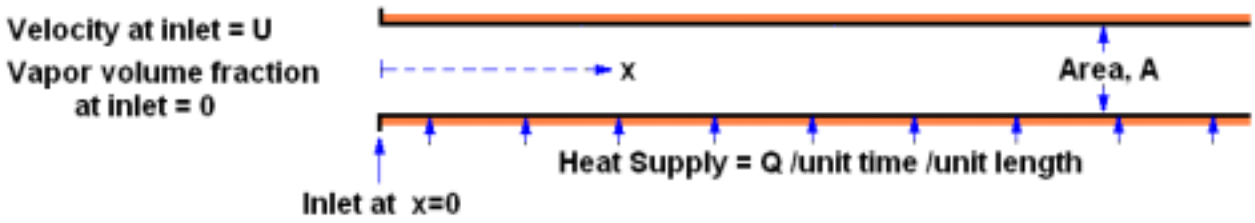
Problem 421A

This problem is concerned with the steady-state operation of a horizontal boiler tube of cross-sectional area, A. Heat is supplied to this tube at a steady, uniform rate denoted by Q units of heat per unit time and per unit length of the tube:



The liquid entering the tube at $x = 0$ has a velocity of U and zero vapor volume fraction. It is also at the boiling point for the prevailing temperature. As the liquid progresses along the tube vapor is formed and the vapor volume fraction, α, increases. Find expressions for the vapor volume fraction, α, and the mixture velocity, u, as functions of the distance, x, from the inlet. Assume

- that the latent heat, L, and the vapor density, ρ_V, are constants which do not vary with position, x.
- that all the liquid and the vapor bubbles travel at the same velocity, u, at each axial location, x. (However u is a function of x)
- that all the heat supplied goes toward vaporization.
- that, although the mass of liquid vaporized must be included in determining the increase of the vapor volume fraction along the tube, that same mass is negligible in so far as the conservation of liquid volume flow is concerned.