AUIS ENGR 352 (Thermodynamics), Section 1, Course Assignment 2

Deadline:[1] October 15, 2017
Tutorial Discussion: October 22, 2017

1) Polytropic process (with pV^n constant)

For a process taking place in a closed system containing a gas, assume that the pressure-volume relationship is given by $pv^{1.4}$ = const.; the process starts with initial conditions given by p_1 = 150 kPa and V_1 = 26 l, and it ends with the volume V_2 = 57 l. Determine the work **done by** the gas, assuming that the expansion occurs without any friction or other dissipation effects.

2) Heat transfer during an isobaric process

R134a (n = 100 mol) is heated isobarically from T_1 = 0 °C to T_2 = 100 °C at p = 700 kPa.

a) Sketch how this transition is represented in a log p-h diagram, including the saturation lines, i.e., the bubble line and the dew line, and the critical point.
b) Using the log p-h diagram for R134a, determine the heat transferred to the system during the process, assuming that the only form of work which is done is expansion work.
c) Repeat this with the NIST database as a source, and also determine how much work is done.
d) Repeat this, now assuming that this process takes two hours and occurs under continuous stirring (still isobarically at p = 700 kPa), where additional work done by an agitator, operating at 100 W, has to be taken into account.

R134a has a molar mass of M = 102.0 g mol^{-1}. The log p-h diagram from the lecture is available on the AUIS Learning Management System, which also includes a link to the NIST WebBook.

3) Vapor-liquid equilibrium of water

A closed, rigid tank with the volume V = 100 l initially contains both liquid water and steam in equilibrium at p_1 = 400 kPa, with the quality $x = n^{II} / (n^{I} + n^{II}) = n^{II}/n$ given by x_1 = 0.08. Heat is transferred to the tank until a pressure of p_2 = 450 kPa is reached. Assume that the process is isochoric, since the tank is rigid, and that no work is done.

a) How much water is in the tank? Give m or n. **b)** How much heat is transferred?

Thermodynamic properties of water are well accessible; please indicate which source you use.

4) Ideal gas law

A rigid tank, whose volume $V = 1.5\ V_1$ is constant, is divided into two parts by a partition. One side, with the volume V_1, contains an ideal gas initially at T_1 = 400 K, while the other side with the volume 0.5 V_1 is evacuated. The partition is removed, and the gas expands adiabatically (assume: polytropically, $pv^{1.4}$ const.), to fill the whole tank (state 2, at $T = T_2$). Then heat is transferred until the pressure equals the initial pressure (state 3, at $T = T_3$). Determine T_2 and T_3.

5) Compressibility factor

Using the same source as for problem 3, determine the compressibility factor $z = pv/RT$ and its deviation from unity (1 – z) for saturated steam at vapor pressures of p = 1, 10, 100, and 1000 kPa. What qualitative behavior do you observe for the dependence of 1 – z on the pressure?

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1 *Each problem contributes 0.5% to the overall grade. Submissions (paper only), individually or in groups of two, can be handed in on October 15 (after the lecture), or deposited in the mailbox (room B-F2-01) by October 14.*