

Chapter 22

22.1 From Figure B.10.1, it can be seen that the molten salt is heated by a fired heater in the circulating loop. This implies that heat is added to the reactor, i.e., the reaction is endothermic. At start-up, if the catalyst activity is lower than designed then the amount of reaction taking place will be less and consequently the amount of heat needed to be added to the reactor should increase in order to increase the temperature and the conversion. Therefore, the flow of circulating molten salt should be increased in order to compensate for the higher heat load.

22.2 Pressure at the bottom of a column decreases.

$$P_{bot} = P_{top} + P_{trays}$$

The pressure drop across the column is due to the pressure drop caused by the gas flowing upwards through the layer of liquid on the trays. This pressure drop is due mainly to the weir height which will not change. Thus, the pressure at the top of the column will also decrease.

As pressure decreases both the top and bottom temperatures also decrease in keeping with Antoine's equation.

As the pressure drop decreases, the vapor density will decrease and the superficial velocity will increase – this will tend to increase the tendency to flood. As the temperature at the bottom of the column decreases the driving force in the reboiler will increase causing more vapor to move up the column and again increasing the tendency to flood (although more steam would have to flow into the reboiler).

22.3

given feed is actually ≈ 7.7 wt% propane
 total G's = 4897.516 kg, which is held
 constant

wt% propane \rightarrow	5%	6%	7%	8%	9%	10%
propylene	4652.640	4603.665	4554.690	4505.715	4456.740	4407.764
propane	244.876	293.851	342.826	391.801	440.776	489.752

above values are kg/h Feed to rxr

Note: This problem is not to be confused with Project 5, App. C and problem 1.10 - there the propane feed impurity is to the process, and the recycle stream affects the rxr feed. In this problem, the reactor is analyzed alone.

Kinetics used - only rxn



$$r = k C_B C_P$$

$$k = 3500 \exp\left[\frac{-13,280 \text{ cal/mol}}{RT}\right]$$

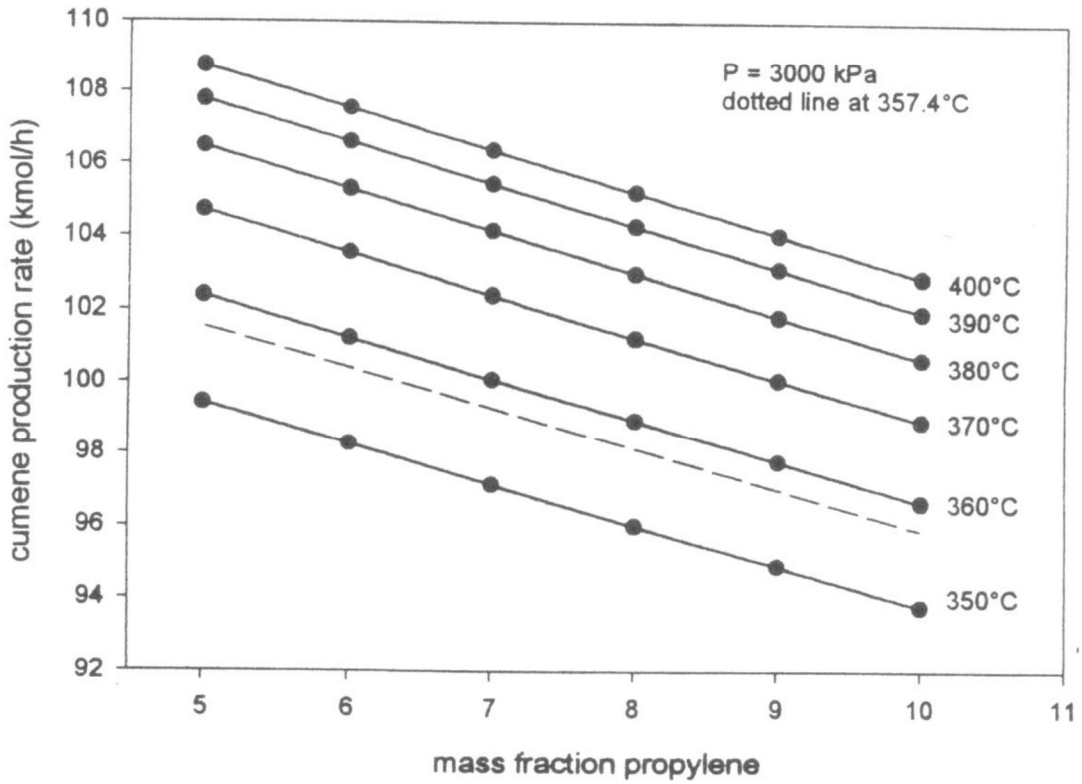
from Example 1.1 - max P $\approx 4800 \text{ kg/hr}$

corresponds to $T = 357.4^\circ\text{C}$ (by interpolation)

22.3 (cont'd)

results of Chemical simulation using SPSS Thermo
 cumene production rate kmol/h

wt % propylene	5	99.42	102.39	104.72	106.49	107.79	108.73
	6	98.28	101.24	103.56	105.32	106.62	107.56
	7	97.15	100.09	102.40	104.16	105.46	106.39
	8	96.02	98.95	101.24	103.00	104.29	105.23
	9	94.90	97.80	100.09	101.84	103.13	104.06
	10	93.77	96.66	98.94	100.68	101.97	102.90
		350°C	360°C	370°C	380°C	390°C	400°C



22.4 (see discussion with Problem 22.3)

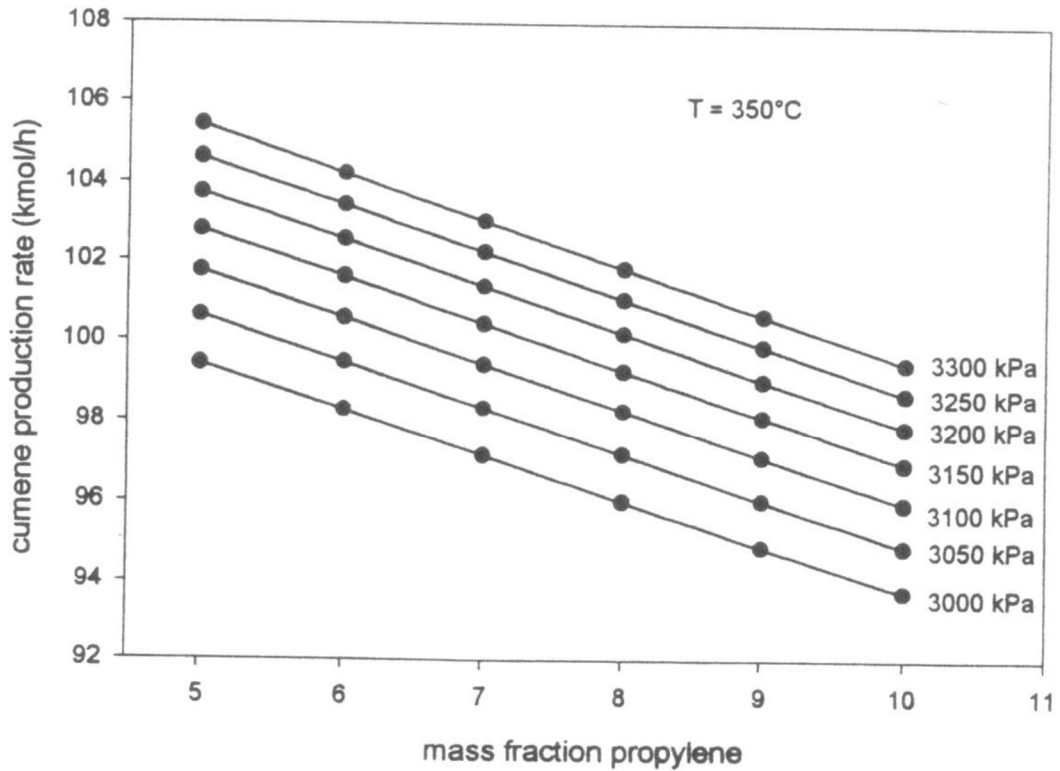
Cumene production rate kmol/h

5	99.42	100.62	101.74	102.79	103.75	104.63	105.44
6	98.28	99.47	100.58	101.61	102.56	103.44	104.24
7	97.15	98.33	99.42	100.44	101.38	102.25	103.04
8	96.02	97.18	98.27	99.27	100.21	101.06	101.84
9	94.90	96.04	97.11	98.11	99.03	99.88	100.65
10	93.77	94.91	95.97	96.95	97.86	98.70	99.47

3000 3050 3100 3150 3200 3250 3300

P in kPa

*propene
wt %*



22.5

This problem is solved using the Chemcad process Simulator. SRK thermodynamics is used. The column is assumed to operate at 2.5 bar.

Upon fixing the boil-up rate at 189.53 kmol/h with the feed tray and total number of trays fixed, a 4th specification is needed for the scaled-down column. There are several possibilities. The one that was used was $D = 17.16$ kmol/h, exactly 50% scale-down of the distillate.

Results: $D = 17.16$ kmol/h $F = 70.65$ kmol/h
 $B = 53.49$ kmol/h (exactly 50% of the original feed)

$L_0 = 168.63$ kmol/h $RR = 9.827$ (reflux ratio)

$V_{N+1} = 189.53$ kmol/h

$L_N = 242.99$ kmol/h

$x_{BD} = 0.999$ benzene mole fr. in top

$x_{BB} = 0.00676$ benzene mole fr. in bottom

Top $T = 112.6$ °C } not much change
 Bot $T = 145.4$ °C } from original