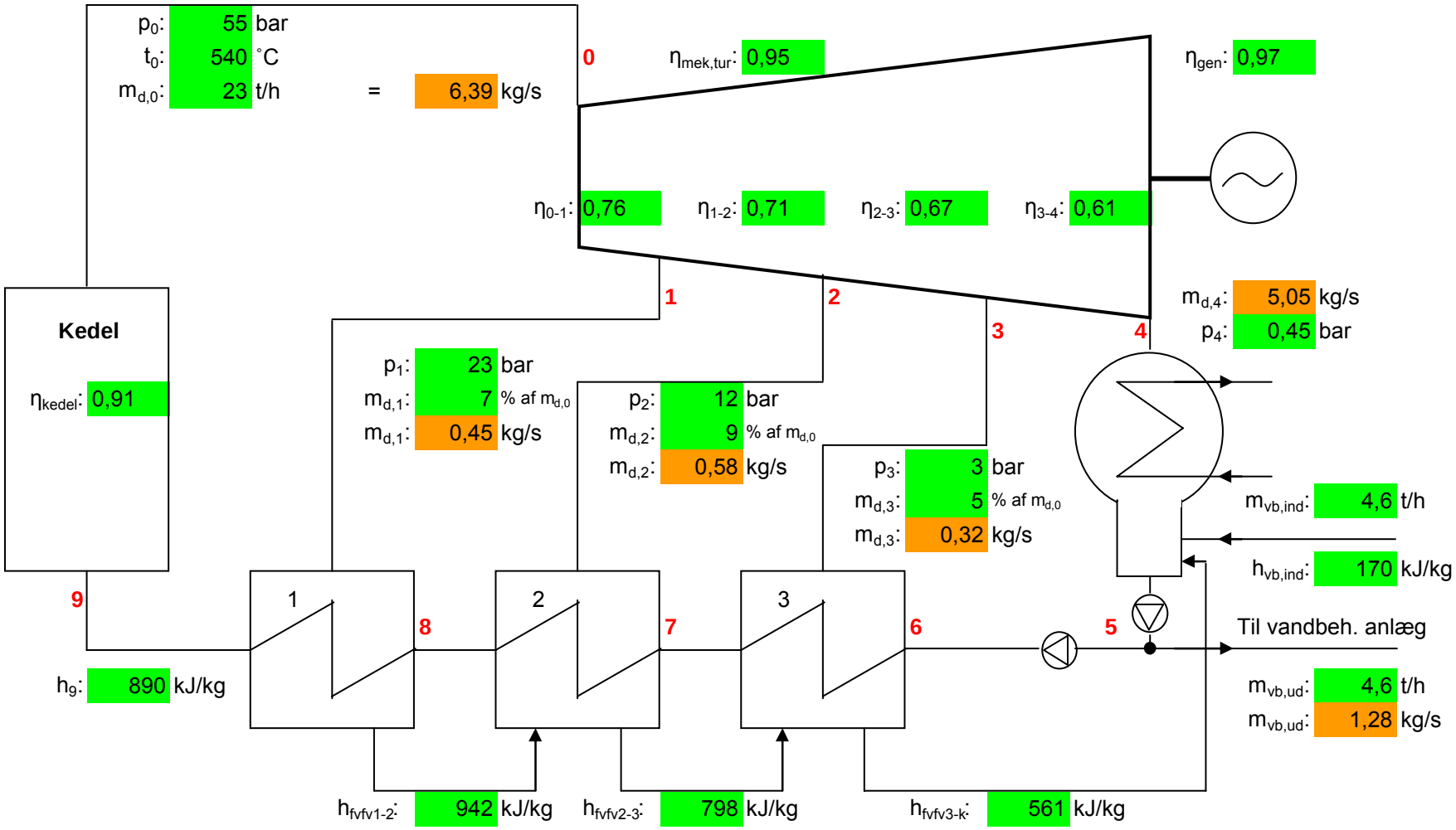
Kraftværksteknik, Juni 1992

Niels Skovmand, M6, Januar 2006



Punkt 0

t_0	=	540 °C
p_0	=	55 Bar
h_0	=	**3521,7 kJ/kg**

Punkter findes i h,s diagram og vha. af Coolpack

$$\eta_{0-1} = \frac{h_0 - h_1}{h_0 - h_{1[teo]}}$$

Punkt 1[teo]

$t_{1[teo]}$	=	396,3 °C
$p_{1[teo]}$	=	23 Bar
$h_{1[teo]}$	=	3234,1 kJ/kg

$$h_1 = h_0 - \eta_{0-1} \cdot (h_0 - h_{1[teo]})$$

$$\mathbf{h_1} = 3521{,}7 - 0{,}76 \cdot (3521{,}7 - 3234{,}1) = 3303{,}1 \text{ kJ/kg}$$

Punkt 1

t_1	=	427,4 °C
p_1	=	23 Bar
h_1	=	**3303,1 kJ/kg**

Punkt 2[teo]

$t_{2[teo]}$	=	331 °C
$p_{2[teo]}$	=	12 Bar
$h_{2[teo]}$	=	3112,5 kJ/kg

$$h_2 = h_1 - \eta_{1-2} \cdot (h_1 - h_{2[teo]})$$

$$\mathbf{h_2} = 3303{,}1 - 0{,}71 \cdot (3303{,}1 - 3112{,}5) = 3167{,}8 \text{ kJ/kg}$$

Punkt 2

t_2	=	356,78 °C
p_2	=	12 Bar
h_2	=	**3167,8 kJ/kg**

Punkt 3[teo]

$t_{3[teo]}$	=	182,84 °C
$p_{3[teo]}$	=	3 Bar
$h_{3[teo]}$	=	2829,8 kJ/kg

$$h_3 = h_2 - \eta_{2-3} \cdot (h_2 - h_{3[teo]})$$

$$\mathbf{h_3} = 3167{,}8 - 0{,}67 \cdot (3167{,}8 - 2829{,}8) = 2941{,}3 \text{ kJ/kg}$$

Punkt 3

t_3	=	237,23 °C
p_3	=	3 Bar
h_3	=	**2941,3 kJ/kg**

Punkt 4[teo]

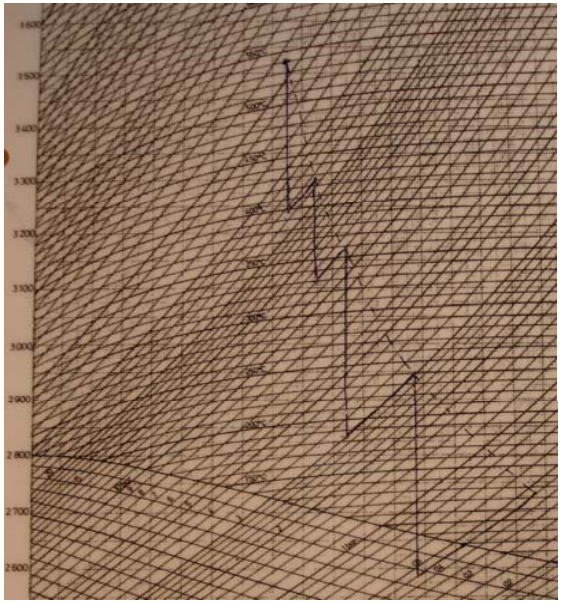
$t_{4[teo]}$	=	50,69 °C
$p_{4[teo]}$	=	0,45 Bar
$h_{4[teo]}$	=	2586 kJ/kg

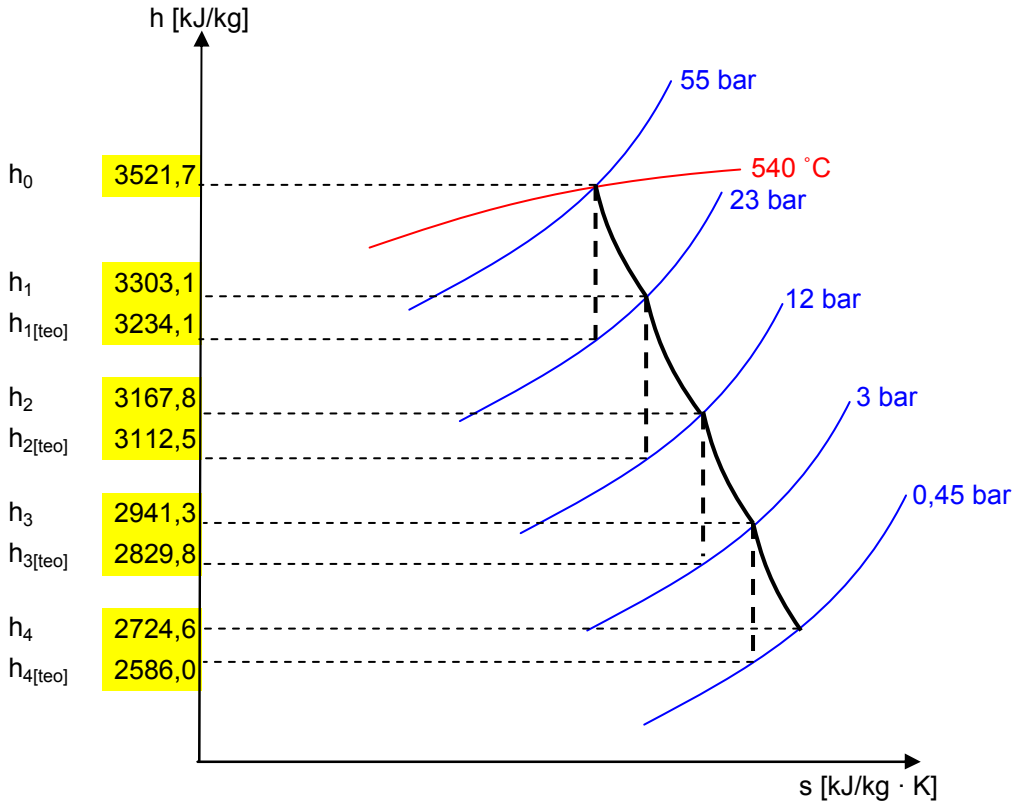
Punkt 4

t_4	=	121,44 °C
p_4	=	0,45 Bar
h_4	=	**2724,6 kJ/kg**

$$h_4 = h_3 - \eta_{3\text{-}4} \cdot \left(h_3 - h_{4[teo]} \right)$$

$$\mathbf{h_4} = 2941{,}3 - 0{,}61 \cdot \left(2941{,}3 - 2586 \right) = 2724{,}6 \text{ kJ/kg}$$





1.1 Beregn varmeoverførslen i fødevandsforvarmer 3, i [kW], når det antages, at kondensatet fra turbinen er på mætningstemperaturen ved tilgangen til varmtvandsbrønden.

$m_{d,1-2} = m_{d,1} = 0{,}45$ kg/s

$m_{d,2-3} = m_{d,1} + m_{d,2} = 0{,}45 + 0{,}58 = 1{,}02$ kg/s

$m_{d,3-k} = m_{d,2-3} + m_{d,3} = 1{,}02 + 0{,}32 = 1{,}34$ kg/s

$Q_{tilf,1} = m_{d,1} \cdot (h_1 - h_{fvfv1-2}) = 0{,}45 \cdot (3303{,}1 - 942) = 1055{,}9$ kW

$Q_{tilf,2} = h_{fvfv1-2} \cdot m_{d,1-2} + h_2 \cdot m_{d,2} - h_{fvfv2-3} \cdot m_{d,2-3}$

$Q_{tilf,2} = 942 \cdot 0{,}45 + 3167{,}8 \cdot 0{,}58 - 798 \cdot 1{,}02 = 1427$ kW

$Q_{tilf,3} = h_{fvfv2-3} \cdot m_{d,2-3} + h_3 \cdot m_{d,3} - h_{fvfv3-k} \cdot m_{d,3-k}$

$\mathbf{Q_{tilf,3}} = 798 \cdot 1{,}02 + 2941{,}3 \cdot 0{,}32 - 561 \cdot 1{,}34 = \mathbf{1002{,}6}$ **kW**

1.2 Opstil en varmebalance for varmeværket (inkl. kedlen), når effekt til pumper, kedelblæsere o.lign. ikke medregnes.

$Q_{kedel,afg.} = m_{d,0} \cdot (h_0 - h_9)$

$Q_{kedel,afg.} = 6{,}39 \cdot (3521{,}7 - 890) = 16814$ kW

$$Q_{kedel,tilf.} = \frac{Q_{kedel,afg.}}{\eta_{kedel}} = \frac{16814}{0{,}91} = 18476 \text{ kW}$$

Energi overført **fra dampen til turbinen**:

0 - 1: $Q_{0-1} = m_{d,0} \cdot (h_0 - h_1)$

$Q_{0-1} = 6{,}39 \cdot (3521{,}7 - 3303{,}1) = 1396{,}5$ kW

1 - 2: $Q_{1-2} = (m_{d,0} - m_{d,1}) \cdot (h_1 - h_2)$

$Q_{1-2} = (6{,}39 - 0{,}45) \cdot (3303{,}1 - 3167{,}8) = 804{,}17$ kW

2 - 3: $Q_{2-3} = (m_{d,0} - m_{d,1} - m_{d,2}) \cdot (h_2 - h_3)$

$Q_{2-3} = (6{,}39 - 0{,}45 - 0{,}58) \cdot (3167{,}8 - 2941{,}3) = 1215{,}2$ kW

3 - 4: $Q_{3-4} = (m_{d,0} - m_{d,1} - m_{d,2} - m_{d,3}) \cdot (h_3 - h_4)$

$Q_{3-4} = (6{,}39 - 0{,}45 - 0{,}58 - 0{,}32) \cdot (2941{,}3 - 2724{,}6) = 1093{,}9$ kW

0 - 4: $Q_{turbine} = Q_{0-1} + Q_{1-2} + Q_{2-3} + Q_{3-4}$

$\mathbf{Q_{turbine}} = 1396{,}5 + 804{,}17 + 1215{,}2 + 1093{,}9 = \mathbf{4509{,}8}$ **kW**

El effekt leveret til nettet:

$P_{el} = Q_{turbine} \cdot \eta_{mek,tur.} \cdot \eta_{gen} = 4509{,}8 \cdot 0{,}95 \cdot 0{,}97 = 4155{,}8$ kW

Energi afsat i **forvarmeren**:

$Q_{forv.} = Q_{tilf,1} + Q_{tilf,2} + Q_{tilf,3} = 1055{,}9 + 1427 + 1002{,}6 = \mathbf{3485{,}6}$ kW

Energiindhold i dampen i tilstand **6**

$m_9 = m_{d,0}$ $\qquad Q_{forv.} = m_{d,0} \cdot (h_9 - h_6)$

$$h_6 = h_9 - \frac{Q_{forv.}}{m_{d,0}} = 890 - \frac{3485,6}{6,39} = 344,4 \text{ kJ/kg}$$

Energi afsat i **vandbehandlingsanlægget**:

$$Q_{vandbeh.} = m_{vb} \cdot (h_6 - h_{vb,ind}) = 1,28 \cdot (344,43 - 170) = \mathbf{222,9} \text{ kW}$$

Energi bortledt fra **kondensatoren**:

$Q_{kond.} = Q_{tilf,kond} - Q_{bortledt,kond}$

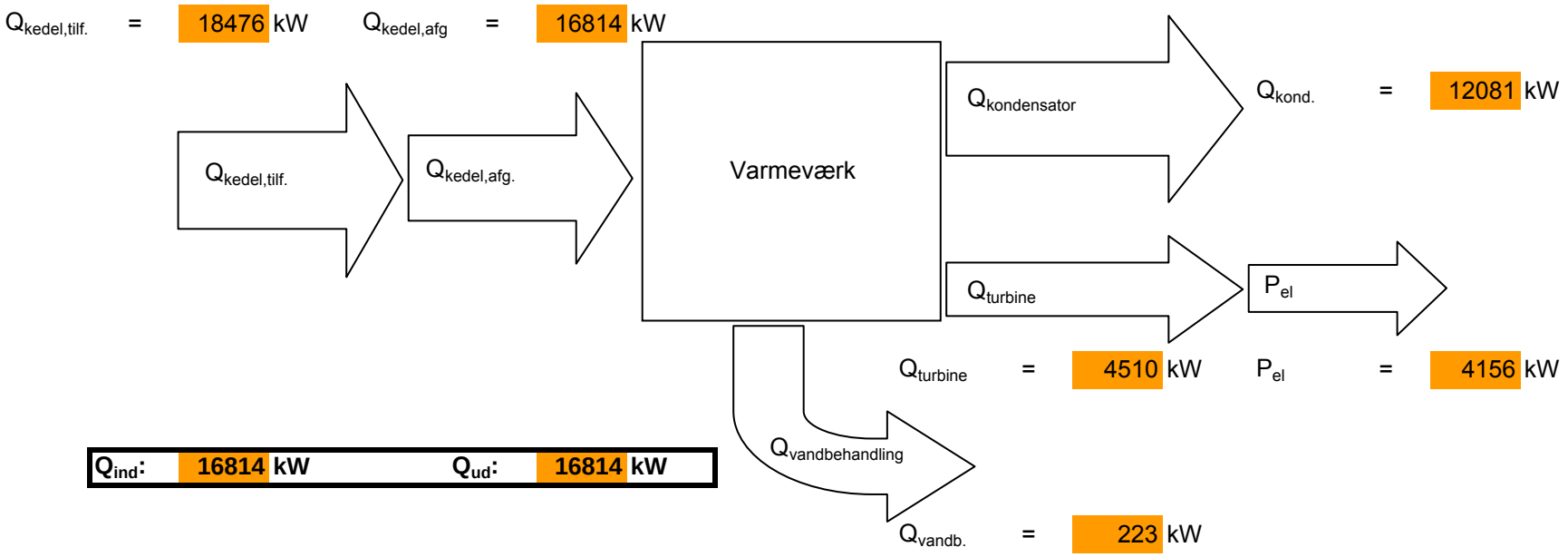
$Q_{tilf,kond} = m_{d,4} \cdot h_4 + m_{vb,ind} \cdot h_{vb,ind} + m_{d,3\text{-}k} \cdot h_{fvfv3\text{-}k}$

$Q_{tilf,kond} = 5,05 \cdot 2724,6 + 1,28 \cdot 170 + 1,34 \cdot 561 = 14721$ kW

$Q_{bortledt,kond} = m_{d,6} \cdot h_6 + m_{vb,ud} \cdot h_{vb,ud}$ $\qquad (m_{d,6} = m_{d,0}\ ,\ h_{vb,ud} = h_6)$

$Q_{bortledt,kond} = 6,39 \cdot 344,4 + 1,28 \cdot 344,4 = 2641$ kW

$Q_{kond.} = Q_{tilf,kond} - Q_{bortledt,kond} = 14721 - 2641 = \mathbf{12081}$ kW


$Q_{kedel,tilf.}$ = 18476 kW
$Q_{kedel,afg}$ = 16814 kW
$Q_{kedel,tilf.}$
$Q_{kedel,afg.}$
Varmeværk
$Q_{kondensator}$
$Q_{kond.}$ = 12081 kW
$Q_{turbine}$
P_{el}
$Q_{turbine}$ = 4510 kW
P_{el} = 4156 kW
$Q_{vandbehandling}$
$Q_{vandb.}$ = 223 kW
Q_{ind}: 16814 kW
Q_{ud}: 16814 kW