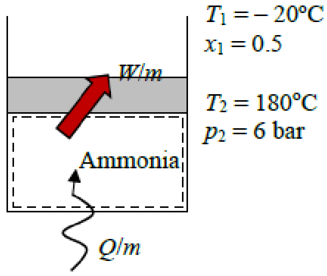
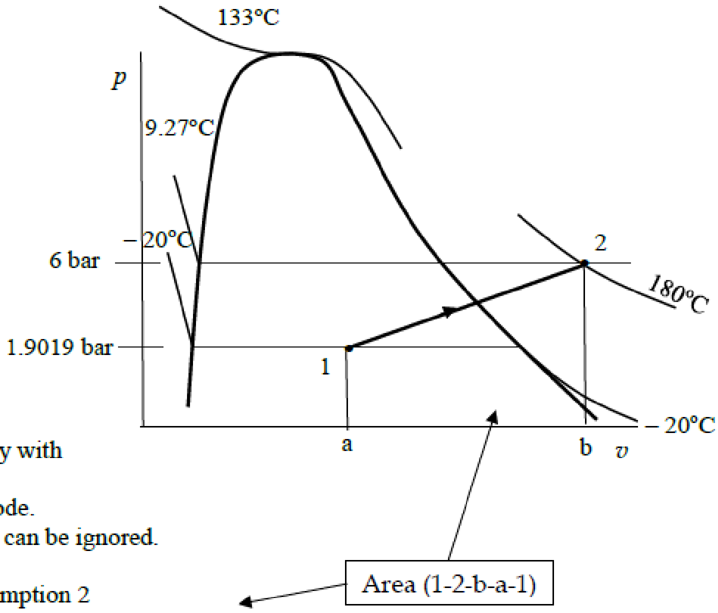
Soluções do Exame de TDF 12/01/2024

Problema I

SCHEMATIC AND GIVEN DATA:





ENGINEERING MODEL:
1. The ammonia is the closed system.
2. The ammonia pressure varies linearly with specific volume.
3. Volume change is the only work mode.
4. Kinetic and potential energy effects can be ignored.

ANALYSIS: Using Eq. 2.17 with assumption 2

$$\frac{W}{m} = \int_1^2 p\,dv = p_{avg}(v_2 - v_1) = \left(\frac{p_2 + p_1}{2}\right)(v_2 - v_1)$$

With data from Table A-13

$$v_1 = v_{f1} + x_1(v_{g1} - v_{f1}) = 1.5038 \times 10^{-3} + (0.5)(0.6233 - 1.5038 \times 10^{-3}) = 0.3124 \text{ m}^3/\text{kg}$$

From Table A-15: $v_2 = 0.3639$ m^3/kg

So

$$\frac{W}{m} = \frac{(6+1.9019)\,\text{bar}}{2}\left|\frac{10^5 \text{ N/m}^2}{1 \text{ bar}}\right|\left(0.3639 - 0.3124\times10^{-3}\right)\frac{\text{m}^3}{\text{kg}}\left|\frac{1 \text{ kJ}}{10^3 \text{ N}\cdot\text{m}}\right|$$

$$= \textbf{20.35 kJ/kg (out)}$$

Applying the closed system energy balance: $\cancel{\Delta PE} + \cancel{\Delta KE} + \Delta U = Q - W$

So

$$Q/m = W/m + (u_2 - u_1)$$

With data from Table A-13:

$$u_1 = u_{f1} + x_1(u_{g1} - u_{f1}) = 88.40 + (0.5)(1299.23 - 88.40) = 693.82 \text{ kJ/kg}$$

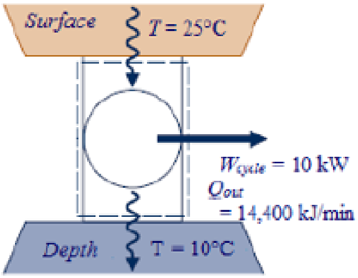
And, from Table A-15: $u_2 = 1649.22$ kJ/kg

Inserting values in the energy balance

$$Q/m = 20.35 \text{ kJ/kg} + (1649.22 - 639.82) \text{ kJ/kg} = \textbf{975.75 kJ/kg (in)}$$

Problema II

Schematic and Given Data:



Engineering Model:

1. The surface and the depth of the lake serve as the hot and cold reservoirs, respectively, for the power cycle.
2. The power cycle operates at steady state.

Analysis:

The thermal efficiency is defined as:

$$\eta = \frac{W_{cycle}}{Q_H}$$

Considering the energy balance for the cycle:

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

The thermal efficiency is:

$$\eta = \frac{W_{cycle}}{Q_H} = \frac{W_{cycle}}{W_{cycle} + Q_C} = \frac{10\ kW}{10\ kW + \left(14{,}400 \frac{kJ}{min}\right)\left|\frac{1\ min}{60\ s}\right|\left|\frac{1\ kW}{1\ kJ/s}\right|} = 0.04$$

$$\eta = 4\% \longleftarrow \textbf{Thermal efficiency}$$

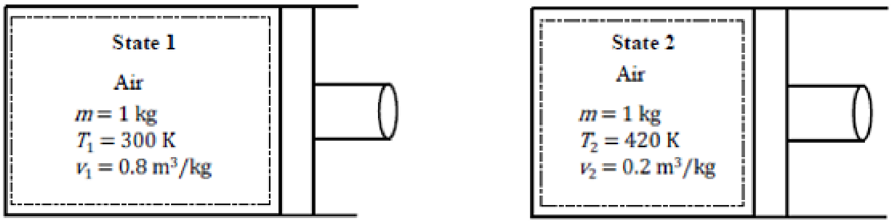
The thermal efficiency for a reversible cycle is:

$$\eta_{max} = 1 - \frac{T_C}{T_H} = 1 - \frac{10 + 273\ K}{25 + 273\ K} = 0.050$$

$$\eta_{max} = 5\% \longleftarrow \textbf{Maximum thermal efficiency}$$

The power cycle is "possible". The thermal efficiency of a power cycle is always less than or equal to the maximum theoretical efficiency.

Problema III



<u>Analysis</u>:

Assuming an adiabatic process, the entropy balance reduces to, $\Delta S = \cancel{\int_1^2 \left(\frac{\delta Q}{T}\right)_b} + \sigma$

This simplifies to, $\sigma = \Delta S = m(s_2 - s_1)$

Using Eq. 6.21, $s_2 - s_1 = c_v \ln\left(\frac{T_2}{T_1}\right) + R\ln\left(\frac{v_2}{v_1}\right)$

Therefore, $\sigma = m\left(c_v \ln\left(\frac{T_2}{T_1}\right) + R\ln\left(\frac{v_2}{v_1}\right)\right)$

Thus, $\sigma = 1\ \text{kg}\left(0.72\frac{\text{kJ}}{\text{kg}\cdot\text{K}}\ln\left(\frac{420}{300}\right) + \left(\frac{8.314}{28.97}\frac{\text{kJ}}{\text{kg}\cdot\text{K}}\right)\ln\left(\frac{0.2}{0.8}\right)\right)$

$\sigma = -0.1556\ \text{kJ/kg}\cdot\text{K}$

Because $\sigma < 0$, this process cannot occur adiabatically. Entropy transfer accompanying heat transfer <u>from the system</u> must occur if $\Delta S < 0$.