MEASUREMENT OF SOLIDS CIRCULATION RATES WITH OPTICAL TECHNIQUES IN CIRCULATING BEDS AND COMPARISON TO PRESSURE DROP METHODS

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The number of applications employing circulating fluidized beds has increased considerably over the last years following the important development of chemical looping technologies for power generation (combustion) or fuel conversion (reforming) with inherent CO2 capture. The performance of these reactors is strongly determined by the amount of solids transferred from one reactor to the other, commonly referred to as the Solids Circulation Rate (SCR). The solids inventory, particle characteristics and gas velocities strongly influence the SCR. The determination of the SCR has been carried out using invasive and non-invasive measurement techniques. The direct measurement through solids collection in the loop seal is the most applied technique, but this technique requires opening of the loop seals and thus may be expensive, whereas other methods suffer from large inaccuracies. There is yet no optimal technique available that combines good accuracy with reasonable costs, as recently also discussed by Alghamdi et al. (1).

In this work, a pseudo 2D internally circulating fluidized bed (Figure 1) has been built to explore the potential of optical techniques like Particle Image Velocimetry (PIV) combined with Digital Image Analysis (DIA) for non-invasive, whole-field measurements. Moreover, the setup allows for the measurement of the pressure drop (fluctuations) along the riser and the collection of particles circulating from one reactor to the other, so that the three different measurement techniques can be compared.

The solids velocities can be well determined with PIV and, combined with the solids hold-up profiles obtained with DIA, the solids fluxes can be determined. These solids fluxes are directly related to the SCR and a good agreement with the measurements of the external solids circulation rates by collecting the particles has been found, also for different experimental conditions (deviation within 20% as indicated in Figure 2). All variables influencing the SCR have been thoroughly investigated in order to quantitatively assess the performance of the optical technique used in this work. In addition, these results have been compared with pressure fluctuation data to help interpreting these data and improving the accuracy of the pressure fluctuation method, which is often used in reactors and at elevated temperatures, making using the more extensive information on the reactor dynamics obtained with PIV/DIA under identical conditions. Therefore, the main outcome of this study is a better understanding on the SCR through optical techniques, which can subsequently be directly correlated to other methods, and in particular the pressure fluctuation method.

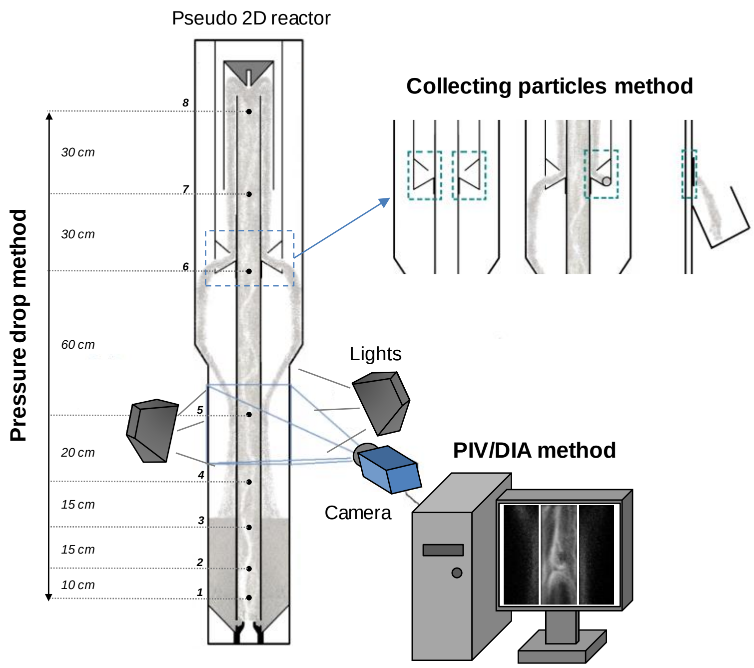

Figure 1. Scheme of the experimental facility used in this work

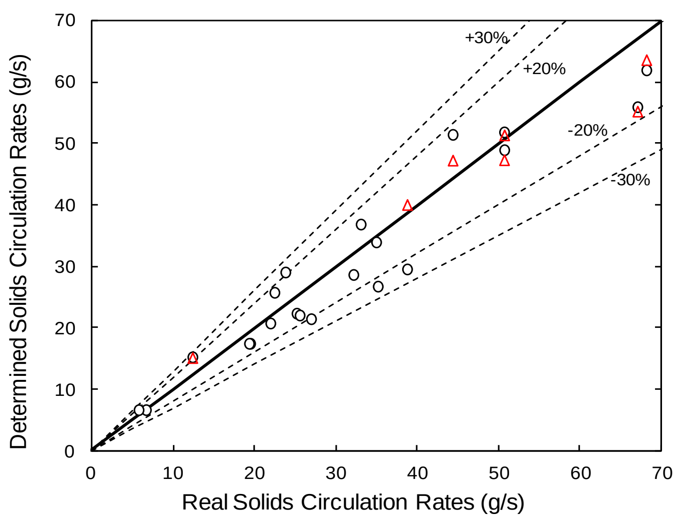

Figure 2. SCR measured with the PIV/DIA technique (open points) and pressure fluctuations (red triangles) in comparison to the SCR measured by collecting particles under different experimental conditions. Dashed lines indicate deviation.

REFERENCES

Y. Alghamdi, Z. Peng, K. Shah, B. Moghtaderi and E. Doroodchi. Predicting the solid circulation rate in chemical looping combustion systems using pressure drop measurements. Powder Technol., 286:572-581, 2015.