Slurry Bubble Columns for Clean Fuels

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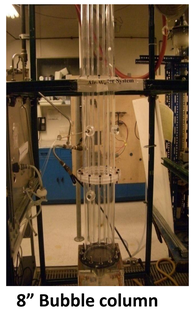
Problem definition

- Bubble column reactors are considered the reactor of choice for numerous applications including oxidation, hydrogenation, waste water treatment, and Fischer-Tropsch (FT) synthesis
- The Fisher-Tropsch process involves environmentally friendly Biomass/Coal/Gas-to-Liquid fuels production
- Many industrial applications for which bubble column reactors are preferred, require the use of heat exchanging internals in order to remove the heat generated by the chemical reaction
- Few studies in the open literature were conducted to examine the effect of internals on the performance and hydrodynamics of bubble columns, although they are essential in industrial setups

Experimental setups

A lab scale (8") and a pilot scale (18") bubble columns are used to study the effect of internals. This allows for the investigation of the effect of the scale in presence of internals

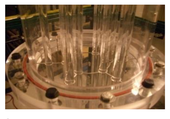
- System: Air-water
- Ambient temperature and pressure
- Dynamic height = 160 cm
- SGV:3-45 cm/s
- Distributor Free area:1.09%

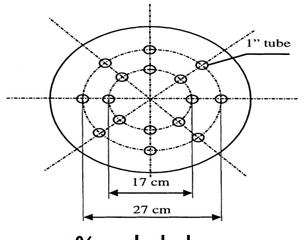


8" Bubble column

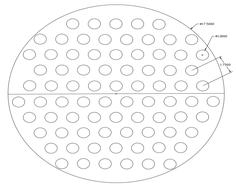
18" Bubble column

Internals design

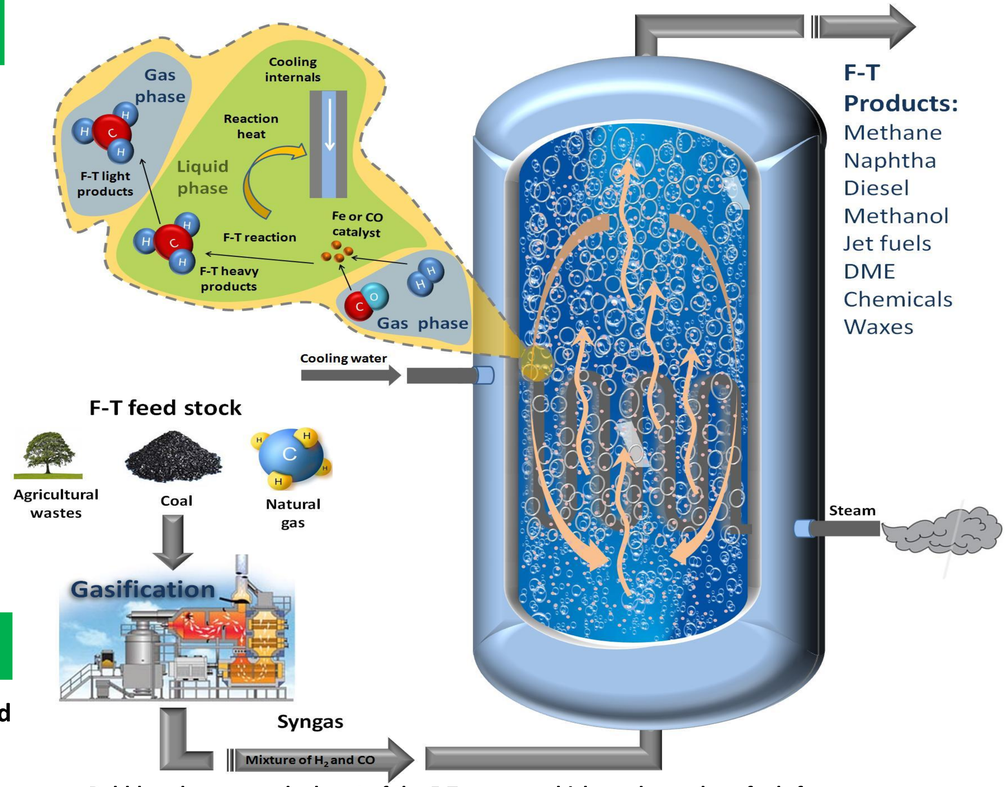




5% occluded area
(liquid phase MeOH synthesis)
Circular pitch: 2 concentric bundles of 17 and 27 cm diameter.
16 rods



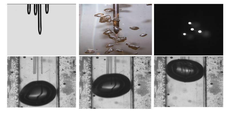
25% occluded area
(Fischer-Tropsch synthesis)
Triangular pitch = 1.75"
79 rods



Bubble columns are the heart of the F-T process which produces clean fuels from different types of abundant feed stock

Measuring techniques

- **Optical probes:** measures bubble dynamics (local holdup, bubble velocity, bubble chord length, interfacial area , bubble angle)



- **Gas analyzers:** used to study gas phase mixing by measuring the RTD of the gas phase. It can be used for different gases and can be combined with mass transfer probes to quantify the gas phase mixing and mass transfer coefficients of soluble gases

Thermal conductivity detector

Total Hydrocarbon analyzer

- **Heat transfer probes :** used to measure the heat transfer coefficients inside slurry bubble columns. They can be built inside internals to measure heat transfer coefficient at the wall of the internals. The Can be used at high pressure to mimic F-T real conditions

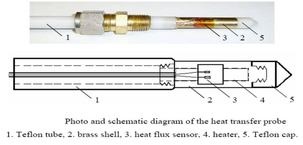
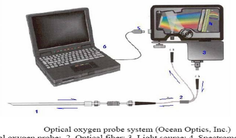


Photo and schematic diagram of the heat transfer probe
1. Teflon tube, 2. brass shell, 3. heat flux sensor, 4. heater, 5. Teflon cap.

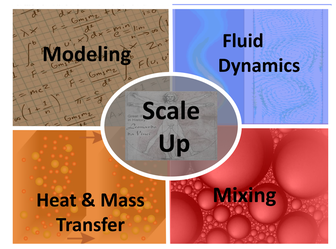
- **Mass transfer probes :** used to measure the mass transfer coefficient (local and overall) of different gases in different types of multiphase reactors



Optical oxygen probe system (Ocean Optics, Inc.)
1. Optical oxygen probe; 2. Optical fiber; 3. Light source; 4. Spectrometer; 5. Integrated A/D converter and USB interface; 6. PC and software

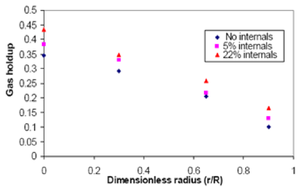
Objectives

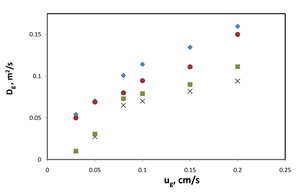
- Investigate the effect of vertical internals on hydrodynamics, mixing, and mass transfer in bubble column reactors



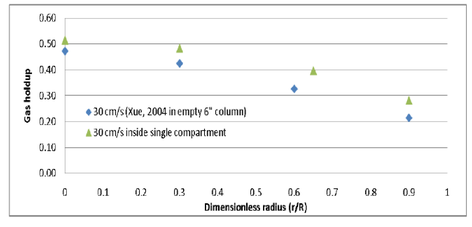
- Develop correlations and models that can describe the effect of internals on the flow behavior
- Combine the experimental data and the developed models to develop of a novel scale-up methodology for the scale-up of bubble columns with internals

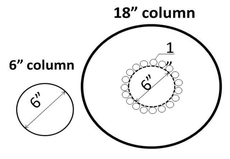
Sample results





Effect of internals on local gas holdup **Effect of internals on gas phase dispersion**





Proof of concept for the proposed scale-up methodology

Future work

- Extend the studied experimental conditions to cover mimicked F-T reaction conditions including high pressures and temperature
- CFD simulation of bubble columns with internals

Acknowledgement

sasol reaching new frontiers
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