References:

- W.L. McCabe, J.C. Smith, P. Harriott., *Unit Operations of Chemical Engineering*, McGraw Hill, N.Y., (7th Ed.) 2005
- J.P. Holman, Heat Transfer, McGraw-Hill, N.Y., 1989.
- F.P. Incropera, D.P. de Witt, Fundamentals of Heat and Mass Transfer, John Wiley & Sons, N.Y., (3th Ed.) 1990.
- C.J. Geankoplis, Transport Processes and Unit Operations, Prentice-Hill Inc., N.J., (3th Ed.) 1993
- Y. Cengel , Introduction to Thermodynamics and Heat Transfer , , McGraw Hill, 2nd Edition 2008

12. Heat transfer to fluids with phase change; heat transfer from condensing vapors, heat transfer to boiling fluids

Horizontal condenser

$$h = 0.725 \left[\frac{k_f{}^3 \rho_f(\rho_f - \rho_v) g\lambda}{N^{\frac{2}{3}} D_o \mu_f (T_h - T_w)}\right]^{1/4}$$

$$T_f = T_h - \frac{3}{4}(T_h - T_w)$$

T_w=70 ^oC'de

Saturated steam at 1 atm T_h=100 ^oC $\lambda = 2.257 * 10^6$ J/kg (Table 17)

$$T_f = 100 - \tfrac{3}{4}(100 - 70) = 77.5\ C$$

$$\rho_v = \frac{PM_A}{RT} = \frac{1\ atm x (18 g/mol)}{0.082 x (\frac{L.atm}{mol.K}) x 373 K} = 0.588\ kg/m^3$$

The properties of water can be calculated at T_f=77.5 ^oC by interpolation (Table 8)

T ^oC	k_F (W/m^oC)	ρ_f (kg/m^3)	μ_f (kg/ms)*10^4
76.67	0.668	973.7	3.72
77.5	0.669	973.18	3.68
82.22	0.673	970.2	3.47

$$h = 0.725 \left[\frac{0.669^3 x 973.18 x (973.18 - 0.588) x 9.81 x (2.257 * 10^6)}{1\frac{2}{3} D_o (3.68 * 10^{-4})(30)} \right]^{1/4} = \frac{3539.94}{D_o{}^{1/4}}$$

$m\lambda = hA\Delta T \quad \Delta T = (T_h - T_w)$

$\frac{125\ kg}{h} \frac{1\ h}{3600\ s} * 2.257 * 10^6 \frac{J}{kg} = \frac{3539.94}{D_o{}^{\frac{1}{4}}} \frac{W}{m^2\ ^oC} * (\pi D_o * 1) m^2 * 30\ ^oC$ D_o=0.144 m