Process Systems Engineering A

Prof. Davide Manca
Dipartimento di Chimica, Materiali e Ingegneria Chimica "G. Natta"
Politecnico di Milano

LAB 4

Calculate the economic potential of the third level considering the following correlations for the installation and operation of the reactor and the compressor.
The costs are expressed in [€]. Consider that the Marshall & Swift cost index is worth 1110.
The F_c factor allows to consider the influence of pressure and material cost.
Consider a period of depreciation equal to 5 years for both the reactor and the compressor.
For the calculation of the investment costs of the reactor, the suggested ratio H/D is 6-10.

❖ Installation cost of pressure vessels

$$I.C._{\text{vessel}} = \frac{M\,\&\,S}{280} 101.9 \cdot D^{1.066} H^{0.802} \left(2.18 + F_c\right)$$

with D and H in [ft]. The factor F_c is calculated as: $F_c = F_p \cdot F_m$

P [psia]	≤ 50	100	200	300	400	500	600	700	800	900	1000
F_p	1.00	1.05	1.15	1.20	1.35	1.45	1.6	1.8	1.9	2.3	2.5

Material	Carbon Steel	Stainless Steel (316)	Monel	Titanium
F_m	1.00	3.67	6.34	7.89

The cost of the reactor should be increased by 15% due to the refractory metal externally added on the vessel for the purpose of thermal insulation.

❖ Installation cost of the centrifugal compressor

$$I.C._{\text{compressor}} = \frac{M\,\&\,S}{280} 517.5 \cdot bhp^{0.82} \left(2.11 + F_c\right)$$

with bhp (power of the motor shaft) in [hp] and $F_c = 1$.

The ideal work of compression for single stage units, whereas the isentropic adiabatic conditions, can be calculated as:

$$\tilde{\ell} = RT_1 \frac{\beta^{\gamma_{mix}} - 1}{\gamma_{mix}}$$

with $\beta = P_2 / P_1$ which considers an overall pressure drop of 6 atm equally distributed in sections downstream of the reactor and downstream of the compressor. The compressor sees the inlet gas at a temperature of 35 °C.

The γ_{mix} can be calculated as $\gamma_{mix} = \sum_{i=1}^{NC} x_i \gamma_i$, in which $\gamma_i = \left(c_{p,i} - c_{v,i}\right) \Big/ c_{p,i}$ (see the following table).

GAS	γ
Monoatomic	0.40
Biatomic	0.29
Complex (*e.g.*, CH_4, CO_2, ...)	0.23

Consider that both the efficiency of real transformation (transformation deviation from ideal isentropic adiabatic) than that of the electric motor shaft is equal to 0.9.

The cost of electricity is 0.061095 €/kWh.

Provide the following charts:

- Volume of the reactor vs. Split factor, as a function of temperature
- Diameter of the reactor vs. Split factor, as a function of temperature
- I.C. of the reactor vs. Split factor, as a function of temperature
- Recycle molar flow R vs. Split factor, as a function of temperature
- I.C. of the compressor vs. Split factor, as a function of temperature
- O.C. of the compressor vs. Split factor, as a function of temperature
- EP3 vs. Split factor, as a function of temperature

Compare the trends of the economic potential of the second and third level.