Examples (condenser)

Example (6.4) A condenser for a steam power plant receives 185 t/h of steam at 40°C, 92% quality. Cooling water enters at 33°C and leaves at 37°C. The condensate leaves at 39°C. The pressure inside the condenser is found to be 0.077 bar. Find (a) the cooling water flow required. (b) the air leakage into the condenser in kg/h.

Solution: $m_s = 185\ t/h\,; T_1 = 40°C; x_1 = 0.92; T_2 = 39°C;\ P_c = 0.077\ bar$

$T_{w,in} = 33°C; T_{w,out} = 37°C;\ C_{pw} = 4.2\ kj/kg.K\ ;\ m_{water}?\ ;\ m_{air}\ ?$

From saturated steam tables:

$@T_1 = 40°C\ \rightarrow P_1 = 7.3851\ kpa;\ h_f = 167.53\ \&\ h_g = 2573.5\ kj/kg.K$

$h_1 = h_f + x_1(h_g - h_f) = 167.53 + 0.92(2573.5 - 167.53)$

$h_1 = 2381\ kj/kg$

$@T_2 = 39°C\ \rightarrow h_f = 163.353\ kj/kg$

(a) $Q_{lost} = Q_{gained}$

$m_s^o \times (h_2 - h_f) = m_w^o \times C_{pw} \times (\Delta T_{water})$

$\frac{185\times10^3}{3600} \times [(2381 - 163.353) \times 10^3] = m_w^o \times (4.2 \times 10^3) \times (37 - 33)$

$m_w^o = 6783.5\ kg/s\ of\ cooling\ water$

(b) $P_c = P_S + P_a$

$P_a = P_c - P_S = 7.7 - 7.3851 = 0.3149\ kpa$

$P_a.v = m_a R_a T \rightarrow m_a = \frac{P_a.v}{R_a T}$

$m_a = \frac{0.3149\times10^3\times1}{287\times(40+273)}$

$m_a = 0.0035\ kg/m^3\ of\ leakage\ air$

Example (6.5) The steam at 100 bar and 400°C is supplied to a steam turbine. The condenser pressure is 0.2 bar. The plant capacity is 125MW. Determine the cooling water required per hour in the condenser. Rise in temperature in cooling water is limit to 11°C.

Solution: $P_1 = 100\ bar; T_1 = 400°C;\ P_2 = 0.2\ bar$

$Power_{turbine} = 120\ MW;\ \Delta T_{water} = 11°C;\ C_{pw} = 4.2\ kj/kg.K\ ;\ m_{water} =?$

From saturated steam tables:

$@P_1 = 100\ bar\ \&T_1 = 400°C \rightarrow h_1 = 3097.4\ kj/kg\ \ S_1 = 6.2139\ kj/kg.K$

$@P_2 = 0.2\ bar \rightarrow S_2 = S_1 = 6.2139\ \rightarrow\ h_2 = 2044.7, h_f = 251.4\ kj/kg$

$$Power = m_s^o \times (h_2 - h_1) \rightarrow m_s^o = \frac{power}{(h_2 - h_1)}$$

$m_s^o = \frac{(125\times10^3 kW)}{(3097.4-2044.7)} = 118.7\frac{kg}{s}$

$Q_{lost} = Q_{gained}$

$m_s^o \times (h_2 - h_f) = m_w^o \times C_{pw} \times (\Delta T_{water})$

$118.7 \times [(2044.7 - 251.4) \times 10^3] = m_w^o \times (4.2 \times 10^3) \times (11)$

$$m_w^o = \frac{212{,}864.71}{46{,}200} \rightarrow m_w^o = 4607.4\ kg/s\ of\ cooling\ water$$

$$m_w^o = 4607.4 \times 3600 = 16{,}586.86\ \ ton/h\ of\ cooling\ water$$