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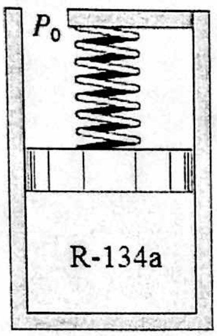
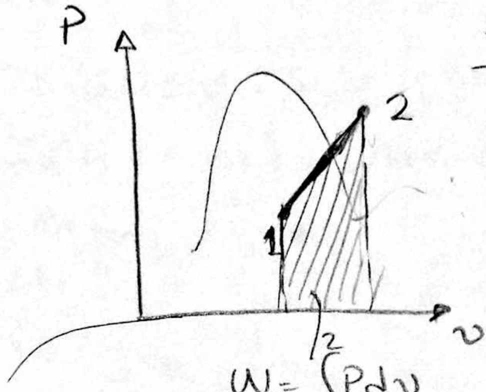
Fall 2015

Çankaya University
Faculty of Engineering
Mechanical Engineering Department
ME 211 Thermodynamics I
Closed Notes and Books
Midterm Exam 2
19.12.2015

Q-1 A piston/cylinder arrangement with a linear spring similar to figure given below contains R-134a at 12 ^{0}C, x=0.45 and a volume of 0.03 m^3. It is heated to 70 ^{0}C, at which point the specific volume is 0.0363 m^3/kg. Find the final pressure, the work, and the heat transfer in the process. Show the process on a P-V diagram.





$_1W_2 = \int_1^2 P dv$

1st law of thermo.

$_1Q_2 - {_1W_2} = m(u_2 - u_1)$

Conservation of mass:

$m_1 = m_2 = m$

$m_1 = \frac{V_1}{v_1}$

State 1

T = 12°C
x = 0,45

From Table A.10 P sat = 4.43 bar = 443 kPa

$v_f = 0{,}7971 \cdot 10^{-3}$ m³/kg $u_f = 65.83$ kJ/kg

$v_g = 0.046$ m³/kg $u_g = 233.63$ kJ/kg

so $v_1 = (1-x) \cdot v_f + x \cdot v_g$ $u_1 = 141{,}34$ kJ/kg

$v_1 = 0{,}021$ m³/kg. $m_1 = \frac{0{,}03}{0{,}021} = 1{,}43$ kg

State 2

T = 70°C
$v_2 = 0{,}0363$ m³/kg } superheated vapor } Table A.12

$P_2 = 0{,}7$ MPa = 7 bar = 700 kPa

$u_2 = 281.57$ kJ/kg.

Work done: $_1W_2 = \int_1^2 P dv = \frac{(P_1 + P_2)}{2} \cdot (v_2 - v_1) \cdot m$

$_1W_2 = \frac{(443 + 700)}{2} \cdot (0{,}0363 - 0{,}021) \cdot 1{,}43 = 12{,}5$ kJ

Heat transfer: $_1Q_2 = m(u_2 - u_1) + {_1W_2} = 1.43(281{,}57 - 141{,}34) + 12{,}5$

$_1Q_2 = 213$ kJ

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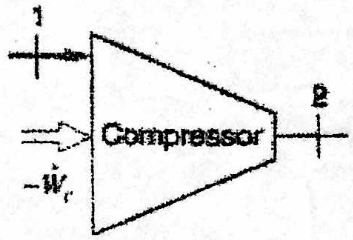
Q-2 Air is to be compressed from 110 kPa and 300 K to 800 kPa and 520 K. A heat loss of 35 kJ/kg occurs during compression. Δke=0. The mass flow rate is 75 kg/min. Find the required power input.



$$\frac{dm_{cv}}{dt} = \dot{m}_1 - \dot{m}_2 \quad (\text{= }0)$$

$$\frac{dE_{cv}}{dt} = \dot{Q}_{cv} - \dot{W}_{cv} + \dot{m}_1\left(h_1 + \frac{V_1^2}{2} + gz_1\right) - \dot{m}_2\left(h_2 + \frac{V_2^2}{2} + gz_2\right) \quad (\text{= }0)$$

$\dot{m}_1 = \dot{m}_2 = \dot{m} = 75/60 = 1,25$ kg/s

$\dot{W}_{cv} = \dot{Q}_{cv} + \dot{m}(h_1 - h_2)$ where $\dot{Q}_{cv} = q \cdot \dot{m}$

From table A.22

$h_1 = 300.19$ kJ/kg

$h_2 = 523,63$ kJ/kg.

so : $\dot{W}_{cv} = -35 \cdot 1.25 + 1.25(300 - 523.63)$

$\rightarrow \dot{W}_{cv} = \underline{-323,3 \text{ kW}}$.

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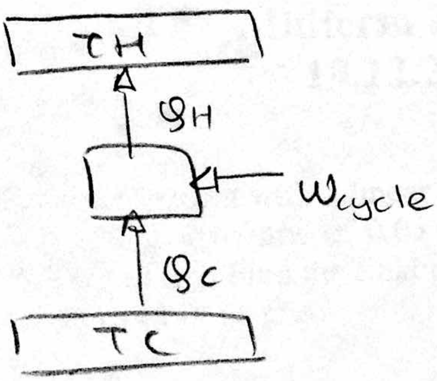
Q-3 A refrigeration cycle rejects Q_H =5400 kJ per cycle to a hot reservoir at T_H =550 K, while receiving Q_C= 4000 kJ per cycle from a cold reservoir at temperature T_C. Determine (a) the net work input, in kJ, and (b) **the minimum theoretical temperature** T_C, in K and (c) the corresponding coefficient of performance of the cycle.



a) $W_{cycle} = Q_H - Q_C$

$W_{cycle} = 1400$ kJ.

b) Cycle should be reversible for minimum theoretical work:

$$\frac{T_C}{T_H - T_C} = \frac{Q_C}{Q_H - Q_C} \Rightarrow \frac{4000}{(5400-4000)} = \frac{T_C}{550 - T_C}$$

$\Rightarrow T_C = 407.5$ K.

c) $$\beta = \frac{T_C}{T_H - T_C} = \frac{Q_C}{W_{cycle}} = 2.857 \simeq 2.86$$