

ENE 230 øving 5

Oppgave 1 - Dimensjonere en varmeveksler i en varmepumpe

Sekundærmedium *Ethylene Glykol/Vann* 30/70%

$$q_v = 0,6 \frac{m^3}{h}$$

$$t_{1u} = 2,046^\circ C$$

$$t_{1i} = 7^\circ C$$

$$\rho = 1054,27 \frac{kg}{m^3}$$

$$c_p = 3561 \frac{J}{kgK}$$

$$\eta = 619,016 \cdot 10^{-5} Pa \cdot s \quad (\text{dynamisk viscositet})$$

$$\lambda = 0,416 \frac{W}{mK}$$

$$Pr = 52,99$$

$$q_{c \min} = 625,71 \frac{W}{K} \quad q_{c \min} = q_v \rho c_p = \frac{0,6 \cdot 1054,27 \cdot 3561}{3600} = 625,71 \frac{W}{K}$$

$$\varepsilon = 0,8$$

$$t_0 = 0,8075^\circ C$$

$$\Delta t_1 = 6,19K \quad 7 - 0,8075 = 6,19K$$

$$\Delta t_2 = 1,239K \quad 2,046 - 0,8075 = 1,239K$$

a) Bestemmer fordampers UA verdi:

$$N_{TU} = \ln \left[\frac{1}{1-\varepsilon} \right] = \ln \left[\frac{1}{1-0,8} \right] = 1,609$$

$$N_{TU} = \frac{UA}{q_{c \min}} \Rightarrow UA = N_{TU} \cdot q_{c \min} = 1,609 \cdot 625,71 = 1006,77 \frac{W}{K}$$

b) Bestemmer sekundærmediets utløpstemperatur fra fordampner:

$$\Phi = q_{c \min} (t_{1i} - t_{1u}) \Rightarrow t_{1u} = t_{1i} - \frac{\Phi}{q_{c \min}} = 7 - \frac{3100}{625,71} = 2,046^\circ C$$

c) Bestemmer fordampningstemperaturen:

$$\varepsilon = \frac{t_{1i} - t_{1u}}{t_{1i} - t_0} \Rightarrow t_0 = t_{1i} - \frac{t_{1i} - t_{1u}}{\varepsilon} = 7 - \frac{7 - 2,046}{0,8} = 0,8075^\circ C$$

d) Beregner LMTD og kontrollerer effekt:

$$\Delta t_{lm} = \frac{\Delta t_1 - \Delta t_2}{\ln \left(\frac{\Delta t_2}{\Delta t_1} \right)} = \frac{6,19 - 1,239}{\ln \left(\frac{6,19}{1,239} \right)} = 3,077K$$

$$\Phi = UA \Delta t_{lm} = 1006,77 \cdot 3,077 = 3098W \approx 3100W$$

e) Bestemmer nødvendig rørdimensjon ved $v = 0,5$

$$D = \sqrt{\frac{4 \cdot q_v}{3600 \cdot v \cdot \pi}} = \sqrt{\frac{4 \cdot 0,6}{3600 \cdot 0,5 \cdot \pi}} = 0,0206m = 20,6mm \approx 3/4''$$

f) Bestemmer Prandtl's tall:

$$Pr = \frac{v \rho c_p}{\lambda} = \frac{619,016 \cdot 10^{-5} \cdot 1054,27 \cdot 3561}{0,416} = 55865,77$$

Oppgave 2

Fluid 1 Smøreolje Data ved $87^{\circ}C$ (360K)

$$\rho = 848 \frac{kg}{m^3}$$

$$\eta = 255 \cdot 10^{-4} Pa \cdot s$$

$$c_p = 2160 \frac{J}{kgK}$$

$$\lambda = 0,136 \frac{W}{mK}$$

$$q_v = 0,6 \frac{m^3}{h} = 1,67 \cdot 10^{-4} \frac{m^3}{s}$$

$$t_{1i} = 100^{\circ}C$$

$$m_h = 0,141 \frac{kg}{h}$$

$$m = q_v \cdot \rho = 1,67 \cdot 10^{-4} \cdot 848 = 0,141$$

$$c_{min} = 304,56 \frac{J}{sK}$$

$$\text{varmekapasitet } c = c_p \cdot m = 2160 \cdot 0,141 = 304,56$$

Fluid 2 Ferskvann Data ved $27^{\circ}C$ (300K)

$$\rho = 996 \frac{kg}{m^3}$$

$$\eta = 8,67 \cdot 10^{-4} Pa \cdot s$$

$$c_p = 4178 \frac{J}{kgK}$$

$$\lambda = 0,136 \frac{W}{m^2K}$$

$$q_v = 1,0 \frac{m^3}{h} = 2,78 \cdot 10^{-4} \frac{m^3}{s}$$

$$t_{2i} = 15^{\circ}C$$

$$U = 450 \frac{W}{m^2K}$$

$$A = 2,5m^2$$

$$m_c = 0,277 \frac{kg}{s}$$

$$m = q_v \cdot \rho = 2,78 \cdot 10^{-4} \cdot 996 = 0,277$$

$$c_{max} = 1157 \frac{J}{sK}$$

$$\text{varmekapasitet } c = c_p \cdot m = 4178 \cdot 0,277 = 1157$$

$$q_{max} = 25888 \frac{J}{s}$$

$$q_{max} = c_{min} \cdot (t_{1i} - t_{2i}) = 304,56 \cdot (100 - 15) = 25888$$

$$t_{2u} = 36,25^{\circ}C$$

$$t_{1u} = 19,25^{\circ}C$$

$$\kappa = 0,263$$

$$N_{TU} = 3,694 \frac{W}{K}$$

$$N_{TU} = \frac{UA}{c_{min}} = \frac{450 \cdot 2,5}{304,56} = 3,694$$

$$\varepsilon = 0,95$$

$$\varepsilon = \frac{1 - e^{-N_{TU} \cdot (1 - \kappa)}}{1 - \kappa \cdot e^{-N_{TU} \cdot (1 - \kappa)}} = 0,95$$

$$\Phi = 24510W$$

$$\Delta T_1 = 63,75K$$

$$\Delta t_1 = t_{1i} - t_{2u} = 100 - 36,25 = 63,75K$$

$$\Delta T_2 = 4,25K$$

$$\Delta t_2 = t_{1u} - t_{2i} = 19,25 - 15 = 4,25K$$

$$\Delta T_{lm} = 21,787K = 24510W$$

$$\Delta T_{lm} = \frac{(\Delta T_1 - \Delta T_2)}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)} = \frac{(63,75 - 4,25)}{\ln\left(\frac{63,75}{4,25}\right)} = 21,787$$

a) Beregner varmevekslerens effektivitet:

$$\kappa = \frac{c_{min}}{c_{max}} = \frac{304,56}{1157} = \underline{\underline{0,263}}$$

b) Beregner utløpstemperaturene:

$$t_{1u} = t_{1i} - \frac{\varepsilon \cdot c_{min} \cdot (t_{1i} - t_{2i})}{c_{min}} = 100 - \frac{0,95 \cdot 304,56(100 - 15)}{3 \Delta T_{2,04,56}} = \underline{\underline{19,25^\circ C}}$$

$$t_{2u} = t_{2i} + \frac{m_h \cdot c_{p(olje)} \cdot (t_{1i} - t_{1u})}{m_c \cdot c_{p(vann)}} = 15 + \frac{0,141 \cdot 2160(100 - 19,25)}{0,277 \cdot 4178} = \underline{\underline{36,25^\circ C}}$$

c) Beregner varmevekslerens effekt:

$$\Phi = UA \Delta T_{lm} = 450 \cdot 2,5 \cdot 21,787 = \underline{\underline{24510W}}$$

$$\Phi_{vann} = m_c c_p (t_{2u} - t_{2i}) = 0,277 \cdot 4178 \cdot 21,25 = \underline{\underline{24593W}}$$

$$\Phi_{olje} = m_h c_p (t_{1i} - t_{1u}) = 0,141 \cdot 2160 \cdot 80,75 = \underline{\underline{24586W}}$$