Opg 73

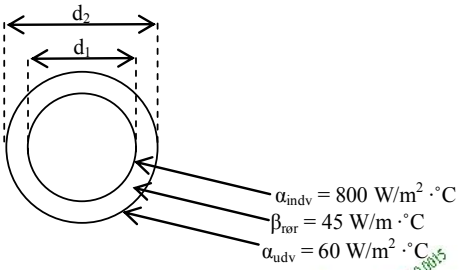
Kølemiddel: R502

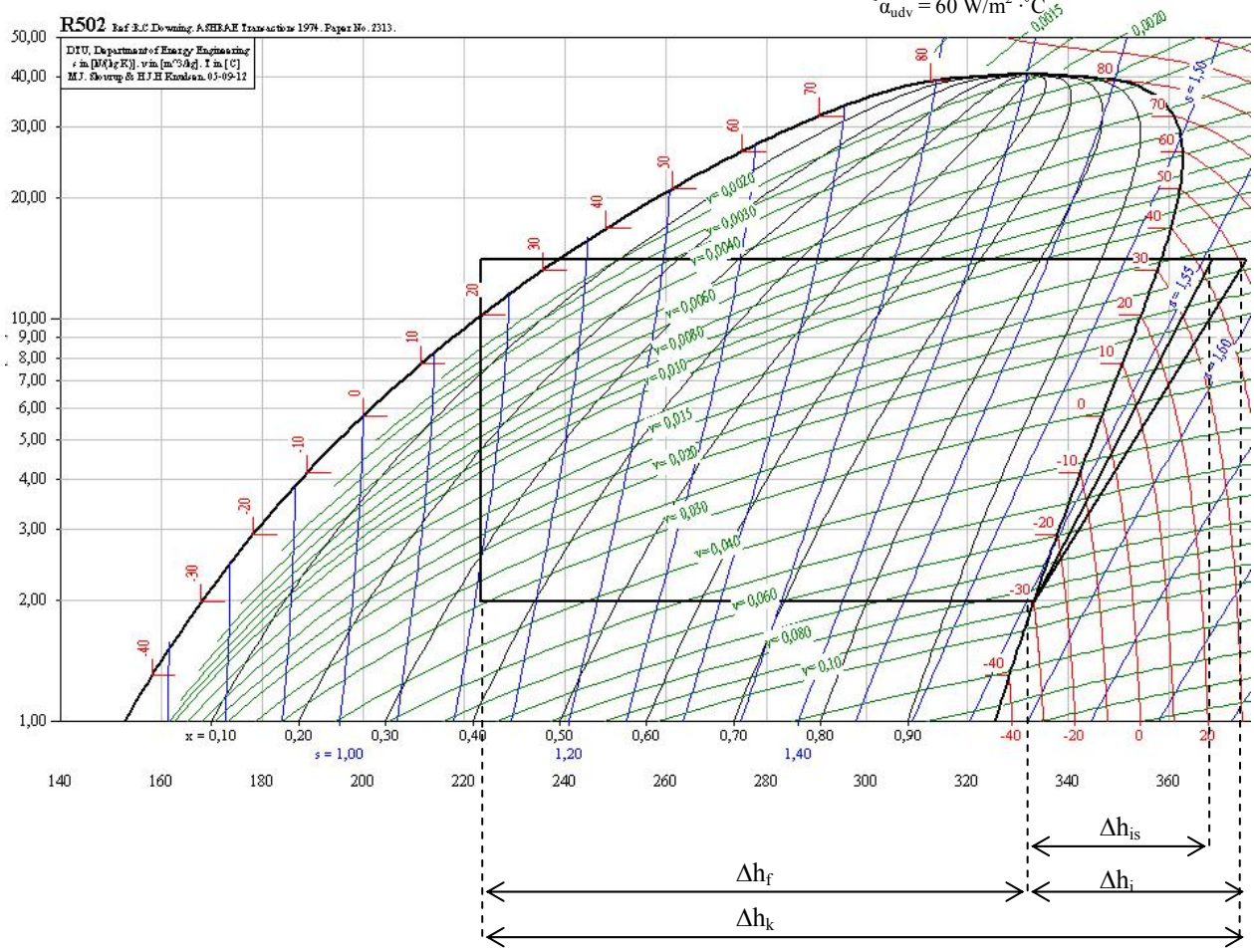
Givet:

$p_k = 14$ bar
$t_{receiver} = 20^\circ C$
$\Delta t_{kv} = 8^\circ C$
$\eta_{is} = 0,84$
$\eta_{mek} = 0,91$

Fordamperslanger:

$l = 1200$ m
$d_1 = 32$mm
$d_2 = 8$mm
$t_{fryserum} = -20^\circ C$
$t_{middel,R502} = -30^\circ C$





$\Delta h_f = 333 - 223,4 = 109,6$ [kJ/kg]
$\Delta h_k = 375,4 - 223,4 = 151,7$ [kJ/kg]
$\Delta h_k = \Delta h_f + \Delta h_i$
$\Delta h_{is} = 368,6 - 333 = 35,6$ [kJ/kg]
$\Delta h_i = 375,4 - 333 = 42,4$ [kJ/kg]

73.1.1 Beregn kuldeydelsen, Q_f:

$Q_f = K \cdot l \cdot \Delta t_{middel}$

$$K = \frac{\pi}{\frac{1}{\alpha_{udv.} \cdot d_2} + \frac{\ln(\frac{d_2}{d_1})}{2 \cdot \beta_{rør}} + \frac{1}{\alpha_{indv.} \cdot d_1}} = \frac{\pi}{\frac{1}{60 \cdot 38 \cdot 10^{-3}} + \frac{\ln(\frac{38}{32})}{2 \cdot 45} + \frac{1}{800 \cdot 32 \cdot 10^{-3}}} = \underline{6{,}55 \left[\frac{W}{m \cdot °C}\right]}$$

$\Delta t_{middel} = t_{middel,R502} - t_{fryserum} = -30 - (-20) = -10°C \rightarrow \Delta t_{middel} = 10°C$

$\underline{Q_f} = K \cdot l \cdot \Delta t_{middel} = 6{,}55 \cdot 1200 \cdot 10 = \underline{78{,}6\ [kW]}$

73.1.2 Beregn den til kompressoren tilførte effekt, $P_{tilført}$:

$$m_R = \frac{Q_f}{\Delta h_f} = \frac{78{,}6}{109{,}6} = \underline{0{,}72 \left[\frac{kg}{s}\right]}$$

$P_{afgivet} = \Delta h_{is} \cdot m_R = 35{,}6 \cdot 0{,}72 = \underline{25{,}2\ [kW]}$ (eller udregn med Δh_i og få $P_{tilført}$ direkte)

$$P_{tilført} = \frac{P_{afgivet}}{\eta_{mek} \cdot \eta_{is}} = \frac{25{,}2}{0{,}91 \cdot 0{,}84} = \underline{\underline{33{,}03 [kW]}}$$ ($COP_{kompr.} = 2{,}1$)

73.1.3 Beregn $m_{kølevand,kondensator}$ i [kg/h]:

Varmeoverførslen i kondensatoren:

	Varm	Flade	Kold
$Q_k =$	$m_R \cdot \Delta h_k =$	$K \cdot l \cdot \Delta t_{middel} =$	$m_{kølevand} \cdot c_{kølevand} \cdot \Delta t_{kølevand}$

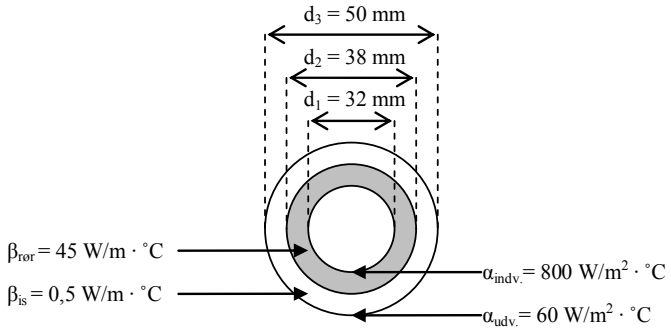
$Q_k = m_R \cdot \Delta h_k = 0{,}72 \cdot 151{,}7 = \underline{108{,}8\ [kW]}$

For kondensatoren gælder: $Q_{ind} = Q_{ud} \rightarrow$

$Q_k = m_{kølevand} \cdot c_{kølevand} \cdot \Delta t_{kølevand} \rightarrow$

$$m_{kølevand} = \frac{Q_k}{c_{kølevand} \cdot \Delta t_{kølevand}} = \frac{108{,}8}{4{,}19 \cdot 8} = 3{,}25 \left[\frac{kg}{s}\right] = \underline{\underline{11684 \left[\frac{kg}{h}\right]}}$$

73.2 Fordamperslangerne dækkes med et 6 mm tykt lag is. $\beta_{is} = 0,5$ [W/m·˚C]
Kuldeydelsen skal opretholdes ved samme fryserumstemperatur.



73.2.1 Beregn den til kompressoren tilførte effekt, $P_{tilført}$:

Ny K-værdi for røret pga. af is belægningen på røret:

$$K = \frac{\pi}{\frac{1}{\alpha_{indv.} \cdot d_1} + \frac{\ln(\frac{d_2}{d_1})}{2 \cdot \beta_{rør}} + \frac{\ln(\frac{d_3}{d_2})}{2 \cdot \beta_{is}} + \frac{1}{\alpha_{udv.} \cdot d_3}} = \frac{\pi}{\frac{1}{800 \cdot 32 \cdot 10^{-3}} + \frac{\ln(\frac{38}{32})}{2 \cdot 45} + \frac{\ln(\frac{50}{38})}{2 \cdot 0,5} + \frac{1}{60 \cdot 50 \cdot 10^{-3}}}$$

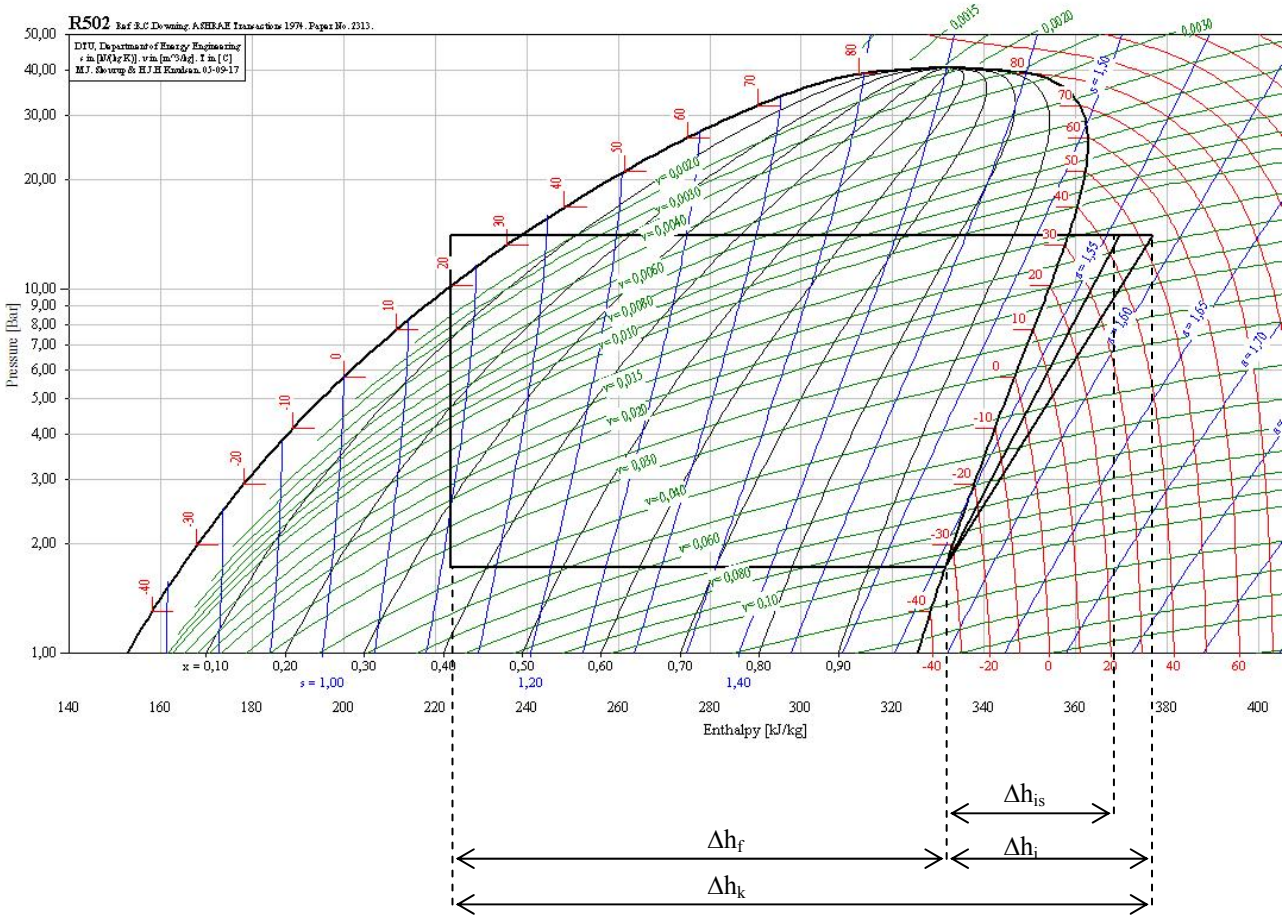
$$\underline{K = 4,84 \left[\frac{W}{m \cdot °C}\right]}$$

Ud fra formlen $\underline{Q_f} = K \cdot l \cdot \Delta t_{middel}$, kan ses at vi for at holde den samme Q_f , må ændre på temperaturen:

$$\Delta t_{middel} = \frac{Qf}{K \cdot l} = \frac{78,6 \cdot 10^3}{4,84 \cdot 1200} = 13,5°C$$

$$t_f = t_{rum} - \Delta t_{middel} = -20 - 13,5 = -33,5°C$$

H-log p diagram for køleprocessen ved fordamperslangerne belagt med is:



$\Delta h_f = 331,4 - 223,4 = 107,7$ [kJ/kg]
$\Delta h_k = 376,9 - 223,4 = 153,5$ [kJ/kg]
$\Delta h_k = \Delta h_f + \Delta h_i$
$\Delta h_{is} = 369,6 - 331,4 = 38,2$ [kJ/kg]
$\Delta h_i = 376,9 - 331,4 = 45,5$[kJ/kg]

Belagt fordamperflade:

$$m_R = \frac{Q_f}{\Delta h_f} = \frac{78,6}{109} = \underline{0,729\left[\frac{kg}{s}\right]}$$

$$\underline{\underline{P_{tilført}}} = \frac{m_R \cdot \Delta h_i}{\eta_{mek}} = \frac{0,729 \cdot 45,5}{0,91} = \underline{\underline{36,5[kW]}} \ (COP_{kompr.} = 2,1)$$

73.2.2 Beregn $m_{kølevand,kondensator}$ i [kg/h]

$Q_k = m_R \cdot \Delta h_k = 0,729 \cdot 153,5 = \underline{112\ [kW]}$

For kondensatoren gælder: $Q_{ind} = Q_{ud} \rightarrow$

$Q_k = m_{kølevand} \cdot c_{kølevand} \cdot \Delta t_{kølevand} \rightarrow$

$$m_{kølevand} = \frac{Q_k}{c_{kølevand} \cdot \Delta t_{kølevand}} = \frac{112}{4,19 \cdot 8} = 3,34\left[\frac{kg}{s}\right] = \underline{\underline{12031\left[\frac{kg}{h}\right]}}$$

Kan også udregnes som:

$$m_{kølevand} = \frac{m_R \cdot \Delta h_k}{c_{kølevand} \cdot \Delta t_{kølevand}} = \frac{0,721 \cdot 155,4}{4,19 \cdot 8} = \left[\frac{kg}{s}\right] = \underline{\underline{12000\left[\frac{kg}{h}\right]}}$$