Book Review

Chr. Boyadjiev, M. Doichinova, B. Boyadjiev, P. Popova-Krumova,
"Modeling of Column Apparatus Processes",
Springer-Verlag, Berlin Heidelberg, 2016.

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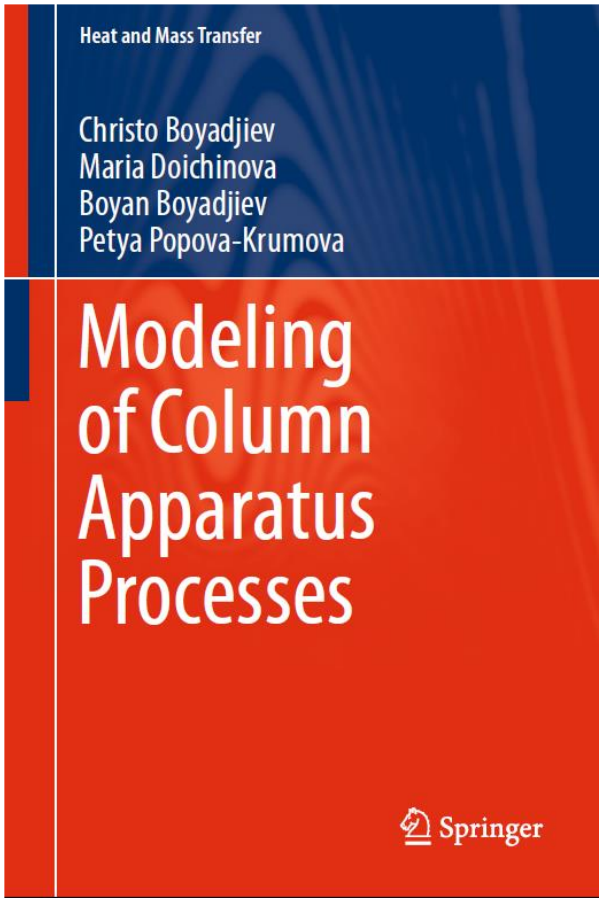

In the book is presented a new physically motivated approach for the modeling of column apparatus processes in industrial conditions, using the mechanics of continua. In the Introduction is presented the contemporary, physically motivated, mass transfer theory.The proposed analysis shows that the presented mass transfer theory is not applicable for the modeling of column apparatus processes in industrial conditions, because the velocities in each phase and the phase surfaces in columns are unknown and practically cannot be determined.

The modeling of column apparatus processes in industrial conditions is made, using new type models as convection-diffusion models (for qualitative analysis) and average concentration models (for quantitative analysis), where as an innovation is the process mechanism identification on the base of the Guhman's generalized model analysis (model analysis in generalized variables).In the book are presented convection-diffusion and average concentration models of one, two and three phase processes.

In the first part of the book are presented the convection-diffusion models and qualitative analysis of the chemical, absorption, adsorption and catalytic processes.

The one-phase processes in column chemical reactors are analized in the cases of complex chemical reaction kinetics, two components chemical reactions and pseudo-first-order reactions. It is shown the influence of the velocity radial non-uniformity on the conversion degree. As an innovation is a new explanation of the "back mixing" effect as a reducing of the average residence time of the flow in the column.

The two-phase processes in column apparatuses are analized in the cases of absorption processes (physical and chemical absorption), adsorption processes (physical and chemical adsorption), catalytic processes (physical and chemical adsorption mechanism).

The absorption processes are presented in co-current and counter-current gas-liquid flows. As innovations are the presentation of the interphase mass transfer as a volume reaction and the distribution of the interphase mass resistances between the gas and liquid phases.

The adsorption processes are presented in the cases of nonstationary process in the solid phase and quasi stationary process in the gas (liquid) phase. As innovation is the presentation of the adsorption process as a volume reaction.

The catalytic processes are presented as stationary processes in gas-solid systems, where the adsorption of the first reagent is physically or chemically. As innovation is the presentation of the catalytic reaction as a volume reaction.

In the srcond part of the book are presented the average concentration models and quantitative analysis of the chemical, absorption, adsorption and catalytic processes. The innovations in this part are:

1. The presented theoretical (averaging) procedure.
2. The ability to be used the average concentration models for modeling of the processes at an unknown velocity distribution in the column, which is introduced in the model by two parameters, which can be determined from experimental data.

3. The explanation of the conversion degree decrease as a result of the radial non-uniformity of the velocity distribution.
4. The experimental data, obtained in a short column with real diameter, are useful for the model parameters identification.

In the third part of the book are presented calculation algorithms as innovations.

In many cases the computer modeling of the processes in column apparatuses, made on the base the convection–diffusion and average concentration models, does not allow a direct use of the MATLAB program. In these cases it is necessary to create combinations of appropriate algorithms.

Practically, the new type models are characterized by the presence of small parameters at the highest derivates. As a result, the use of the conventional software for solving the model differential equations is difficult. This difficulty may be eliminated by an appropriate combination of MATLAB and perturbations method.

In the cases of counter-current gas-liquid or liquid-liquid processes the mass transfer process models are presented in two-coordinate systems, because in a one-coordinate system one of the equations has no solution by reason of the negative value in the equation Laplacian. Thus, a combination of an iterative algorithm and MATLAB has to be used for solving the equations set in different coordinate systems.

In the practical cases of non-stationary adsorption in gas-solid systems, the presence of mobile (gas) and immobile (solid) phases in the conditions of lengthy (long-term) processes leads to a non-stationary process in the immobile phase and a stationary process in the mobile phase. As a result different coordinate systems must be used for the gas and solid phase models. A combination of a multi-step algorithm and MATLAB has to be used for the solutions of the equations set in different coordinate systems.

Practically, the waste gases purification in the thermal power plants uses absorption methods. The SO_2 absorption intensification needs a quantitative description of the process using a suitable mathematical model, which has to be created on the basis of a qualitative analysis of the process mechanism. The new convection-diffusion and average concentration models lead to the creation of three patents as innovations.

In the cases of comparable interphase mass transfer resistances in the gas and liquid phases, an intensification of the mass transfer should be realized in two phases. In these conditions a new patent is proposed, where the process optimization is realized in a two-zone column, where the upper zone the process is physical absorption in a gas-liquid drops system (intensification of the gas phase mass transfer), while in the lower zone it is a physical absorption in liquid-gas bubbles system (intensification of the liquid phase mass transfer) and the chemical reaction takes place in the column tank.

The waste gases purification from SO_2 is solved in a new patent, using a two-step process – physical absorption of SO_2 by water and adsorption of SO_2 from the water solution by synthetic anionite particles. The adsorbent regeneration is made by NH_4OH solution. The obtained $(NH_4)_2SO_3$ (NH_4HSO_3) is used (after reaction with HNO_3) for production of concentrated solutions of SO_2 and NH_4NO_3.

The decrease of the column diameter is realized in a new patent, where a co-current SO_2 absorption is used.

The created methods for modeling of column apparatus processes are a base for solution of many industrial problems.