Institute for Technical Chemistry (ITC)
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Bachelor/Master Thesis

„Numerical Simulation of Up-Scaled Fluidized Bed Reactor"
„Numerische Simulation eines hochskalierten Wirbelschichtreaktors"

Requirements

This thesis is intended for students of chemical engineering, process engineering, or a related discipline who are interested in numerical simulation and programming. Prior knowledge of computational fluid dynamics (CFD), multiphase-flow simulation, or fluidized-bed technology is beneficial but not required.

Motivation

Plastic pyrolysis is a promising technology for the sustainable management of plastic waste and the recovery of valuable resources. During pyrolysis, plastics are thermally decomposed in the absence of oxygen, producing liquid and gaseous products such as pyrolysis oil. These products can subsequently be used as feedstocks for the production of new plastics, chemicals, and other high-value products.

A key advantage of pyrolysis is its ability to process waste streams that are unsuitable for mechanical recycling because of their composition, contamination, or specific material properties. Examples include mixed or contaminated plastic waste and plastics that are otherwise difficult to recycle.

At the laboratory scale, fluidized-bed reactors (FBRs) have shown considerable potential for plastic pyrolysis because they provide rapid and homogeneous heating of the feedstock. However, the experimental development and scale-up of this technology to industrial dimensions are complex and costly. Numerical simulations can support this process by providing detailed insight into fluidized-bed hydrodynamics and by enabling a systematic investigation of scale-up effects.

Objective and Scope

The objective of this thesis is to investigate the effect of reactor scale-up on the hydrodynamic behavior of fluidized-bed reactors using an Euler–Lagrange simulation approach.

An existing solver implemented in the open-source CFD framework OpenFOAM will be used to simulate gas–solid flow in fluidized-bed reactors. The solver accounts for particle–particle collisions, heat transfer between particle classes, and plastic pyrolysis reactions.

The main tasks include:

- setting up fluidized-bed reactor simulations for reactor diameters of 5, 10, and 20 cm;

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- conducting transient Euler–Lagrange simulations of the gas–solid flow;
- validating the simulation results against transient pressure measurements;
- evaluating relevant hydrodynamic quantities, including:
  - bed pressure drops,
  - specific kinetic energy,
  - bubble surface area, and
  - bubble frequency;
- quantitatively determining the relationships between these hydrodynamic quantities and the reactor dimensions; and
- assessing the implications of reactor scale-up for fluidized-bed hydrodynamics.

The complete study, including the introduction, theoretical background, numerical methodology, results and discussion, and conclusions, will be documented in a written thesis. The findings will also be presented at the ITC seminar.

Date of start: Immediately

Advisors: Dr. Feichi Zhang, Dr. Salar Tavakkol

Supervisor Prof. Dr. Dieter Stapf