INVESTIGATING THE PERFORMANCE OF DIFFERENT FLUIDIZED BED MEMBRANE REACTOR GEOMETRIES

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The hydrodynamics and mass transfer phenomena occurring in different fluidized bed membrane reactors have been studied with a Two Fluid Model (TFM). The present work focuses on the in-situ selective extraction of hydrogen from a fluidized bed membrane reactor, aiming to study and quantify the membrane performance, including possible concentration polarization. Using a hydrogen-nitrogen gas mixture as fluidizing gas, various fluidized bed geometries containing vertically or horizontally immersed membranes were simulated.
The hydrodynamics and mass transfer phenomena of a fluidized bed can be strongly affected by the membrane configuration. Previous work by the group of Van Sint Annaland (1) showed the appearance of densified particle zones near the membranes, which could affect their performance. Furthermore, so called gas pockets (solids free non-rising bubbles, attached to the membrane) are formed underneath horizontal membrane tubes, see Medrano *et al.* (2). These phenomena are identified, their adverse effect on the membrane flux is quantified and possible remedies are discussed.

Hydrogen fluxes of a membrane placed vertically in a fluidized bed were obtained from the TFM, experiments and a 1D model that does not take concentration polarization into account. These fluxes are compared in Figure 1. Concentration polarization is clearly very important in fluidized bed reactors with state-of-the-art high-flux membranes. The TFM predicts the fluxes quite accurately, whereas the model that does not account for concentration polarization severely overpredicts them.

Figure 2 shows volumetric hydrogen fluxes obtained from a TFM simulation of a fluidized bed with 22 membranes placed in a horizontal staggered configuration. The membranes near the walls have a significantly lower flux than those in the middle of the bed. The polar plot inset shows the fluxes at various angles around the membranes, indicating that the lower fluxes can be attributed to the occurrence of densified zones on top of the membranes near the walls.

It has been demonstrated that both fluidized beds with vertically and horizontally immersed membranes suffer from reduced fluxes due to reduced hydrogen concentrations near the membranes. Further analysis of TFM data will reveal which membrane configuration has the highest efficiency and could be most suitable for industrial applications.

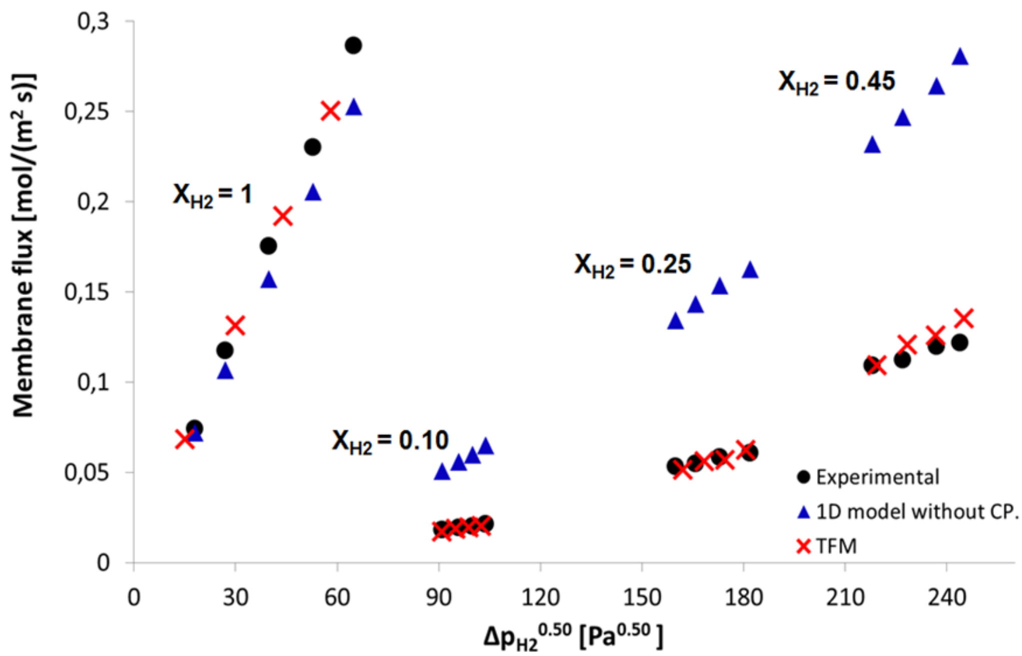

Figure 1: Hydrogen membrane fluxes at various hydrogen inlet fractions for the vertical membrane set-up.

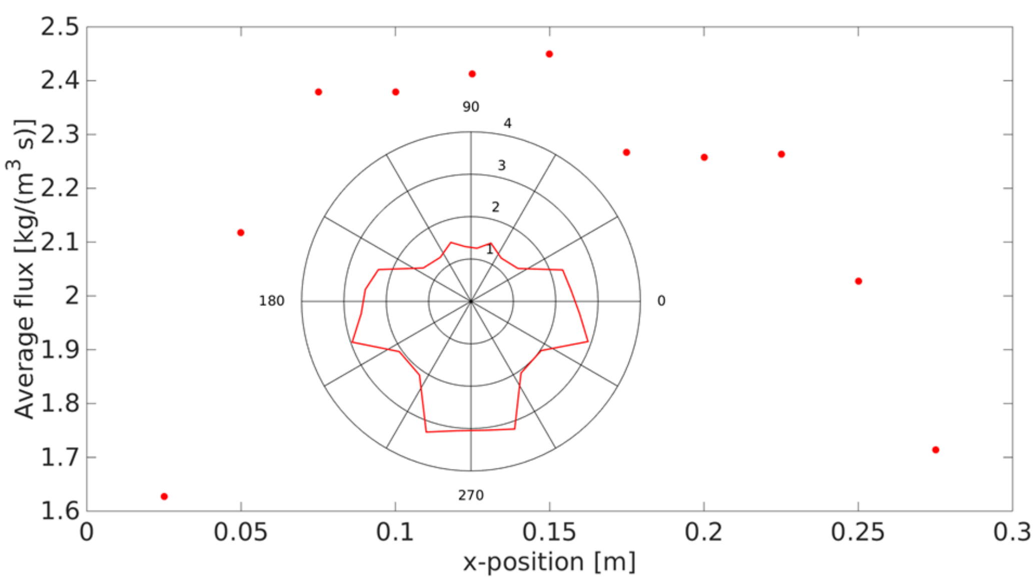

Figure 2: Volumetric hydrogen fluxes in kg/(m^3·s) at various x-positions and angles in a fluidized bed with a horizontal staggered membrane set-up.

REFERENCES

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