_{sp}).
- The average linear power (q')
- The maximum clad surface (T_{cs}) and fuel centerline (T_{CL}) temperatures. Ignore the effect of wire wrapping on the heat transfer coefficient.