Køleopgave - December 2004 - opg 2

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Kølemiddel: R134a

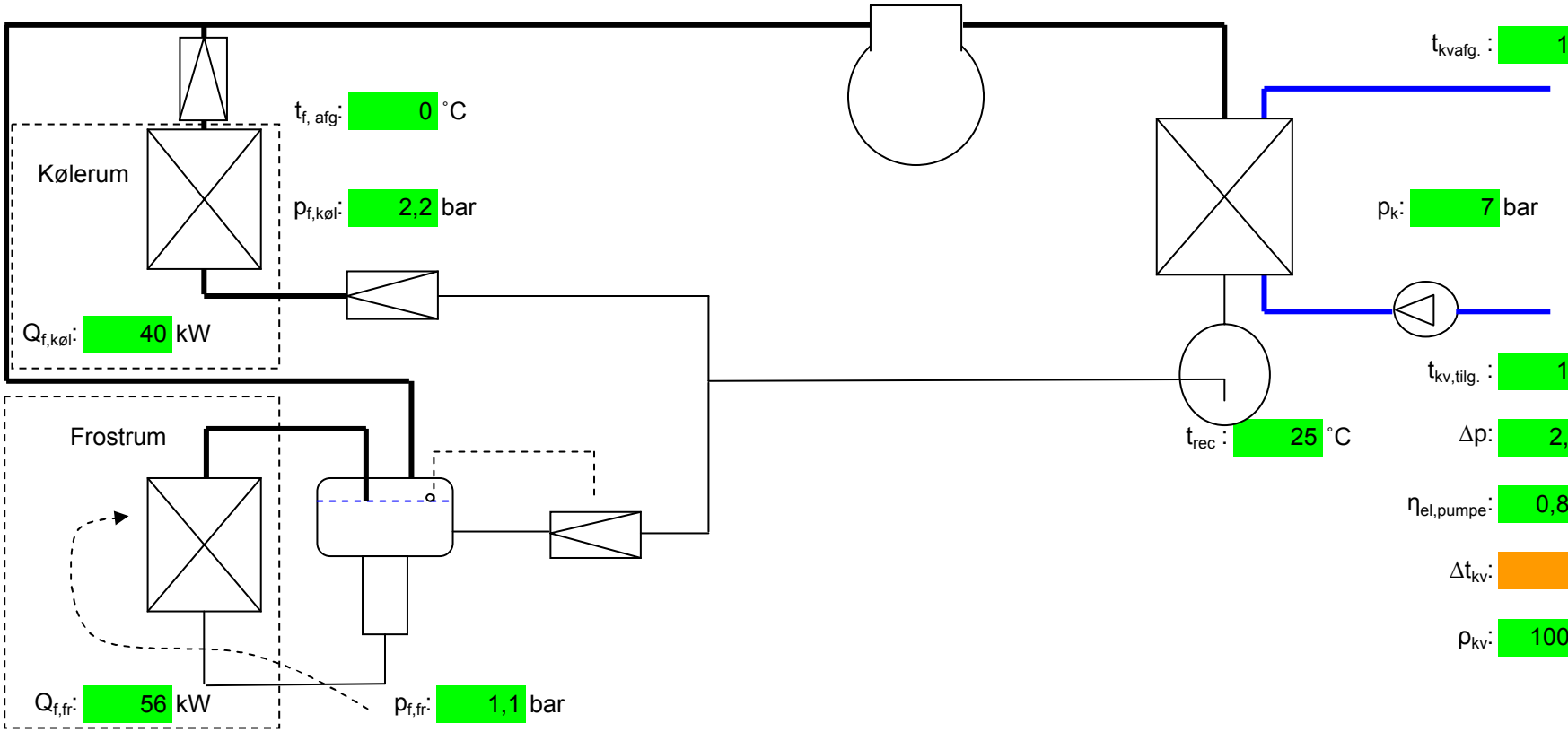
Kompressor:

z:	16	stk		
d:	100	mm	→	0,1 m
s:	80	mm	→	0,08 m
η_{mek}:	0,91			
η_{el}:	0,93			
n:	950-1450	o/min		

t_{komp} : 60 °C

c_{kv} : 4,19 kJ/kg

$t_{kvafg.}$: 19 °C



$t_{f,\ afg}$: 0 °C

$p_{f,køl}$: 2,2 bar

$Q_{f,køl}$: 40 kW

p_k: 7 bar

$t_{kv,tilg.}$: 11 °C

t_{rec} : 25 °C

Δp: 2,2 bar

$\eta_{el,pumpe}$: 0,86

Δt_{kv}: 8 °C

ρ_{kv}: 1000 kg/m³

$Q_{f,fr}$: 56 kW

$p_{f,fr}$: 1,1 bar

2.1 Beregn masseflow af kølemiddel gennem kølerumsfordamperen.

$\Delta h_{f,fr} = h_{afg,fr} - h_{tilg,f} = 383 - 234 =$ **149** kJ/kg

$\Delta h_{f,køl} = h_{afg,køl} - h_{tilg,f} = 399 - 234 =$ **165** kJ/kg

$$\mathbf{m_{R,køl}} = \frac{Q_{f,køl}}{\Delta h_{f,køl}} = \frac{40}{165} =$$ **0,24 kg/s**

2.2 Beregn entalpien ved tilgangen til kompressoren.

$$m_{R,fr} = \frac{Q_{f,fr}}{\Delta h_{f,fr}} = \frac{56}{149} =$$ 0,38 kg/s

$\Sigma m_R = m_{R,køl} + m_{R,fr} = 0,24 + 0,38 =$ 0,62 kg/s

$$h_{bl} = \frac{m_{R,køl} \cdot h_{afg,køl} + m_{R,fr} \cdot h_{afg,fr}}{\Sigma m_R}$$

$$\mathbf{h_{bl}} = \frac{0,24 \cdot 399 + 0,38 \cdot 383}{0,62} =$$ **389,27 kJ/kg**

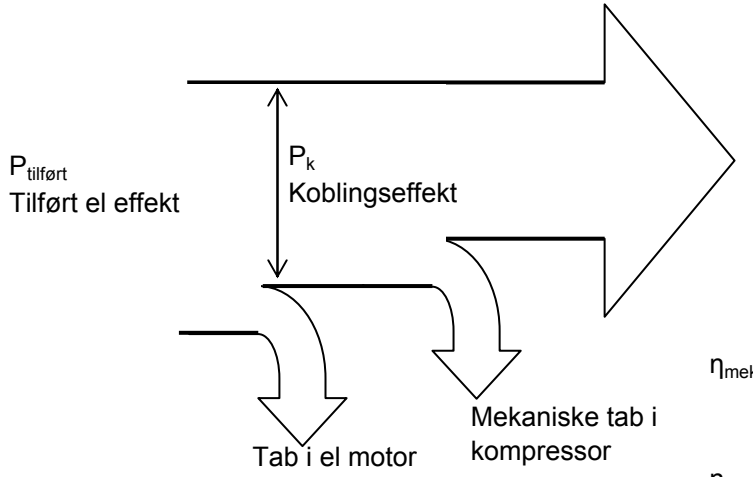
2.3 Beregn kompressorens indre isentropiske virkningsgrad.

$\Delta h_{is} = h_{afg,k,teo} - h_{bl} = 430 - 389,3 =$ 40,7 kJ/kg

$\Delta h_i = h_{afg,k,reel} - h_{bl} = 447 - 389,3 =$ 57,7 kJ/kg

$$\mathbf{\eta_{i,is}} = \frac{\Delta h_{is}}{\Delta h_i} = \frac{40,7}{57,7} =$$ **0,71**

2.4 Beregn den tilførte effekt til kompressorens elmotor.



$$\eta_{mek} = \frac{P_i}{P_k}$$

$$\eta_{elmotor} = \frac{P_k}{P_{tilført}}$$

$$P_{tilført,komp} = \frac{P_i}{\eta_{mek} \cdot \eta_{elmotor}} = \frac{\Sigma m_R}{\eta_{mek}} \cdot \frac{\Delta h_i}{\eta_{elmotor}}$$

$$P_{tilført,komp} = \frac{0{,}62}{0{,}91} \cdot \frac{57{,}7}{0{,}93} = \mathbf{42{,}17\ kW}$$

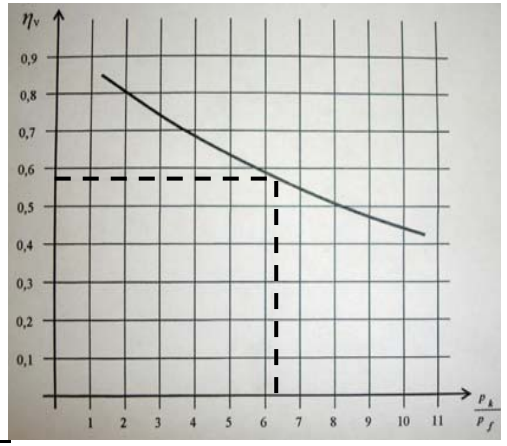
2.5 Bestem volumenflow ved tilgang til kompressoren.

$$\mathbf{V_{R,sug}} = \Sigma m_R \cdot v_{sug} = 0{,}62 \cdot 0{,}18 = \mathbf{0{,}111\ m^3/s}$$

2.6 Bestem volumenflow ved afgang til kompressoren.

$$\mathbf{V_{R,afg}} = \Sigma m_R \cdot v_{afg} = 0{,}62 \cdot 0{,}035 = \mathbf{0{,}022\ m^3/s}$$

2.7 Beregn kompressorens omdrejningstal pr. minut.



$$\frac{p_{afg}}{p_{sug}} = \frac{7}{1{,}1} = 6{,}36 \Rightarrow \eta_{vol} = 0{,}57$$

$$V_{teo} = \frac{V_{R,sug}}{\eta_{vol}} = \frac{0{,}111}{0{,}57} = 0{,}195 \text{ m}^3/\text{s}$$

$$V_{teo} = \frac{z \cdot \pi \cdot d^2}{4} \cdot \frac{s \cdot n}{60}$$

$$n = \frac{4 \cdot 60 \cdot V_{teo}}{z \cdot \pi \cdot d^2 \cdot s}$$

$$\mathbf{n} = \frac{4 \cdot 60 \cdot 0{,}195}{16 \cdot \pi \cdot 0{,}1^2 \cdot 0{,}08} = \mathbf{1165} \text{ o/min}$$

2.8 Beregn masseflow af kølevand gennem kondensatoren.

$$\Delta h_k = h_{afg,k,reel} - h_{tilg,f} = 447 - 234 = 213 \text{ kJ/kg}$$

For kondensatoren gælder:

$$Q_k = \Sigma m_R \cdot \Delta h_k = m_{kv} \cdot c_{kv} \cdot \Delta t_{kv}$$

$$\mathbf{m_{kv,\,kon}} = \frac{\Sigma m_R \cdot \Delta h_k}{c_{kv} \cdot \Delta t_{kv}} = \frac{0{,}62 \cdot 213}{4{,}19 \cdot 8} = 3{,}93 \text{ kg/s}$$

$$\mathbf{m_{kv,\,kon}} = \mathbf{14143} \text{ kg/h}$$

2.9 Beregn tilført effekt til kølevands elmotoren.

$$P_{afg,pumpe} = V_{kv} \cdot \Delta p = \frac{m_{kv}}{\rho} \cdot \Delta p$$

$$P_{afg,pumpe} = \frac{3{,}93}{1000} \cdot 2{,}2 \cdot 10^{5-3} = 0{,}86 \text{ kW}$$

(5: bar → Pa, 3: W → kW)

$$\mathbf{P_{tilført,pumpe}} = \frac{P_{afg,pumpe}}{\eta_{el,pumpe}} = \frac{0{,}86}{0{,}86} = \mathbf{1{,}005 \text{ kW}}$$

2.10 Beregn COP for hele anlægget.

$$COP_{anlæg} = \frac{\Sigma Q_f}{\Sigma P_{tilført}} = \frac{Q_{f,fr} + Q_{f,køl}}{P_{tilf,komp} + P_{tilf,pumpe}}$$

$$\mathbf{COP_{anlæg}} = \frac{56 + 40}{42{,}17 + 1{,}005} = \mathbf{2{,}22}$$