Problem Statement

- A tank having a volume of **0.85 cubic meter** initially contains water as a two phase liquid vapor mixture at **260 degree celsius** and a quality of **0.7**. Saturated water vapor at **260 degree celsius** is **slowly withdrawn** through a **pressure regulating valve at the top of the tank as energy is transferred by heat to maintain the pressure constant in the tank**. This continues until the tank is filled with saturated vapor at **260 degree celsius** . Determine the **amount of heat transfer in kJ**. *Neglect all kinetic and potential energy*

Solution

- $\frac{dE}{dt} = \dot{Q} - \quad + \dot{m}_1 \left(h_1 + \quad + \quad\right) - \dot{m}_2 \left(h_2 + \quad + \quad\right)$
- $\frac{dE}{dt} = \dot{Q} + \dot{m}_1 h_1 - \dot{m}_2 h_2$
- Since nothing is coming inside the tank thus $\dot{m}_1 h_1 = 0$
- Therefore $\frac{dE}{dt} = \dot{Q} - \dot{m}_2 h_2$

Solution

- $\frac{dE}{dt} = \dot{Q} - \dot{m}_2 h_2$
- $\frac{dm_{cv}}{dt} = -\dot{m}_2$
- $\frac{dE}{dt} = \dot{Q} + \frac{dm_{cv}}{dt} h_2$
- $\Delta E = \Delta Q + h_2 \Delta m_{cv} \ldots 1$
- Initial mass inside the tank is calculated as

since the vapor and water are in saturated state so from the steam table at 260 degree celsius.

Solution

- $v_m = v_l * 0.3 + (v_g * 0.7)$
- =(0.001276*0.3)+(0.7*0.04276)=0.029906 m^3/kg
- Thus 0.85/0.029906 gives 28.422 kg
- Similarly mass when it is pure steam inside is 0.85/0.04276 =20.14 kg
- h_2 is saturated steam enthalpy at 260 degree celsius , 2796.6 kJ/kg

Solution

- ΔE is calculated from specific internal energy and the initial and final mass of the system
- Specific internal energy (initially): (0.3*1128.4)+(0.7*2599)=2157.8 kJ/kg
- Specific internal energy (after)=2599 kJ/kg
- Thus plugging everything in 1
- We get **Q=14.16 kJ**