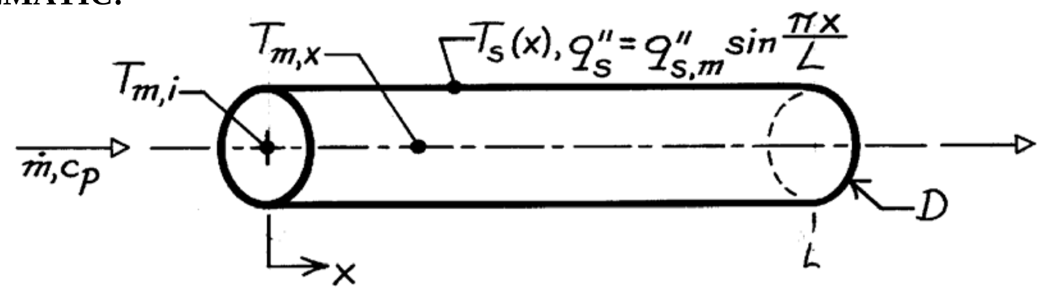
PROBLEM 8.16

KNOWN: Axial variation of surface heat flux for flow through a tube.

FIND: Axial variation of fluid and surface temperatures.

SCHEMATIC:



ASSUMPTIONS: (1) Convection coefficient is independent of x, (2) Applicability of Eq. 8.34.

ANALYSIS: Since Equation 8.37 is applicable,

$$\frac{dT_m}{dx} = \frac{q''_s P}{\dot{m}\, c_p} = \frac{(\pi\, D) q''_{s,m} \sin(\pi\, x/L)}{\dot{m}\, c_p}$$

Separating variables and integrating from x = 0

$$\int_{T_{m,i}}^{T_{m,o}} dT_m = \frac{\pi D q''_{s,m}}{\dot{m}\, c_p} \int_0^x \sin \frac{\pi\, x}{L}\, dx$$

$$T_m(x) - T_{m,i} = -\frac{L D q''_{s,m}}{\dot{m}\, c_p} \cos \frac{\pi\, x}{L} \Bigg|_0^x$$

$$T_m(x) = T_{m,i} + \frac{L D q''_{s,m}}{\dot{m}\, c_p}(1 - \cos \pi x/L).$$ <

From Newton's law of cooling, Eq. 8.27,

$$T_s(x) = (q''_s / h) + T_m(x)$$

$$T_s(x) = \frac{q''_{s,m}}{h} \sin \frac{\pi\, x}{L} + T_{m,i} + \frac{L D q''_{s,m}}{\dot{m}\, c_p}(1 - \cos\, \pi\, x/L).$$ <

COMMENTS: For the prescribed surface condition, the flow is not fully developed. Hence, the assumption of constant h should be viewed as a first approximation.