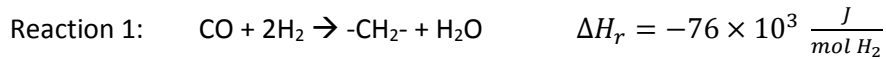


# Fischer-Tropsch

There are several Fischer-Tropsch reactors in operation: multi-tubular fixed bed (trickle flow), fluidized bed / risers and slurry columns. For this workshop we will consider the low temperature (< 260 °C) slurry reactor. We will approach the problem in the simplest way possible while still capturing the essentials.

For simplicity we will only consider the main reaction:

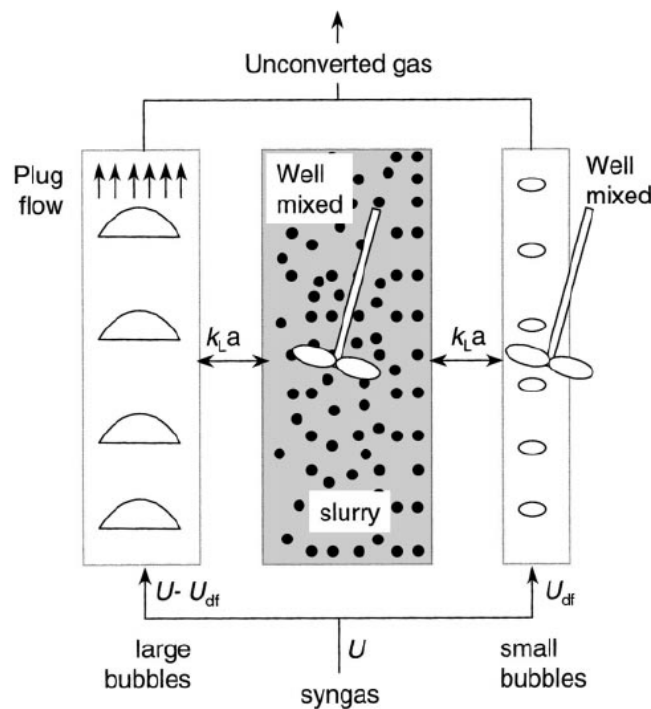


The reaction rate is given by:

$$-R_{\text{CO}} = K_r C_{\text{CO}}^l = 1.5 \times 10^{-4} C_{\text{CO}}^l \quad \frac{\text{mol CO}}{\text{kg}_{\text{cat}} \text{s}}$$

$C_{\text{CO}}^l$  is the CO concentration in the liquid phase.  $K_r$  is determined at 515 K.

For the modelling we use the model proposed by Krishna, which includes the liquid phase, small bubbles and large bubbles. The large bubbles move in plug flow, while the liquid and the small bubbles are close to a CSTR. The latter we will model using the axial dispersion model.



The following correlations can be used:

Rise (linear) velocity of the small bubbles:  $V_{SB} = 0.095 \times (1 + \frac{0.8\epsilon_p}{0.095})$

In which  $\epsilon_p$  is the hold-up of catalyst in the liquid phase in m<sup>3</sup> catalyst / m<sup>3</sup> dense phase. The dense phase is the liquid plus catalyst plus the small bubbles.

The hold-up of small bubbles is given by (m<sup>3</sup> small bubble / m<sup>3</sup> total volume (small bubbles + large bubble + liquid+catalyst):

$$\epsilon_{SB} = 0.6072 \times (1 - \frac{0.7\epsilon_p}{0.27})$$

The hold-up of large bubbles is given by (m<sup>3</sup> large bubble / m<sup>3</sup> total volume (small bubbles + large bubble + liquid+catalyst):

$$\epsilon_{LB} = 0.7 \times U_{LB}^{0.58}$$

In which  $U_{LB}$  is the superficial velocity of the large bubbles.

For  $k_a$  the following relations hold:  $kla_{LB} = 2.25\epsilon_{LB}$ ,  $kla_{SB} = 4.5\epsilon_{SB}$

#### Assignment:

- Design a slurry reactor system for the production of 6000 ton / day -CH<sub>2</sub>-. T = 515 K, P = 30 bar. You may use a constant gas velocity and work with an isothermal model.
- Calculate how many vertically placed cooling tubes of 2 inch are required (cooling medium = 500K).
- Investigate numerically the effects of mixing in the liquid phase.

#### Restrictions:

Maximal reactor diameter = 8 m  
Maximal reactor height = 30 m  
Maximal catalyst hold-up,  $\epsilon_p = 0.3$   
Maximal superficial gas velocity = 0.4 m/s

#### Other parameters:

You can use a superficial liquid velocity of 0.01 m/s  
Catalyst density = 2000 kg/m<sup>3</sup> catalyst  
No mass transfer limitation in the gas phase  
The equilibrium distribution for CO is 2.5 (C<sup>g</sup>/C<sup>l</sup>)

Information on dispersion coefficients and heat transfer: see slides on bubble columns & slurry reactors