Lecture notes

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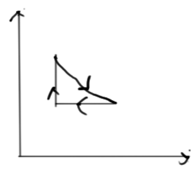
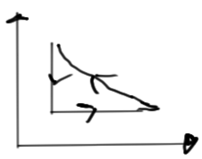
Kretsproccesser, Värmeledning, Stöttalet

Kretsprocesser



Värme maskin

mål: producera mekansikt arbete
pris: tillförd värme
Note: går medurs



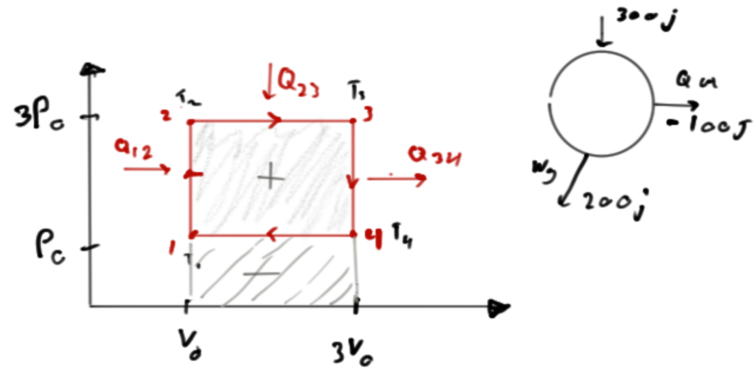
Kylmaskin

Två typer

1. Kylskåp

2. Värmepump

Kretsprocess



Enatomig gas

$$C_v = \frac{3}{2}R,\ C_p = \frac{5}{2}R$$

$$e = \frac{\sum W_i}{\sum Q_{pos}} = \frac{\sum Q}{\sum Q_{pos}}$$

$$1 \to 2 : Q_{12} = nC_v(T_2 - T_1)\ (> 0) = n\frac{3}{2}R(3T_1 - T_1)$$

$$2 \to 3 : Q_{23} = nC_p(T_3 - T_2)\ (> 0) = n\frac{5}{2}R(9T_1 - 3T_1)$$

$$3 \to 4 : Q_{34} = nC_v(T_4 - T_3)\ (< 0) = n\frac{3}{2}R(3T_1 - 9T_1)$$

$$4 \to 1 : Q_{41} = nC_p(T_1 - T_4)\ (< 0) = n\frac{5}{2}R(T_1 - 3T_1)$$

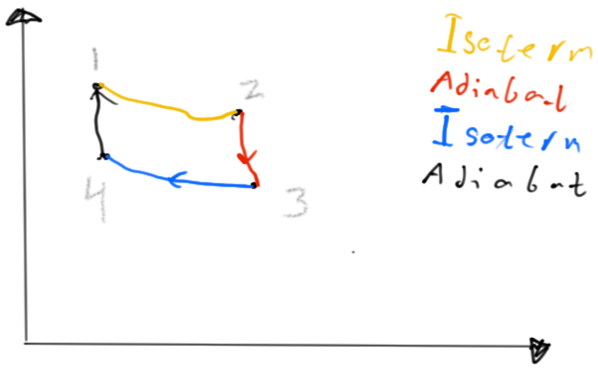
$$e = \frac{Q_{12} + Q_{23} + Q_{34} + Q_{41}}{Q_{12} + Q_{23}} =$$

$$= \frac{\frac{3}{2} * 2 + \frac{5}{2} * 6 - \frac{3}{2} * 6 - \frac{5}{2} * 2}{\frac{3}{2} * 2 + \frac{5}{2} * 6} = \frac{3 + 15 - 9 - 5}{3 + 5} = \frac{4}{18}$$

$$e = \frac{\sum W_g}{\sum Q_{pos}}, \sum W_g = 2P_0 * 2V_0 = 4P_0V_0 = 4nRT_1, e = \frac{4}{18}$$

Carnotprocessen

T_l: Låg temperatur
T_h: Hög temperatur



$$W_{12} = nRT_n \cdot \ln\left(\frac{V_2}{V_1}\right), \qquad w_{23} = nC_v(T_h - T_l)?$$

$$w_{34} = nRT_l \cdot \ln\left(\frac{V_4}{V_3}\right), \qquad w_{41} = nC_V(T_v - T_l)$$

$$e = \frac{nRT_h \ln\left(\frac{V_2}{V_1}\right) + nRT_l \ln\left(\frac{V_4}{V_3}\right)}{nRT_h \ln\left(\frac{V_2}{V1}\right)}$$

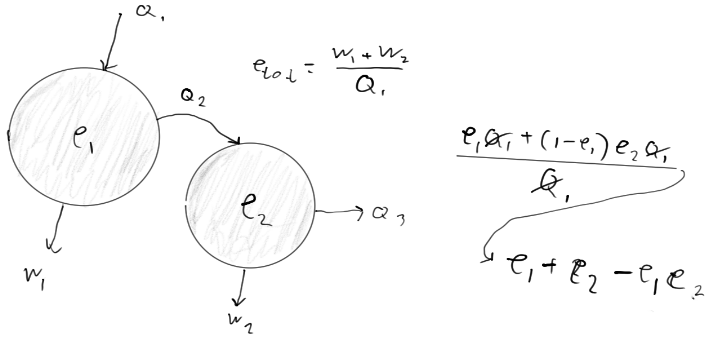
Förenkling:

$$P_1V_1 = P_2V_2\text{Isoterm}, P_2V_2^\gamma = P_3V_3^\gamma\text{adiabat}$$
$$P_3V_3 = P_4V_4\text{Isoterm}, P_4V_4^\gamma = P_1V_1^\gamma\text{adiabat}$$
$$\rightarrow V_1V_2^\gamma V_3V_4^\gamma = V_2V_3^\gamma V_4V_1^\gamma \rightarrow V_1^{\gamma-1}V_3^{\gamma-1} = V_2^{\gamma-1}V_4^{\gamma-1}$$
$$\rightarrow V_1V_3 = V_2V_4 \rightarrow \frac{V_4}{V_3} = \frac{V_1}{V_2}$$
$$e = \frac{T_h \ln\left(\frac{V_2}{V_1}\right) + T_l \ln\left(\frac{V_1}{V_2}\right)}{T_h \ln\left(\frac{V_2}{V_1}\right)} = \frac{T_h - T_l}{T_h}$$

Ration $\frac{T_h - T_l}{T_h}$ kallas energi kvalite

$\ln\left(\frac{A}{B}\right) = -\ln\left(\frac{B}{A}\right)$

Uppgift 1

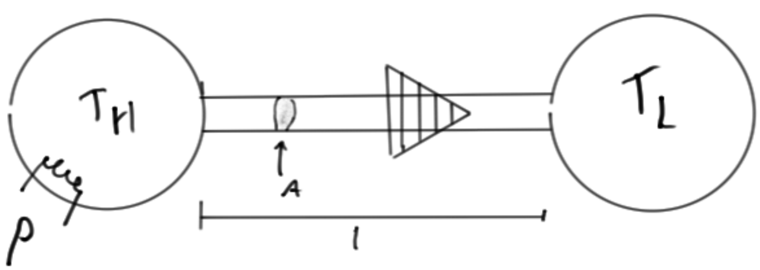


(Med min lösning) Skilljer sig lite från den som visades

Kylmaskiner

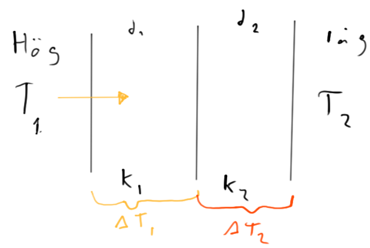
$$\text{"coefficient of performance"} = \frac{\text{Önskat resultat}}{\text{input}} = \frac{?}{\text{arbete utfört av kompressor}}$$

Vämreledning



k är värmeledningsförmågan $W/m \cdot K$

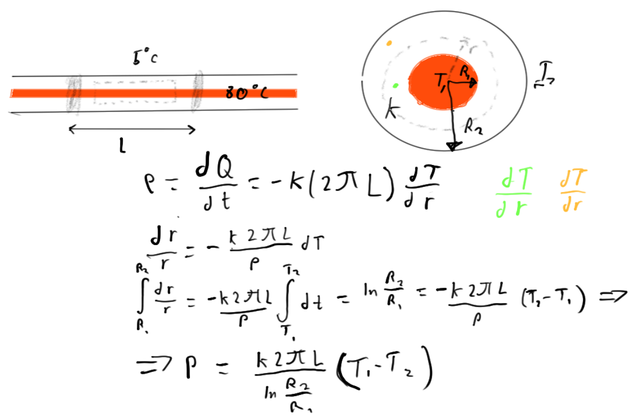
$$P = \frac{dQ}{dt} = Ak\frac{T_h - T_l}{l}$$



Nästa steg

$$Ak_1 \frac{\Delta T_1}{d_1} = Ak_2 = \frac{\Delta T_2}{d_2}$$
$$Ak_1 \frac{T_1 - T_x}{d_1} = Ak_2 \frac{T_x - T_2}{d_2}$$

Exempel

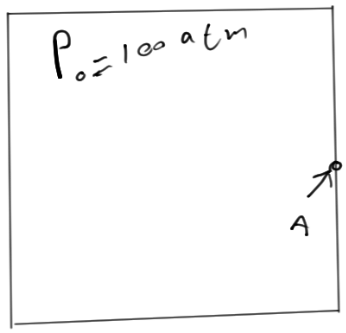


Stötttalet

$$n^* = \frac{1}{4}\left(\frac{N}{V}\right) < v >$$

antal stötar per sekund och m^2

$$PV = nRT \rightarrow PV = \frac{N}{N_A}RT \rightarrow P = \left(\frac{N}{V}\right)\left(\frac{R}{N_A}\right)T = \left(\frac{N}{V}\right)k_BT$$
$$\rightarrow \frac{N}{V} = \frac{P}{k_BT}$$

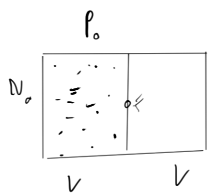


$\langle v \rangle = 500$ m/s
$A = 1$ mm^2
$P = \left(\frac{N}{V}\right) k_B T$

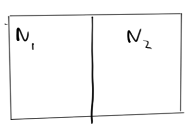
Hur många molekyler försvinner ut den första sekunden efter att hålet uppstt.

$$n^* \frac{1}{4}\left(\frac{P}{k_B T}\right) < v >= \frac{1}{4}\left(\frac{100 * 1,013 * 10^5}{1,23 * 10^{-23} * 300}\right) 500$$

Hur lång tid tar det innan trycket har halverats? Försumma inläckage. Rel mellan tryck och antal partiklar : $PV = \frac{N}{N_A} RT, P \sim N$



N : vänstra delen som funktion av t.



$dN_1 = -\frac{1}{4}\frac{N_1}{V}\langle v \rangle dt \cdot A + \frac{1}{4}\frac{N_2}{V}\langle v \rangle A \cdot dt$

$N_2 = N_0 - N_1$

$dN_1 = -\frac{1}{4}\frac{\langle v \rangle}{V}\left(N_1 - (N_0 - N_1)\right) dt$

$\frac{dN_1}{2N_1 - N_0} = \frac{1}{4}\frac{\langle v \rangle A}{V} dt \Rightarrow$

$\frac{1}{2}\left[\ln \frac{1}{2N_1 - N_0}\right]_{N_0}^{N_1} = -\frac{1}{4}\frac{\langle v \rangle A}{V} t \Rightarrow$

To be continued...