AEE 331 Heat Transfer Hw 3 questions

3.82 The cross section of a long cylindrical fuel element in a nuclear reactor is shown. Energy generation occurs uniformly in the thorium fuel rod, which is of diameter \(D = 25\) mm and is wrapped in a thin aluminum cladding.

(a) It is proposed that, under steady-state conditions, the system operates with a generation rate of \(q = 7 \times 10^6\) W/m\(^2\) and cooling system characteristics of \(T_w = 95^\circ\)C and \(h = 7000\) W/m\(^2\) \cdot K. Is this proposal satisfactory?

(b) Explore the effect of variations in \(q\) and \(h\) by plotting temperature distributions, \(T(r)\), for a range of parameter values. Suggest an envelope of acceptable operating conditions.

3.99 A motor draws electric power \(P_{\text{elec}}\) from a supply line and delivers mechanical power \(P_{\text{mech}}\) to a pump through a rotating copper shaft of thermal conductivity \(k_c\), length \(L\), and diameter \(D\). The motor is mounted on a square pad of width \(W\), thickness \(t\), and thermal conductivity \(k_p\). The surface of the housing exposed to ambient air at \(T_a\) is of area \(A_h\), and the corresponding convection coefficient is \(h_r\). Opposite ends of the shaft are at temperatures of \(T_h\) and \(T_w\), and heat transfer from the shaft to the ambient air is characterized by the convection coefficient \(h_t\). The base of the pad is at \(T_m\).

(a) Expressing your result in terms of \(P_{\text{elec}}, P_{\text{mech}}, k_c, L, D, W, t, k_p, A_h, h_t,\) and \(h_r\), obtain an expression for \((T_h - T_w)\).

(b) What is the value of \(T_h\) if \(P_{\text{elec}} = 25\) kW, \(P_{\text{mech}} = 15\) kW, \(k_c = 400\) W/m \cdot K, \(L = 0.5\) m, \(D = 0.05\) m, \(W = 0.7\) m, \(t = 0.05\) m, \(k_p = 0.5\) W/m \cdot K, \(A_h = 2\) m\(^2\), \(h_t = 10\) W/m\(^2\) \cdot K, \(h_r = 300\) W/m\(^2\) \cdot K, and \(T_w = 25^\circ\)C?