

EN 634 – Nuclear Reactor Thermal Hydraulics and safety

Assignment -6

1. (a) Consider a single phase flow of liquid, whose velocity is V , density is ρ and viscosity μ . Derive the relation that will express the frictional pressure drop over the length of pipe L , if the flow is laminar. Note that there will be no dependence on ρ .
 (b) Now let us idealize two-phase flow to be a train of alternate lumps of liquid (L_l, ρ_l, μ_l) and gas (L_g, ρ_g, μ_g) both traveling at the same velocity V . This is an idealized representation of slug flow in horizontal pipes. Now estimate the frictional pressure drop for a length $L_l + L_g$ as done in part A. Show that this is same as that for a homogenized fluid whose viscosity will be $\mu = \alpha\mu_g + (1 - \alpha)\mu_l$
2. A vertical test section is installed in an experimental high pressure loop. The tube is 1 cm in diameter and 2.1 m long and is heated uniformly with constant heat flux. Sub-cooled water (10°C below saturated temperature) enters at the base at 50 bar and with a flow rate of 480 kg/hr. Evaluate the accelerational, frictional and gravitational pressure drop across the test section using homogeneous model.
3. Consider a tube of 12 mm ID and 3 m long subjected to uniform linear heat rate of 16 kW/m with water flowing entering at 70 bar, 200°C and 3 m/s. Using the relevant properties from steam table, obtain and plot the axial variation of bulk coolant temperature under steady conditions. Now due to some malfunction, the heat rate increases linearly at a rate of 0.01 kW/m-s, with the fluid entering at the same state as earlier. Noting the fact that the exit fluid temperature will be maximum, (a) compute the time taken for boiling to begin in the system using MoC? (b) the exit quality turns to 1 (fluid becomes fully steam)
4. Consider a natural circulation boiling water reactor designed to operate on natural circulation in the vessel. to remove the heat from the core shown in the figure 2. Assume that the separator completely separates steam and water with no pressure loss. It may be assumed that in the separator, we have homogeneous liquid and vapour, whereas in the downcomer it is fully liquid. The chimney region may be assumed to have double the flow area and five times the hydraulic diameter. Estimate the maximum allowable core thermal power such that the core exit quality is less than 15%. The friction factor for single phase may be taken as 0.02. The design parameters of the system is as given below.
 System pressure = 7.0 Mpa, Flow area = $9.55 \times 10^{-3} \text{ m}^2$, Length of the core = 4 m, Length of the chimney region = 2 m, Hydraulic diameter of the passage in core = 0.013 m, condensate vessel inlet sub-cooling = 25°C , Separator effective length = 2 m. Neglect separator pressure drop and assume separation occurs at the exit of the separator instantly (fluid state in separator is same as the chimney till the exit). For simplicity heat flux may be assumed uniform. State all assumptions and proceed systematically.

