PROBLEM 13-12N QUESTION

Thermal Behavior Of A Plate Fuel Element Following A Loss Of Coolant

A reactor fuel assembly of the MIT research reactor is made up of plate elements as shown in Fig. 1 (only 4 of 13 elements are shown). Suppose the flow channel between plates 2 and 3 is blocked at the inlet (Fig. 2) What is the axial location of the maximum fuel temperature in plate 3? Solve this in the following steps: (Steps A and B can be solved independently of each other).

A) Find $T_w(z)$ where T_w is the element 3 surface temperature on the cooled side (RHS).

B) Find $T_{Fuel_{LHS}}(z) - T_w(z)$ where $T_{Fuel_{LHS}}(z)$ is the element 3 surface temperature on the insulated side (LHS).

C) Find the axial location of the maximum $T_{Fuel_{LHS}}(z)$.

In solving this problem you can make the following assumptions:

- All heat transfer through the fuel element is radial, i.e. there is not axial heat transfer within the fuel element.
- All of the energy generated in plate 3 flow radially to the right to the coolant channel between elements 3 and 4, i.e., the left side of element 3 has an insulated boundary (see Fig. 3).
- For simplicity, we neglect the clad and take the elements as only composed of fuel - a metallic fuel.
- Assume the flow is fully developed.

Operating Conditions:

P = 55 psi	(0.379 MPa)
T_{inlet} = 123.8 F	(51°C)
$\dot{m}$ = 0.32 kg	
$q'''(z) = 8.54E5\cos(\pi z/L)$ kW/m^3	

Geometry:

L = 23 inches	(58.42 cm)
s = 0.098 inches	(0.249 cm)
t = 0.030 inches	(0.0762 cm)
w = 2.082 inches	(5.288 cm)

Properties:

Water: c_p = 4.181 kJ/kg-K
ρ = 987.2 kg/m^3
k = 0.644 W/m-K
μ = 544E-6 kg/m-s
Pr = 3.597

Fuel: k = 41.2 W/m-K

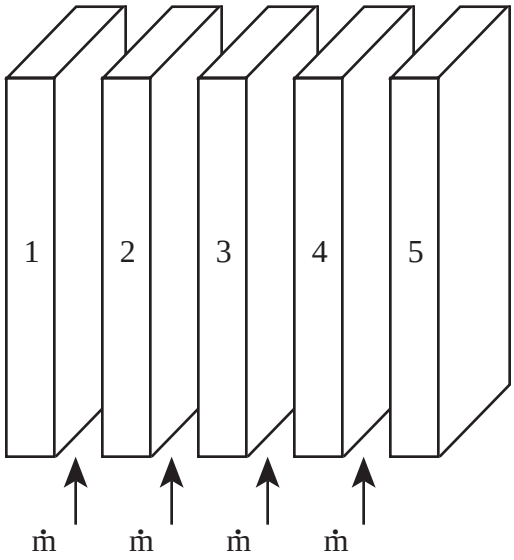

Figure 1

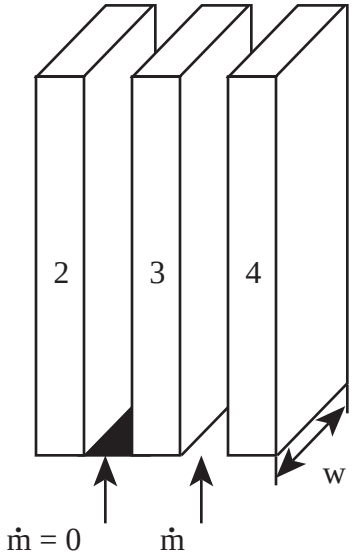

Figure 2

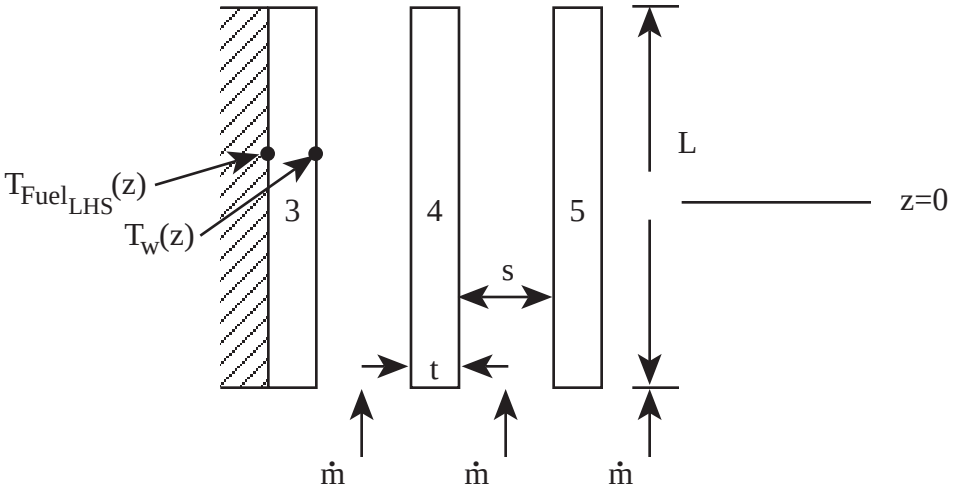

Figure 3