MULTIPHASE FLOWS IN CHEM. ENGINEERING DECIPHERING HYDRODYNAMICS OF PACKED COLUMNS

MARTIN ISOZ[1]

[1]*University of Chemistry and Technology in Prague, Martin.Isoz@vscht.cz*

Keywords: *Free surface flow, finite volume method, liquid spreading*

Multiphase flow of thin films, rivulets and drops is of key importance throughout many areas of chemical engineering, including the mass transfer, trickle bed reactors, heat exchangers and various coating processes. However, on an industrial scale most of those processes are performed in complex apparatuses, the hydrodynamics of which remains still rather mysterious.

Examples of such apparatuses are the separation columns that are used in chemical engineering to perform the mass transfer operations in large scales. The fluid flow in these columns is multiphase and it occurs in a geometrically complex domain, see Figure 1.

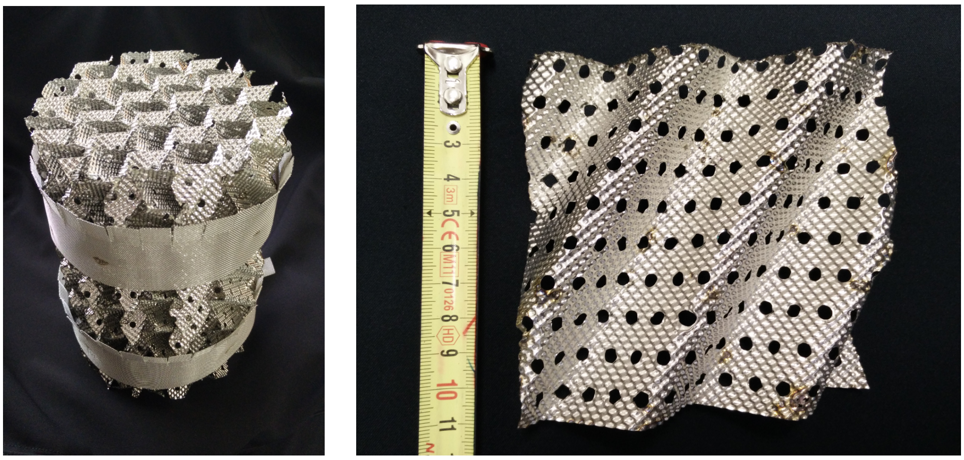

Figure 1: Example of a separation column packing – Mellapak 250Y. An overall view of the packing is depicted on the left. On the right, there is shown a detail of one element of a dismantled packing. Structured packing usually consists of curled, perforated and textured steel plates. Standard mode of operation is typically counter-current: liquid phase flows down and gas phase up.

Due to the geometrical complexity of the column packing, a direct simulation of its hydrodynamics is yet to be developed. However, even models of the liquid flow on simplified geometries may shed some light on the behavior of the original system. Currently, the most common geometry simplification is an approximation of a small part of one element of the packing by an inclined plate.

In the present study, we aim to provide characteristics for a gravity driven free surface flow of a liquid on an inclined plate. We are considering four different surface treatments of the investigated plate. The studied flow parameter is the ratio of the wetted area to the total surface area of the plate.

At first, we validate our simulations for the case of a smooth plate against the existing experimental data published by Hoffman et al.[1, 2] and against the published CFD results[3, 4, 5, 6]. Then, we proceed to the simulations of a liquid flow on the plate equipped with either longitudinal, transversal or pyramidal texture, see Figure 2.

This study is intended as a stepping stone for the work on optimization of surface texture parameters.

Acknowledgments

The author thankfully acknowledges financial support from IGA of UCT Prague, grant numbers A2_FTOP_2016_024 and A1_FCHI_2016_004.

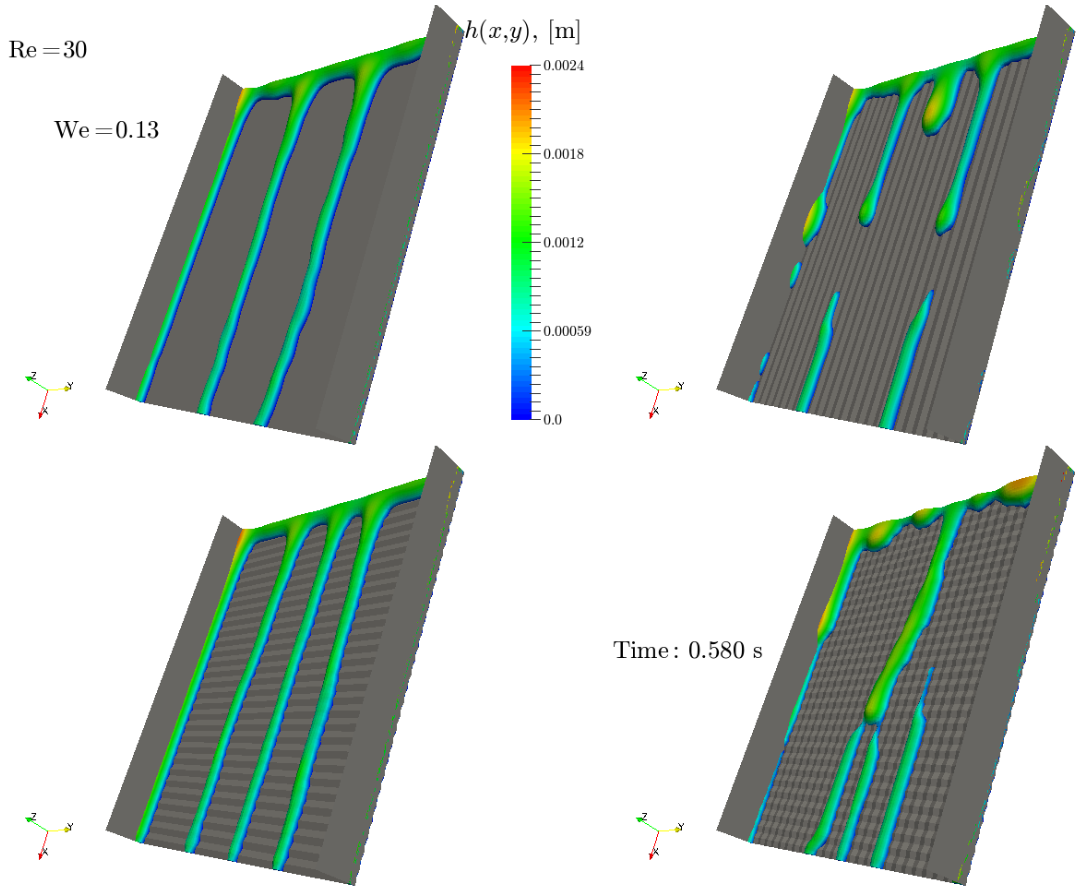

Figure 2: Qualitative comparison of flow behavior for the cases of a smooth plate and plates equipped with longitudinal, transversal and pyramidal textures. Texture roughness is 0.2 mm and the width of one texture fold is 2 mm.

References

[1] A. Hoffmann, I. Ausner, J.-U. Repke, and G. Wozny, “Fluid dynamics in multiphase distillation processes in packed towers.” *Computers & hemical Engineering*, vol. 29, no. 6, pp. 1433–1437, 2005.

[2] ——, “Detailed investigation of multiphase (gas-liquid and gas-liquid-liquid) flow behaviour on inclined plates.” *Chemical Engineering Research and Design*, vol. 84, no. A2, pp. 147–154, 2006.

[3] J. J. Cooke, S. Gu, L. M. Armstrong, and K. H. Luo, “Gas-liquid flow on smooth and textured inclined planes.” *World Academy of Science, Engineering and Technology*, vol. 68, pp. 1712–1719, 2012.

[4] Y. Xu, J. Yuan, J.-U. Repke, and G. Wozny, “CFD study on liquid flow behavior on flat plate focusing on effect of flow rate.” *Engineering Applications of Computational FLuid Mechanics*, vol. 6, no. 2, pp. 186–194, 2012.

[5] D. Sebastia-Saez, S. Gu, and P. Ranganathan, “3D modeling of hydrodynamics and physical mass transfer characteristics of liquid flom flows in structured packing elements.” *International Journal of Greenhouse Gas Control*, vol. 19, pp. 492–502, 2013.

[6] Y. Haroun, L. Raynal, and P. Alix, “Prediction of effective area and liquid hold-up in structured packings by CFD.” *Chemical Engineering Research and Design*, vol. 92, pp. 2247–2254, 2014.