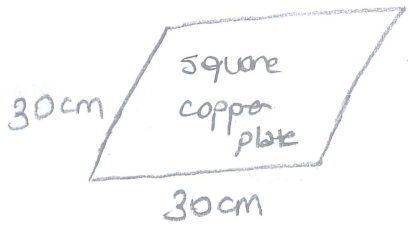
04/12/2017

KHÜ 331 - 21/22 Damla

- Homework 4 -

(4)



water @ 1 atm → Boiling of water
$T_w = 117°C$ $T_{sat} = 100°C$ ($P = 1$ atm)
$q = ?$

$\Delta T = T_w - T_{sat} = 117 - 100 = 17°C = 17K$ → Nucleate boiling

For horizontal surface;

$\Rightarrow h_o = 5,56(\Delta T)^3 = 5,56(17)^3 = 27316\ W/m^2.K$

$A = 0,3 \times 0,3 = 0,09\ m^2$

$q = h_o A \Delta T$

$q = (27316\ W/m^2.K)(0,09\ m^2)(17)K$

$q = 41793,5\ W$

$41793,5 \frac{J}{s} \times \frac{3600s.}{1h} = 150 \times 10^6\ J/h$

Check if $16 < q/A, kW/m^2, < 240$

$q = 41,7935\ kW$ $A = 0,09\ m^2$ $\Rightarrow q/A = 464,4\ kW/m^2$

So; $h = 1043(\Delta T\ K)^{1/3} = 1043(17K)^{1/3} = 2681,8\ W/m^2K$

$q = 4,1\ kW$ $q/A = 45\ kW/m^2$ $(q < A < 16)$

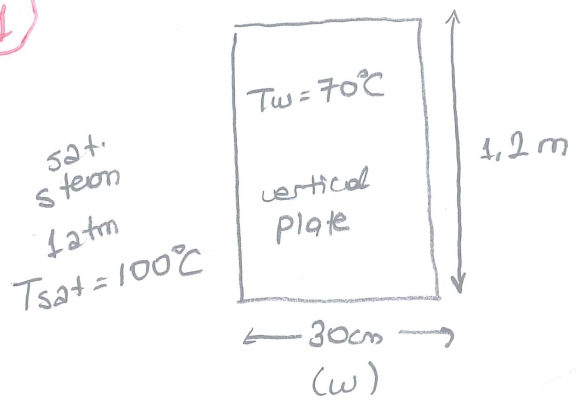
for a vertical surface;

$h = 7,95(\Delta T)^3 = 7,95(17)^3 = 39058\ W/m^2.K \Rightarrow q/A = 663\ kW$
$(3 < q/A < 63)$

So; $h = 537(\Delta T)^{1/7} = 805 W/m^2.K \Rightarrow q/A = 13,684 kW$
$(q/A < 3)$

Choose one of them!

(1)



App. A.2.9

Prop. of sat. steam

1 atm = 101,35 kPa ⇒ 100°C

$\dot{q} = ?$

$\dot{m} = ?$

h_{fg} is unknown

$h_{fg} = h_v - h_L$

$h_v = 2676,1 \times 10^3$ J/kg

$h_L = 419,04 \times 10^3$ J/kg. $\Big\}$ $h_{fg} = 2257,1 \times 10^3$ J/kg.

$$T_f = \frac{T_w + T_b}{2} = \frac{70 + 100}{2} = 85°C$$

Properties of water at film temp;

$\rho_l = 968,45$ kg/m^3 $\quad k_l = 0,675$ w/m.K

$\mu_l = 0,344 \times 10^{-3}$ kg/m.s $\quad \rho_v = 0,5978$ kg/m^3

Assume Laminar flow;

$$N_{Nu} = \frac{hL}{k_l} = 1,13 \left(\frac{\rho_l (\rho_l - \rho_v) g h_{fg} L^3}{\mu_L k_l \Delta T} \right)^{1/4} \quad (\text{Eq. } 4.8\text{-}20)$$

$$\frac{h(1,2m)}{(0,675 w/m.K)} = 1,13 \left(\frac{(968,45 \text{ kg/m}^3)(968,45 - 0,5978) \text{kg/m}^3 \times 9,81 \frac{m}{s^2} (1,2)^3 m^3 (2257100) \frac{J}{kg}}{(0,344 \times 10^{-3} \text{kg/m.s})(0,675 w/m.K)(30)K} \right)^{1/4}$$

$h = 5384,1$ w/m^2.°C

$q = h A \Delta T$ $\quad A = (0,3)(1,2) m^2 = 0,36 m^2$

$\Delta T = 100 - 70 = 30°C = 30K$

$q = (5384,1 \text{ w/m}^2 °C)(0,36 m^2)(30K)$ $\quad \boxed{q = 58151,5 \text{ w}}$

$q = \dot{m} \cdot h_{fg}$

$58151{,}5 \frac{J}{s} = \dot{m} \cdot 2257100 \frac{J}{kg} \Rightarrow \dot{m} = 0{,}0258 \, kg/s$

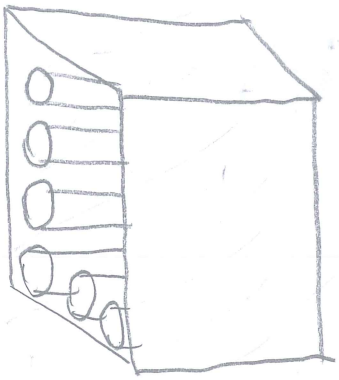
$0{,}0258 \frac{kg}{s} \times \frac{3600 s}{1 h} = \boxed{92{,}75 \, kg/h = \dot{m}}$ //

Check if flow is laminar:

$Re = \frac{4\dot{m}}{\pi W \mu_l} = \frac{4(0{,}0258 kg/h)}{\pi (0{,}3m)(0{,}344 \times 10^{-3} kg/m \cdot s)} = 318 < 1800$

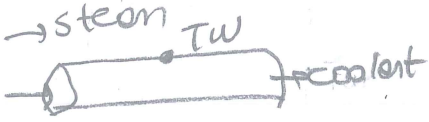
Laminar!

(2)



$n = 400$ tubes $\Rightarrow N = 20$

$D = 0{,}00635\,m$ $\quad T_w = 88°C$



$\dot{m} = ?$

$L = 1\,m$ (assume)

Condensate steam at $1\,atm \rightarrow T_{sat} = 100°C$

$$T_f = \frac{T_w + T_{sat}}{2} = \frac{(88+100)°C}{2} = 94°C$$

at $T_f \longrightarrow \rho_L = 962{,}2\,kg/m^3$

$\mu_L = 0{,}3049 \times 10^{-3}\,kg/m.s$

$k_L = 0{,}6803\,w/m.K$

$\rho_v = 0{,}598\,kg/m^3$

$h_{fg} = 2676{,}1 - 419{,}04 = 2257{,}06\,kJ/kg$

Equation 4.8.26

$$Nu_D = \frac{h(0{,}00635\,m)}{(0{,}6803\,w/m.K)} = 0{,}725 \left(\frac{962{,}2(962{,}2 - 0{,}598)(9{,}81)(2257060)(0{,}00635)^3}{(20)(0{,}3049\times10^{-3})(0{,}6803)(12)} \right)^{1/4}$$

$h = 7870\,W/m^2.K$

$q = hA\Delta T.n$ $\qquad A = \pi DL = \pi(0{,}00635\,m)(1\,m) = 0{,}0199\,m^2$

$q = (7870\,W/m^2.K)(0{,}0199\,m^2)(12K)(400)$

$$\boxed{q = 7{,}52\times10^5\,W}$$

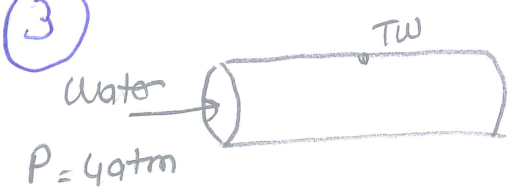
$$q = \dot{m} h_{fg}$$

$$7{,}52 \times 10^5 \frac{J}{s} = \dot{m} \left(2257060 J/kg \right)$$

$$\dot{m} = 0{,}333 \frac{kg}{s} \times \frac{3600 s}{1 h}$$

$$\boxed{\dot{m} = 1199 kg/h}$$ //

(3)



D = 0,02m

Local boiling

$T_w = 12°C + T_{sat}$.

L = 60cm = 0,6m

q = ?

$\Delta T = 12°C$

For forced convection boiling inside tubes; Eq. 4.8-5

$h = 2,55(\Delta T)^3 e^{P/1551}$ $\quad p \rightarrow kPa$.

$4\,atm \times \frac{101,325\,kPa}{1\,atm} = 405,3\,kPa$

$h = 2,55(12)^3 e^{405,3/1551}$

$h = 5722\,w/m^2°C$

$q = hA\Delta T \qquad A = \pi DL = \pi(0,02m)(0,6m) = 0,012m^2$

$q = (5722\,w/m^2°C)(0,012m^2)(12K)$

$\boxed{q = 824,01\,w}$ //