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Experimental Investigation of Hydrodynamics and Heat Transfer in Vortex Reactors using PIV/IR/DIA Techniques

Aim

Understanding the hydrodynamics and heat transfer behaviour of gas, liquid and solid phases in vortex reactors by using PIV/IR/DIA measurement techniques.

Justification

Process intensification (PI), i.e. increasing the efficiency of a process and/or decreasing the volume of the equipment, plants, etc., has received a lot of attention in the past decades. A possible reactor technology for process intensification is the vortex reactor (VR) [1] (Figure 1), which has been studied at the Laboratory for Chemical Technology (LCT) in the last decade. In this type of fluidized bed reactor, a centrifugal force (instead of the gravity force) acts against the drag force. Therefore, higher gas velocities are possible compared to conventional gravitational fluidized bed operation. This results in higher slip velocity between the two phases and consequently, increased heat and mass transfer rate. Moreover, denser particle beds (in case of gas-solid systems), short and narrow residence time distributions and uniform bed temperatures could be achieved using this reactor.

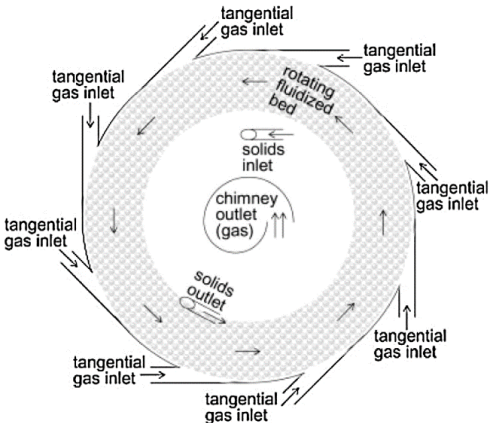

Figure 1 Schematic of a gas-solid vortex reactor [1]

To reach an optimized design and configuration for this type of reactor in different applications such as OCM (Oxidative Coupling of Methane), biomass fast pyrolysis, CO_2 absorption and plastic pyrolysis and gasification, it is essential to scrutinize all reactor characteristics and degrees of freedom.

Particle Image Velocimetry (PIV) and Infra-Red (IR) camera temperature recording are frequently used non-invasive techniques to investigate the hydrodynamics and heat transfer in a fluidized bed system. Besides, other post processing methods, such as Digital Image Analysis (DIA) could help in obtaining more practical and useful information out of the basic raw experimental data. Hence, in this project the PIV/IR/DIA techniques and their coupling are used to investigate the momentum and heat transfer in vortex reactors for different phase systems. While these analyses have been separately performed at the LCT in previous works, their combination poses some rearrangement of the current infrastructure. Also, the post-processing codes need to be developed accordingly.

Program

1. Literature study on transport phenomena in vortex reactors
2. Re-arrange the available infrastructure and develop the (post-)processing codes in both MATLAB and Python for the desired setup.
3. Experiments in the vortex reactor.
4. Processing and post-processing of the obtained data to obtain velocity fields, solid volume fractions, solid flux, thermal maps, heat flux, bubble size distribution, etc.

[1] J. De Wilde, Gas-solid fluidized beds in vortex chambers, Chem. Eng. Process., 85 (**2014**) 256-290.