New Scale-Up Technologies for Hydrogenation Reactions in Multipurpose Pharmaceutical Production Plants

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Within this project, a strategy (including technologies as part of this strategy) to increase the scale-up efficiency of chemical reaction processes from laboratory-scale results to production-scale was developed. The focus was set on hydrogenation reactions and one specific production-scale plant (4000L agitated autoclave) located at the Siegfried AG site in Zofingen. A laboratory-scale prototype reactor (Scale-Down-Reactor, Figure 1) that is able to mimic the production plant's heat and mass transport behavior was designed and installed at the Process Technology Center (PTC) of the FHNW. Furthermore, a dynamic process model of the production plant was developed. This model can simulate any hydrogenation processes in this specific reactor. A more detailed introduction and summary of the first part of the project can be found in the corresponding publications[a,b] and presentation[c].

Heat transport: The centerpiece of the novel scale-down-reactor is a heat exchanger, the heating / cooling – finger (H/C-Finger), used to imitate the heat transport behavior of the production-scale plant. To achieve a design of the H/C-Finger that results in the same heat transport behavior and surface to volume ratio as the production plant, the oil running through the H/C-Finger and the heat transport was simulated with Computational Fluid Dynamics (CFD). For those calculations, the Institute of Thermal and Fluid Engineering of the FHNW in Windisch provided support. The final design of the H/C-Finger was then 3D printed in stainless steel and installed within the Scale-Down-Reactor. The heat transport behavior of the printed H/C-Finger was determined experimentally and compared to the CFD model and the equivalent of the production plant (Figure 2, left). The design based on the CFD computation was a success and this concept can now be applied to further production-scale vessels.

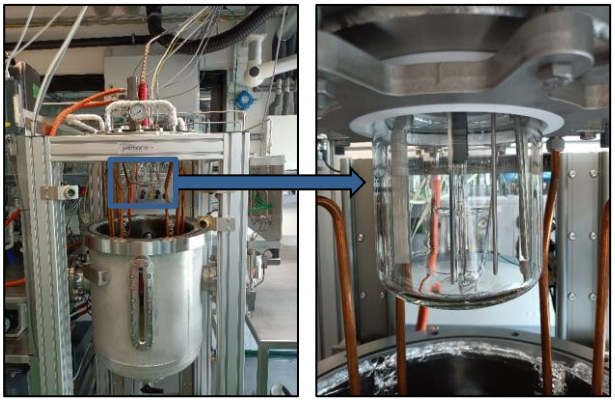

Figure 1: Picture of the finalized Scale-Down-Reactor (SDR) installation at the FHNW/PTC. Link to video: Testing of the safety concept.

Mass transport: To keep a similar mixing profile and mass transfer compared to the production-scale plant, the geometry of the SDR (agitator, bottom shape, baffles) was designed to be as similar as possible to production-scale. The mass transport coefficient for the solvation of H_2-Gas in Methanol was experimentally determined for both, the production plant and the SDR. Figure 2 (right) shows the resulting k_{La}-values (mass transport coefficients) plotted against the volume specific mechanical power dissipation due to agitation. It can clearly be seen that the mass transport of the SDR is similar to the production-scale plant.

As a next step, a reaction that was carried out in the production-scale vessel will be conducted in the novel Scale-Down-Reactor to further prove the scale-down concept developed within this project.

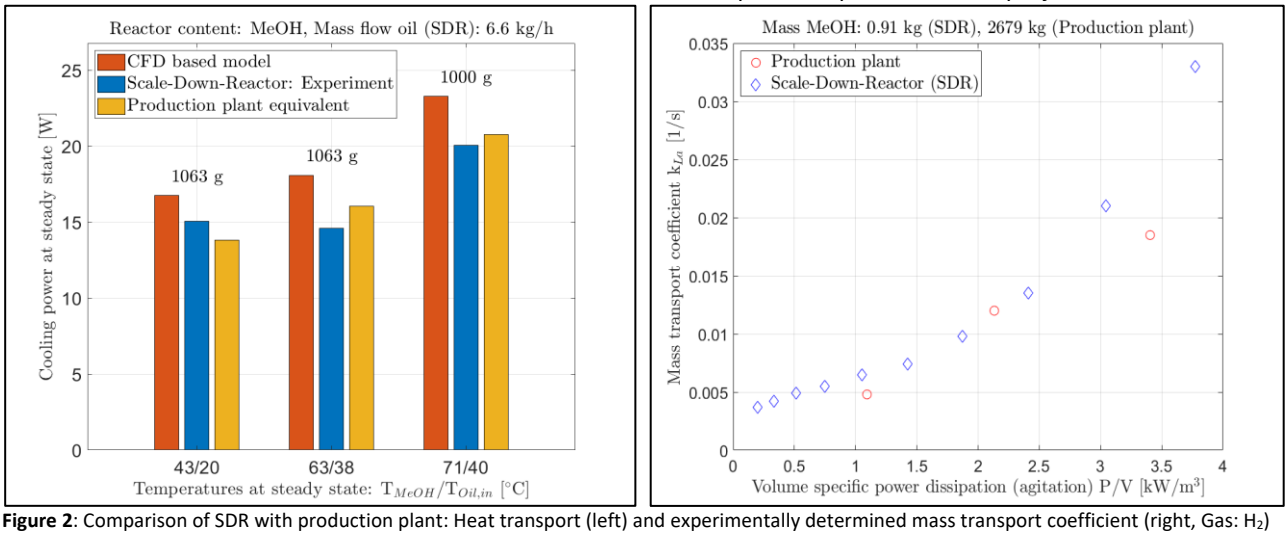

Figure 2: Comparison of SDR with production plant: Heat transport (left) and experimentally determined mass transport coefficient (right, Gas: H_2)

[1] FHNW-HLS, Muttenz. [2] Siegfried AG, Zofingen.

[a] T. Furrer, B. Müller, C. Hasler, B. Berger, M. K. Levis, A. Zogg, «New Scale-up Technologies for Hydrogenation Reactions in Multipurpose Pharmaceutical Production Plants», Chimia 75 (2021) 948–956. https://doi.org/10.2533/chimia.2021.948.

[b] M. K. Levis, B. Berger, "Toolboxes for Process Development", Specialty Chemical Magazine, Accepted for Publication, Link to SCM

[c] A. Zogg, T. Furrer, "New Scale-Up Technologies; For Hydrogenation Reactions in Multipurpose Plants", presentation held December 7, 2021 at the Praxiszirkel Life Sciences in Muttenz. Link to IRF of the FHNW.