MASS TRANSFER IN FLUIDIZED BED REACTORS USING A NOVEL NON-INVASIVE, WHOLE FIELD AND HIGH TEMPORAL RESOLUTION INFRA-RED TECHNIQUE

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Mass transfer rates between bubble and emulsion phases in fluidized beds, together with solids motion, determine the performance of fluidized bed reactors. Mass transfer has widely been studied in the literature using many different experimental techniques, such as colored gases, X-Ray or MRI. They show, however, important disadvantages like high costs or the use of unsafe gases. Moreover, they often lack the required spatial and temporal resolution and many assumptions have to be taken in order to determine mass transfer coefficients, e.g. the concentration is measured in a single point and this concentration is subsequently assumed to be representative for the entire bubble.

In a recent work by Dang et al. (1) a novel technique has been developed for non-invasive, whole-field concentration measurements in the dilute regions of a fluidized bed with a high temporal resolution. The technique is based on the measurement of the decrease in the IR intensity at a specific wavelength inside the bubbles due to the absorption by a tracer gas using a high-speed IR camera. Because of the required IR accessibility, the application is limited to pseudo 2D columns and the walls of the column should be made of a material with a high transmittance for IR radiation. This novel technique has shown very promising results, but it is limited to small reactors due to the use of expensive materials (viz. sapphire) causing the results to be influenced by wall effects. In this work, this technique has been further developed in order to allow scaling-up of the system through the use of less expensive materials. The developed system is based on selective IR absorption by propane as tracer gas in a mixture with N_2 in a pseudo-2D quartz column (see Figure 1). The decrease in the IR intensity is measured and calibrated, so that the instantaneous propane concentration profiles inside the bubbles are determined. By solving the component mass balances for the bubble phase, the mass transfer coefficients are calculated.

Mass transfer measurements have been conducted by injecting a single bubble into a bed at incipient fluidization conditions with different gas velocities and particle properties (see Figure 2, where convective through flow dominates over diffusion). Furthermore, mass transfer measurements have been extended to freely bubbling beds with selective feeding of propane. In a next step of the development of the technique the IR technique is coupled with PIV/DIA (Particle Image Velocimetry/Digital Image Analysis) in the visual wavelength to combine for the first time the hydrodynamics with mass transfer rates inside the bubbles in a fluidized bed reactor.

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Figure 1. Picture of the experimental setup used in this work.

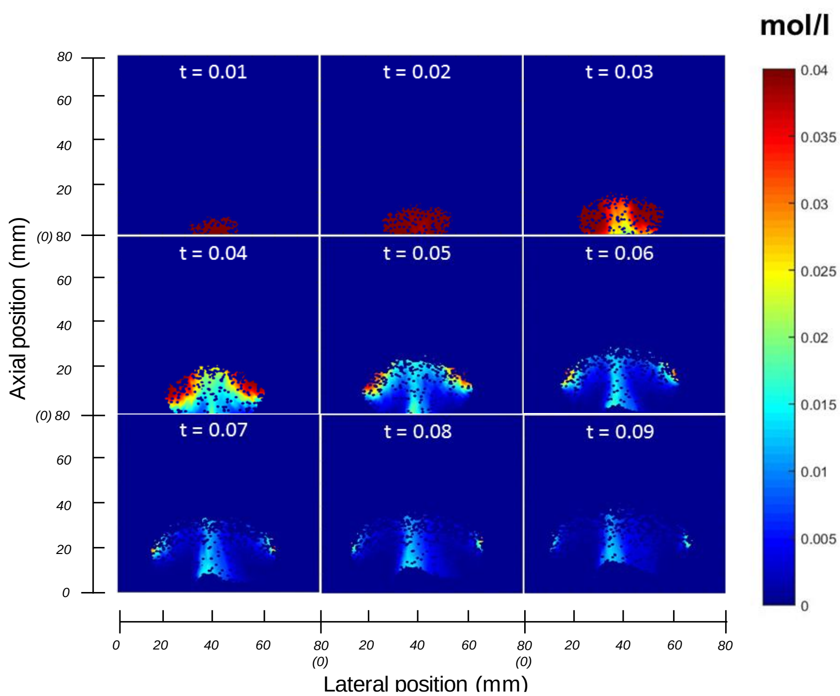

Figure 2. Tracer concentration inside a bubble injected into a pseudo 2D reactor using the IR technique.

REFERENCES

1. T.Y.N. Dang, T. Kolkman, F. Gallucci and M. van Sint Annaland. Development of a novel infrared technique for instantaneous, whole-field, non invasive gas concentration measurements in gas-solid fluidized beds. Chem. Eng. J., 219:545-557,2013