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Book review

Model-Based Control of Particulate Processes, P.D. Christofides, Kluwer Academic Publishers (2002)

Prior to the appearance of this monograph, all available modern treatments of ChE process control emphasized single-phase- or pseudo-homogeneous-chemical reactors, and perhaps less nonlinear but also challenging multiphase separators, including networks thereof. Christofides instead focuses here on the control of 3 classes of suspended particle devices — batch- and continuous-crystallizers (Chapter 3), aerosol-route pigment reactors (Chapter 7), and combustion-based powder accelerators ("thermal spray" devices) for applying protective coatings (Chapter 8). Many high-value products are now synthesized as powders suspended in a carrier fluid (liquid or gas) — including pharmaceuticals (sometimes precipitated from supercritical fluid solvents) and electronic/magnetic/optical materials, increasing the incentive to design/apply effective controllers, especially when the reagents are themselves expensive. An interesting feature of mathematical models of such processes is the central role played by the so-called population-balance equation (PBE) – a Boltzmann-like nonlinear integro-PDE governing the evolution (dynamics in space and time) of the particle distribution function – often presumed continuous, and sometimes even "mono-modal". Christofides, who here presumes a basic knowledge of nonlinear control theory and PB-methods in ChE, explicitly considers distributions with respect to particle size — a timely emphasis in view of recent advances in/extensive use of on-line measurements of PSDs and DSDs (for sprays). However, extensions of the methods he describes will be required to deal with the model-based control of emerging multi-attribute particle systems — i.e., those for which particle size alone does not dictate product acceptability. His examples demonstrate that acceptable control is possible even in the absence of a "complete" mathematical model, and even when the sensors used in the feedback loop do not directly measure the quantities of greatest theoretical interest. The mathematical tools of modern control theory, especially those developed in the last 30 years, and several by the author and his students (1997, 1999, 2001[1]), are invoked in an effective manner, with the underlying theorems/proofs relegated to concise Appendices. While there have been important developments in moment-based multivariable PBE simulation methods since the 2002 publication date of this book, especially those based on Gaussian quadrature closure methods (abbreviated QMOM and its extension: DQMOM), Christofides has brought together here concepts/techniques previously scattered in many individual research papers in the ChE- and Controls/EE-literature. This 209p book (ISBN 1-4020-0936) comprises Vol. 14 in a Kluwer Particle Technology Series (Dordrecht, Netherlands), several previous volumes of which deal with the sampling/characterization methods routinely invoked in the present class of particle technology applications.

Daniel E. Rosner
Chemical Engineering, Yale University
New Haven CT, USA
E-mail address: Daniel.Rosner@yale.edu.

[1] Christofides, P.D. (2001) Nonlinear and robust control of PDE systems; Methods and Applications to Transport–Reaction Processes, Birkhauser (Boston).

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