PhD proposal

Hydrodynamics of bubble columns in the heterogeneous regime: mechanisms, scale-up and modelling.

Duration: 3 years, starting 2017.

Location: LEGI (http://www.legi.grenoble-inp.fr/) & **LGP2** (http://pagora.grenoble-inp.fr/recherche/) laboratories at Grenoble, France. **IFPEN-Lyon** (http://www.ifpenergiesnouvelles.com) at Solaize, France.

Candidate profile: engineering or physics background with strong formation in fluid mechanics. Interest in experimentation measuring techniques and modelling. Experience using Matlab is recommended.

Topic: Bubble column reactors are widely used in the chemical and biological industry, as Fischer-Tropsch reactors, α-olefins oxidation reactors and as aerobic fermenters (see figure). They typically consist in a cylindrical vessel filled with liquid at the bottom of which gas is injected. Despite their widespread use in industry, the modelling of such devices remains unsatisfactory due to the lack of reliable physical model describing the interactions between phases. So far, the exploitation of these systems relies on semi-empirical approaches based on experiments at different scales to adjust parameters such as bubble size, turbulent viscosity, etc.

Figure 1: bubble column at LEGI (400mm diameter, left) and at IFPEN-Solaize (3000mm, right)

The goal is to improve our understanding of the hydrodynamics in such columns using combined measurements of various parameters such as void fraction, bubble sizes and velocities, carrier phase velocity... Experiments will be performed in columns of different sizes, typically from I.D. 400 mm (column available at LEGI) up to I.D. 3000 mm (column available at IFPEN-Solaize), using aqueous as well as organic liquids in order to vary the coalescence efficiency. Measuring techniques are available (such as optical probes, endoscopic camera, Pavlov tube, hot film probes...) but some developments may be required. Different advances are to be achieved:

- Improve measurement techniques (Pavlov tube) and deploy new ones (optical probes) to measure the velocities of both liquid and gas phases.
- Acquire and process long time series to better characterize clusters and voids, notably by Voronoï analysis, with the objective of quantifying concentration gradients, velocities and sizes of these

structures as a function of column size and gas flow rate injected. Conduct combined concentration-liquid velocity measurements to characterize cluster dynamics.

- Investigate the role of such meso-scale structures on turbulence generation and propose adapted closures.
- Analyse the competition between coalescence and clustering on the homogeneous-heterogeneous transition.
- Test and develop new models in agreement with the results obtained.

The resulting database will be used to derive physical models, with a special focus on momentum exchanges between phases, bubble size distributions, turbulence generation, with the objective to characterise the flow of the carrier phase (maximum velocity, turbulence intensity, etc.) in industrial columns. These data will be exploited to improve an existing 1D model and to test the predictive capabilities of 2D/3D numerical simulations currently under development at IFPEN.

Contacts:

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Applications received until 10/07/2017. For applying send an academic CV to M. Obligado and/or A. Cartellier.