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}	$= 2,046^oC$	
t_{1i}	$= 7^oC$	
ρ	$= 1054,27 \frac{kg}{m^3}$	
c_p	$= 3561 \frac{J}{kgK}$	
η	$= 619,016 \cdot 10^{-5} Pa \cdot s$	(dynamisk viscositet)
λ	$= 0,416 \frac{W}{mK}$	
Pr	$= 52,99$	
$q_{c\ \min}$	$= 625,71 \frac{W}{K}$	$q_{c\ \min} = q_v \rho c_p = \frac{0,6 \cdot 1054,27 \cdot 3561}{3600} = 625,71 \frac{W}{K}$
ε	$= 0,8$	
t_0	$= 0,8075^0C$	
Δt_1	$= 6,19K$	$7 - 0,8075 = 6,19K$
Δt_2	$= 1,239K$	$2,046 - 0,8075 = 1,239K$

a) Bestemmer fordamperens UA verdi:

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

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

b) Bestemmer sekundærmediets utløpstemperatur fra fordamper:

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

c) Bestemmer fordampningstemperaturen:

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

d) Beregner LMTD og kontrollerer effekt:

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

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

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

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

f) Bestemmer Prandtl's tall:

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

Oppgave 2

Fluid 1	Smøreolje Data ved 87^0C (360K)	
ρ	$= 848\frac{kg}{m^3}$	
η	$= 255 \cdot 10^{-4} Pa \cdot 10^{-4}$	
c_p	$= 2160\frac{J}{kgK}$	
λ	$= 0,136\frac{W}{mK}$	
q_v	$= 0,6\frac{m^3}{h} = 1,67 \cdot 10^{-4}\frac{m^3}{s}$	
t_{1i}	$= 100^oC$	
m_h	$= 0,141\frac{kg}{h}$	$m = q_v \cdot \rho = 1,67 \cdot 10^{-4} \cdot 848 = 0,141$
c_{min}	$= 304,56\frac{J}{sK}$	varmekapasitet $c = c_p \cdot m = 2160 \cdot 0,141 = 304,56$
Fluid 2	Ferskvann Data ved 27^oC (300K)	
ρ	$= 996\frac{kg}{m^3}$	
η	$= 8,67 \cdot 10^{-4} Pa \cdot s$	
c_p	$= 4178\frac{J}{kgK}$	
λ	$= 0,136\frac{W}{m^2K}$	
q_v	$= 1,0\frac{m^3}{h} = 2,78 \cdot 10^{-4}\frac{m^3}{s}$	
t_{2i}	$= 15^oC$	
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}	$= 1157\frac{J}{sK}$	varmekapasitet $c = c_p \cdot \rho = 4178 \cdot 0,277 = 1157$
q_{max}	$= 25888\frac{J}{s}$	$q_{max} = c_{min} \cdot (t_{1i} - t_{2i}) = 304,56 \cdot (100 - 15) = 25888$
t_{2u}	$= 36,25^oC$	
t_{1u}	$= 19,25^oC$	
κ	$= 0,263$	
N_{TU}	$= 3,694\frac{W}{K}$	$N_{TU} = \frac{UA}{c_{min}} = \frac{450 \cdot 2,5}{304,56} = 3,694$
ε	$= 0,95$	$\varepsilon = \frac{1-e^{-N_{TU} \cdot (1-\kappa)}}{1-\kappa \cdot e^{-N_{TU} \cdot (1-\kappa)}} = 0,95$
Φ	$= 24510W$	
ΔT_1	$= 63,75K$	$\Delta t_1 = t_{1i} - t_{2u} = 100 - 36,25 = 63,75K$
ΔT_2	$= 4,25K$	$\Delta t_2 = t_{1u} - t_{2i} = 19,25 - 15 = 4,25K$
ΔT_{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:
$t_{1u} = t_{1i} - \frac{\varepsilon \cdot c_{min} \cdot (t_{1i} - t_{2i})}{c_{min}} = 100 - \frac{0,95 \cdot 304,56 (100 - 15)}{3 \Delta T_2 04,56} = \underline{\underline{19,25^o C}}$

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

c) Beregner varmevekslerens effekt:
$\Phi = UA\Delta T_{lm} = 450 \cdot 2,5 \cdot 21,787 = \underline{\underline{24510W}}$
$\Phi_{vann} = m_c c_p \left(t_{2u} - t_{2i}\right) = 0,277 \cdot 4178 \cdot 21,25 = \underline{24593W}$
$\Phi_{olje} = m_h c_p \left(t_{1i} - t_{1u}\right) = 0,141 \cdot 2160 \cdot 80,75 = \underline{24586W}$