Nuclear Thermal-Hydraulics

Problem Sheet 2

1. (Without referring to your notes)

(a) Derive from first principles a pde, expressed in terms of the Laplacian, the solution of which (could) describe the steady temperature distribution in a nuclear fuel pellet.

(b) Write this in a two-dimensional 'r-θ' coordinate system.

2. Derive an expression for the radial variation of temperature in a fuel pellet with a known surface temperature.

3. Sketch the variation of pellet temperature for a pellet with typical PWR dimensions, and where the pin generates 30 kW/m. Check your answer using TF_Interactive.

4. Derive from first principles an equation that describes the steady temperature distribution of the bulk coolant temperature along a nuclear reactor subchannel.

5. Extend this to give the axial variation of cladding surface temperature.

6. (a) Sketch the axial variation of bulk coolant temperature, cladding surface temperature and fuel centre temperature in a central PWR fuel channel. Relative temperatures and temperature differences should be qualitatively correct, and typical temperatures shown.

(b) Derive from first principles an expression for the axial gradient of fuel cladding surface temperature for a cylindrical reactor. (Use your solution of Q5 as a starting point.)

(c) Find the value and axial position of the maximum cladding surface temperature for the PWR sub-channel given in Table Q4 below. (630K, at 0.6802m above centreline.)

Pin length	m	3.66
Pin outside diameter	mm	9.5
Pin centres (square pitch)	mm	12.6
Mass flow rate per pin	kg/s	0.366
Peak linear rating	W/m	4.13E+04
Coolant inlet temperature	K	566.5

(d) How would the heat flux through the cladding change if the coolant flow rate were to be reduced by 5%? Explain your answer.