Reservoarfluider og Strømning
Reservoir Fluids and Flow
Course TPG 4145

Homework Problem 1

Handed Out: Jan. 16, 2017
Due Date: One week after handed out
Hand in on ItsLearning as a single Excel file; one sheet for 1.1 and another sheet for 1.2.
File Naming (mandatory!!!): LastName-Problem-1-Solution.xls

Problem 1 – **Gas Grill Propane Tank Depletion**

Consider a domestic outdoor grilling propane (C_3) tank with 10 kg of propane filling a 25 L (liter) container.

Determine the following quantities at the end of each usage of the grill, where the cumulative amount removed is given as a percentage of the initial propane mass in the tank – e.g. 2%, … 28%, … 92%, for an arbitrary number of usages until the tank "runs empty".

Known after each usage:

(a) Outdoor (tank) temperature (^oC); could vary after each usage (ranging from -20^{o}C to +60^{o}C).
(b) Cumulative propane used (% of mass initially in tank).

To be calculated after each usage:

(a) Pressure in the tank.
(b) Mass propane remaining in the tank (kg).
(c) Gas volume as a % of tank volume.
(d) Whether the tank has two phases or one phase (1 or 2); if 1, which phase (gas or liquid).

Plot tank pressure (left y-axis) and liquid vol-% (right y-axis) in tank versus cumulative propane mass consumed.

The properties of propane are estimated by the Soave-Redlich-Kwong (SRK) equation of state model as given in Table 1. Using the three hints below, find simple equations that give the vapor pressure and phase densities as a function of temperature or vapor pressure.

Hint 1. Fit *all* of the vapor pressure "data" in Table 1 to the Antoine equation given by $p_v(T)=A–B/(C+T)$, where you minimize the sum of squares of $\Delta p_v=(p_v^{Antoine}-p_v^{Table})$ by changing A, B, and C. Use this (your) custom best-fit Antoine equation to solve the problem above.

Hint 2. Use Excel Trend Line to fit the gas density "data" (only up to 60^{o}C) in Table 1 as a linear function of pressure and zero intercept. What do we call this best-fit equation?

Hint 3. Use Excel Trend Line to fit the liquid density "data" (only up to 60^{o}C) in Table 1 to a 2nd-degree polynomial in temperature.

TABLE 1 – Properties of Propane from SRK EOS.

TEMP	PSAT	LDEN	GDEN	LMV	GMV	LVIS	GVIS
C	BAR	KG/M3	KG/M3	M3/KGMOL	M3/KGMOL	CP	CP
-40	1.102	588.98	2.596	0.07487	16.9862	0.18924	0.0069
-30	1.670	574.92	3.825	0.07670	11.5300	0.16289	0.0072
-20	2.442	560.00	5.460	0.07874	8.07610	0.14040	0.0075
-10	3.460	544.14	7.592	0.08104	5.80830	0.12126	0.0078
0	4.769	527.22	10.325	0.08364	4.27070	0.10505	0.0081
10	6.416	509.10	13.788	0.08662	3.19830	0.09134	0.0084
15	7.381	499.55	15.841	0.08827	2.78380	0.08530	0.0086
20	8.450	489.63	18.139	0.09006	2.43110	0.07975	0.0088
25	9.628	479.32	20.710	0.09200	2.12920	0.07463	0.0089
30	10.922	468.57	23.587	0.09411	1.86960	0.06992	0.0091
40	13.882	445.64	30.414	0.09895	1.44990	0.06154	0.0096
50	17.384	420.41	39.029	0.10489	1.12980	0.05427	0.0100
60	21.480	392.21	50.067	0.11243	0.88080	0.04782	0.0106
96.68	42.480	187.17	187.17	0.23559	0.23560	0.0201	0.0201

TEMP = temperature, ^oC
PSAT = vapor (saturation) pressure, bara
LDEN = liquid density at (T,p_v), kg/m^3
GDEN = gas density at (T,p_v), kg/m^3
LMV = liquid molar volume at (T,p_v), $m^3/kmol$
GMV = gas molar volume at (T,p_v), $m^3/kmol$
LVIS = liquid viscosity at (T,p_v), cp
GVIS = gas viscosity at (T,p_v), cp

0.00133322 bar/mm Hg : Antoine equation usually given for pressure in mm Hg and temperature in ^oC.