Hydrodynamics of Trickle Bed Reactors
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Introduction – trickle flow

Focus of this work
- Experimental hydrodynamics investigation focused on the flow distribution
- Eulerian CFD modeling
- Development of validation methodology
- Extension of model – development of closures capable of capturing the effect of flow pattern

Experimental
High pressure trickle bed reactor

Characterization of the uniformity of liquid distribution

\[
M_i = \frac{1}{N(N-1)} \sum_{j \neq i} \frac{\text{FLUX}_{ij}}{\text{FLUX}_{ii}}
\]

- \( N \) - Number of compartments (15)
- \( \text{FLUX} \) - Average flux
- \( \text{FLUX}_{ij} \) - Flux in the compartment \( i \) to \( j \)

Maldistribution factor
- \( M_i = 0 \) - Uniform distribution
- \( M_i = 1 \) - Completely maldistributed

- Most pronounced effect – liquid velocity
- Increased operating pressure or gas velocity do not significantly increase uniformity of liquid phase distribution

Hysteresis in trickle flow

- Dependence of the extent of hysteresis on the operating pressure is a strong function of the operating flowrates
- At the lower flowrates, hysteresis persists regardless of pressure

Computational Fluid Dynamics Modeling

Computational fluid dynamics modeling

Equations solved on the computational domain:

- Conservation of mass
- Conservation of momentum

Need:
- Porosity distribution on the domain – Gaussian (Jiang et al., 2001)
- Phase interactions closures (Attou et al., 1999)
- Capillary closure (Grosser et al., 1998)
- Solution strategy, Boundary and Initial Conditions

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