

ELEMENTS OF COMPUTATIONAL FLUID DYNAMICS

Computer Assignment

Consider the cross-section of a nuclear fuel rod as shown in the figure 1. Nuclear energy at a uniform rate of q''' W/m^3 is generated in the rod. The surrounding coolant is at temperature T_∞ and the heat transfer coefficient is h .

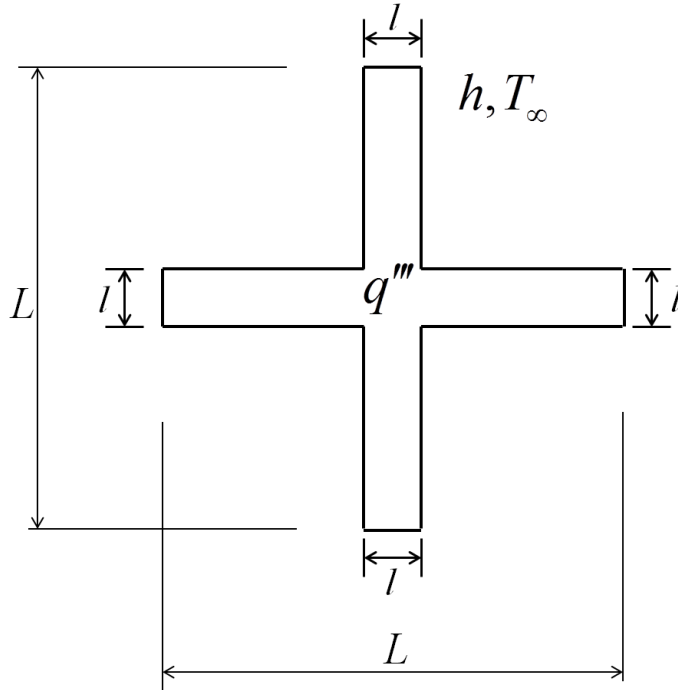


Figure 1

The governing equation for the above problem can be written as:

$$k \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right) + q''' = 0 \quad (1)$$

The boundary condition along the horizontal boundary

$$-k \frac{\partial T}{\partial y} = h(T - T_\infty) \quad (2)$$

The boundary condition along the vertical boundary

$$-k \frac{\partial T}{\partial x} = h(T - T_\infty) \quad (3)$$

Employing the dimensionless variables as follows: $\theta = \frac{T - T_\infty}{(q'' L^2 / k)}$, $X = \frac{x}{L}$, $Y = \frac{y}{L}$, the dimensionless set of governing equation and boundary conditions are obtained as,

$$\frac{\partial^2 \theta}{\partial X^2} + \frac{\partial^2 \theta}{\partial Y^2} + 1 = 0 \quad (4)$$

$$\frac{\partial \theta}{\partial Y} + Bi \cdot \theta = 0 \quad (5)$$

$$\frac{\partial \theta}{\partial X} + Bi \cdot \theta = 0 \quad (6)$$

Where, the Biot number is defined as $Bi = \frac{hL}{k}$.

Obtain the steady state dimensionless temperature distribution $\theta(X, Y)$ in the rod using the finite-difference method discussed in the class for:

[A] **Group – 1:** $\frac{l}{L} = 0.25$, $Bi = 0.1, 2, 5, 10, 50$

[B] **Group – 2:** $\frac{l}{L} = 0.15$, $Bi = 0.02, 1, 3, 7, 20$

[C] **Group – 3:** $\frac{l}{L} = 0.2$, $Bi = 0.01, 0.3, 2, 7, 100$

[D] **Group – 4:** $\frac{l}{L} = 0.3$, $Bi = 0.01, 1, 4, 8, 30$

Instructions: You **must** need to write the following steps while preparing a report.

- a) **Problem formulation:** It will contain all assumptions for formulating the problem including governing equations, boundary conditions, etc.
- b) **Computational method:** Here you need to detail about the computational method you are employing for the solution to the problem, discretized equations and boundary conditions, computational geometry etc.
- c) **Method of solution:** You need to detail the numerical method used for the solution.

- d) **Results and discussions:** You need to plot all post-processing results, such as contours of temperatures, etc. using the Tecplot software for different values of the parameters as mentioned.
- e) **Submission of the code:** You have to attach your computer program that you have used for obtaining the numerical solution.

Please make sure, all the steps mentioned above must be completed while preparing the final report.