Q.1 In a counter flow heat double pipe heat exchanger, water is heated from 25^{0}C to 65^{0}C by oil with specific heat of 1.45 kJ/kg K and mass flow rate of 0.9 kg/s. The oil is cooled from 230^{0}C to 160^{0}C. If overall Heat transfer coefficient is 420 W/m2 ^{0}C. Calculate following (i) The rate of heat transfer (ii) The mass flow rate of water, and (iii) The surface area of heat exchanger **(GTU-Dec-2013)**

Given Data

$T_{c1} = 25°C$

$T_{c2} = 65°C$

$T_{h1} = 230°C$

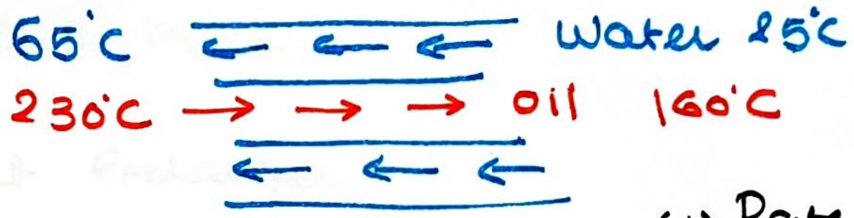
$T_{h2} = 160°C$

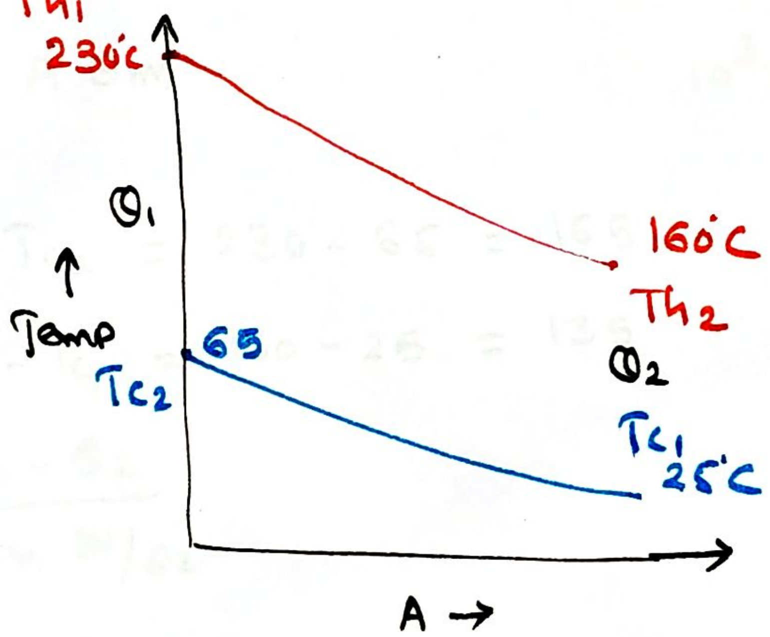
$C_{ph} = 1.45$ kJ/kg K

$m_h = 0.9$ kg/s

$U = 420$ W/m^2 K

$C_{pc} = 4.2$ kJ/kg K





(1) Rate of Heat Transfer

$\phi = m_h C_h (T_{h1} - T_{h2})$

$= m_c C_c (T_{c2} - T_{c1})$

$= 0.9 \times 1.45 \times (230 - 160)$

$= 91.35$ kJ/sec

(2) mass flow rate of water

$$Q_h = Q_c$$

$$m_h c_h (T_{h1} - T_{h2}) = m_c c_c (T_{c2} - T_{c1})$$

$$0.9 \times 1.45 \times (230 - 160) = m_c \times 4.2 \times (65 - 25)$$

$$m_c = 0.545 \text{ kg/sec}$$

(3) Surface area of Heat Exchanger

$$Q = U A \theta_m$$

$$10^3 \times 91.35 = 420 \times A \times 149.5$$

$$A = 1.45 \text{ m}^2$$

$$\theta_1 = T_{h1} - T_{c2} = 230 - 65 = 165$$

$$\theta_2 = T_{h2} - T_{c1} = 160 - 25 = 135$$

$$\theta_m = \frac{\theta_1 - \theta_2}{\ln \theta_1/\theta_2}$$

$$= \frac{165 - 135}{\ln(165/135)} = 149.5^\circ C$$

Q.2 Hot air at 66 °C is cooled up to 38 °C by means of cold air at 15.5 °C. mass flow rates of hot and cold air are 1.25 kg/s and 1.6 kg/s respectively. Specific heat of hot and cold air are 1.05 kJ/kg k, U= 80 W/m^{2}K, find the area of the heat exchanger for parallel flow configuration. If the same heat exchanger is operated in counter flow mode, find the area required.

(GTU-May 2014)

Given Data

$T_{h_1} = 66°C$

$T_{h_2} = 38°C$

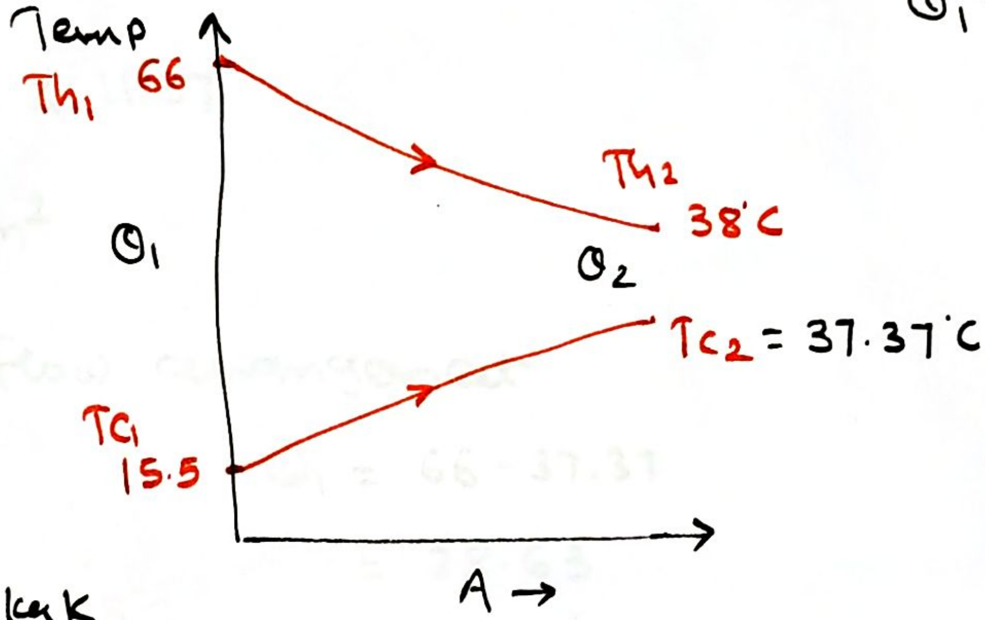
$T_{c_1} = 15.5°C$

$m_h = 1.25$ kg/s

$m_c = 1.6$ kg/s

$C_{ph} = C_{pc} = C = 1.05$ kJ/kg K

$U = 80$ W/m^{2}K



$\varphi = \varphi_h = \varphi_c$

$m_h C_{ph}(T_{h_1} - T_{h_2}) = m_c C_{pc}(T_{c_2} - T_{c_1})$

$1.25(66-38) = 1.6(T_{c_2} - 15.5)$

$T_{c_2} = 37.37°C$

$\theta_1 = T_{h_1} - T_{c_1}$

$= 66 - 15.5$

$= 50.5$

$\theta_2 = T_{h_2} - T_{c_2}$

$= 38 - 37.37$

$= 0.63$

$$\theta_m = \frac{\theta_1 - \theta_2}{\ln \theta_1/\theta_2}$$

$$= \frac{50.5 - 0.63}{\ln(50.5/0.63)}$$

$\theta_m = 11.37°C$

$\varphi = UA\theta_m$

$\varphi = m_h c_h (T_{h_1} - T_{h_2})$

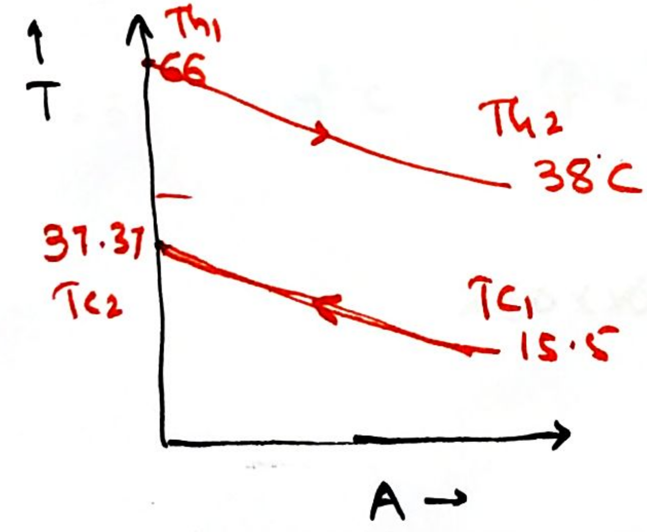
$= 1.25 \times 1.05 \times (66 - 38)$

$= 36.75$ KJ/sec

$10^3 \times 36.75 = 80 \times A \times 11.37$

$A = 39.26\ m^2$

Case - II   counter flow arrangement



$\theta_1 = 66 - 37.37$

$= 28.63$

$\theta_2 = 38 - 15$

$= 23$

$$\theta_m = \frac{\theta_1 - \theta_2}{\ln \theta_1/\theta_2} = \frac{28.63 - 23}{\ln \frac{28.63}{23}} = 25.71^\circ C$$

$\varphi = UA\theta_m$

$36.75 \times 10^3 = 80 \times A \times 25.71$

$A = 17.87\ m^2$

Q.3 A steam condenser is transferring 250 KW of thermal energy at a condensing temperature of 65°C. the cooling water enter the condenser at 20°C with a flow rate of 7500 kg/hr. calculate the log mean temperature difference. If overall heat transfer co efficient for condenser surface is 1250 w/m2-deg, what surface area is required to handle this load. **(GTU- Dec 2014)**

Given Data

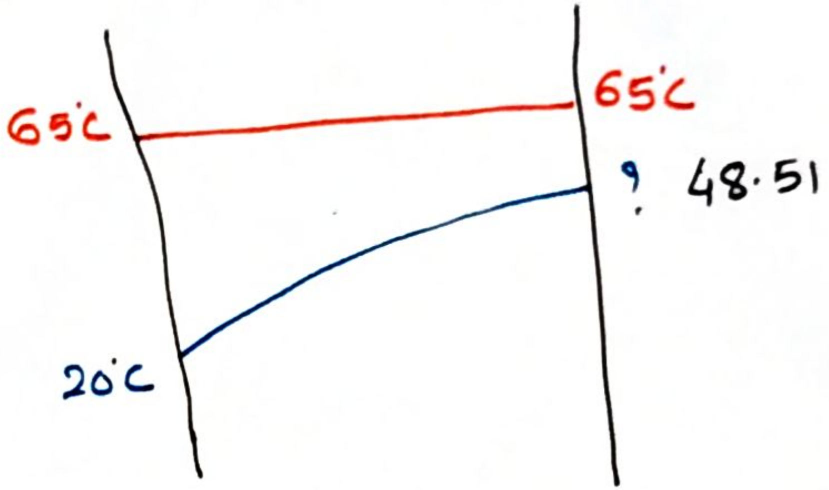
$T_{h1} = T_{h2} = 65°C$

$T_{c1} = 20°C$

$\phi = 250 \times 10^3$ W

$m_c = \frac{7500}{3600}$ kg/sec

$U = 1250$ W/m²·°C



$\phi = m_f h_{fg}$

$= m_c c_c (T_{c2} - T_{c1})$

$250 \times 10^3 = \frac{7500}{3600} \times 4.2 \times (T_{c2} - 20)$

$T_{c2} = 48.51$

$\theta_1 = 65 - 20$

$= 45$

$\theta_2 = 65 - 48.51$

$= 16.49$

$\theta_m = \frac{\theta_1 - \theta_2}{\ln \theta_1/\theta_2}$

$= \frac{45 - 16.49}{\ln 45/16.49}$

$\theta_m = 28.3$

$\phi = U A \theta_m$

$250 \times 10^3 = 1250 \times A \times 28.3$

$A = 8.979 \text{ m}^2$