Preface

The first German edition of the book “Fluid dynamics of packed columns with modern random and structured packings for gas/liquid systems” was published in 1991. It sold out within a few years. Added to this were numerous enquiries, in particular within the industry, prompting me to publish a second, extended edition.

A packed column remains the core element of any diffusional separation process. This underlines the need for basic design principles for packed columns, which enhance the design process by making it more accurate and reliable.

The SBD (suspended bed of droplets) model introduced in the first German edition of the book was well received by the experts and is now used by a large number of companies in the industry, as it offers improved reliability in the fluid dynamic design of packed columns. For the purpose of facilitating the design process, the SBD model was integrated into the simulation programme ChemCAD. The software programme FDPAK, which is available for Windows, has certainly contributed to the widespread use of the SBD model. The programme is very user-friendly and the calculation results are presented in tabular as well as graphic form, showing flood load, pressure drop and hold-up diagrams in the entire operating range.

The first German edition concentrates on the description of the fluid dynamics of columns with random and structured packings in the vacuum and normal pressure range of up to approx. 2 bar and for specific liquid loads of up to 100 $m^3m^{-2}h^{-1}$ for gas-liquid systems. This range covers a majority of the applications and tasks relevant in the absorption and desorption of highly and/or moderately soluble gases as well as in rectification under vacuum and normal pressure.

The importance of absorption and rectification under high pressure has steadily increased in the past 10 years, calling for an upgrading of the existing model. Fortunately, new publications emerged during the last 15 years, presenting experimental data on pressure drop, flooding point and hold-up parameters for high-pressure systems. Based on this, it was possible to and expand the validity of the correlation derived in the first German edition for determining the hold-up at flooding point to include the range of high liquid loads and therefore higher hold-up parameters (Chap. 2).

Using the SBD model, it is now possible to describe operations under higher pressure, which is very significant in practice, as it is linked to high liquid loads and low gas velocities. The SBD model has been verified using experimental data taken at high pressure of up to 100 bar. There are some practical numerical examples at the end of each chapter, which provide an insight into the application of the model.

The current edition will introduce a generally valid procedure of the single pressure drop calculating based on the knowledge of the form factor (P and an additional model for calculating the pressure drop of irrigated structured and random packings, based on the knowledge of the law of resistance $\psi_{LV} = f(Re_L)$ for two-phase counter-current flows and of the liquid hold-up $h_L{}^0$ in the entire operating range up to flooding point. This model is suitable for applications, in which the only available data for determining the law of resistance is experimental pressure drop data for a two-phase system (no given pressure drop data for dry random packings), or in which the pressure drop above the loading line for low viscous mixtures needs to be determined more accurately.

A large amount of experimental data has shown that this model generates satisfactory results up to flooding point for laminar $Re_L < 2$ as well as for turbulent liquid flow $Re_L > 2$.

The correlation for determining the gas velocity at flooding point introduced in the first edition has been modified further and can now also be applied to any type of structured packing, tube columns with regularly stacked Pall rings, Hiflow rings and Białecki rings and regularly stacked layers of Pall rings, Raschig rings, Hiflow rings and Białecki rings. Following the latest findings, it has been possible to mathematically compute various loading capacities of structured column internals of types X and Y with flow channels at different gradients. This has also been taken into account in the expanded general correlation for calculating the gas velocity at flooding point, which makes this correlation applicable to any type of column internal.

Chapter 7 introduces for the first time the basic fluid dynamics principles of packed columns for liquid/liquid extraction. The previously mentioned SBD model for gas/liquid systems is transferable to liquid/liquid systems. The method used to calculate the gas velocity at flooding point of the disperse and continuous phases will be explained by means of some numerical examples.

The guiding idea behind this book was to develop a closed, consistent concept for designing packed columns for gas/liquid and liquid/liquid systems, in order to make the calculation of individual parameters more transparent and create a basis for objective comparisons between different column internals.

In contrast to other studies, this book uses a different approach for logging processes within packed columns, which is based on the specific flow behaviour of droplet systems.

The occurrence of droplet systems in packed columns was confirmed by Bornhütter and Mersmann in 1991. Hence, despite the highly complicated processes of two-phase flows in packed columns, it was possible to form straight-forward, user-friendly correlations, which are ideal for practical applications when it comes to developing solutions for a wide range of tasks. The simple correlations are particularly advantageous when comparing a large number of different columns internals. In addition, this book should help scientists as well as students to gain a better understanding of flow processes in gas/liquid and liquid/liquid systems.

As opposed to other studies, this book draws on the publications of other authors to support and expand the application ranges of the SBD model. However, it does not use them for the illustration and comparison of different calculation models. This work is based on more than 10,000 experimental pressure drop data, in excess of 1,200 flooding point data and approx. 1,100 liquid hold-up data for nearly 200 different types of packings. Compared to the 1st edition, the figures have more or less doubled.

What is particularly significant from a scientific point of view, is the knowledge that the experimental work and test systems under vacuum and high pressure previously required for the research and development of new types of column design can be reduced to just a few steps, thus allowing the user to determine the model parameters of the SBD model fast and with minimal experimental effort using the air/water test system. It is worth noting that tests using single-phase air flows under ambient conditions are sufficient to determine the system-independent law of resistance $\psi = f(Re_V)$. In the case of simple types of packing, it is possible to determine the resistance factor of single-phase flow simply based on the geometric configuration without requiring experimental evidence, as described in Chap. 3. It is therefore possible to transfer the entire fluid dynamics of one type of column internal to any application in diffusional separation technology.

J. Maćkowiak

Springer
http://www.springer.com/978-3-540-88780-5

Fluid Dynamics of Packed Columns
Principles of the Fluid Dynamic Design of Columns for Gas/Liquid and Liquid/Liquid Systems
Mackowiak, J.
2010, XXI, 355 p., Hardcover
ISBN: 978-3-540-88780-5