



Beyond Brewing - BBB (Borrow)

New Directions in Bioprocess Modeling and Control

By Michael Boudreau and Gregory McMillan

Reviewed by Nick Sands

McMillan is an ISA fellow, a former "Control Engineer of the Year", one of the first inductees in to the "Process Control Hall of Fame", an affiliate professor at Washington University in St. Louis, and, because he shares his 33 years of experience at Monsanto and Solutia, one of ISA's most prolific authors. This is neither the first nor the last review of one of McMillan's books. Michael Boudreau, P.E., is a control systems engineer for Emerson Process Management and has worked on control systems at Amgen, Bayer, and Genentech.

Many bioprocesses have not optimized control because the pharmaceutical industry must, by regulation, validate the control system after each change. This has stifled the usual continuous improvement. The Process Analytical Technology (PAT) initiative is aimed at demonstrating control of the process and allowing improvements if the process remains within control limits. The control techniques in this book can help accomplish the PAT objectives.

Boudreau and McMillan explain the basics of dynamics for both self-regulating and integrating processes, and describe the general characteristics for bioprocess variables such as pH, DO, and various concentrations. The loop deadtime limits controller performance. The authors explain the structure and operation of various PID controllers and which is appropriate for different process variables such as temperature and pressure. They recommend the lambda tuning method.

Beyond basic control, model predictive control (MPC) is a powerful tool for optimization. MPC is particularly well suited for processes with dynamic interactions and complex dynamics, like inverse response. MPC can also control against a trajectory. Because of the limited opportunity to test operating conditions, dynamic simulations, or virtual plants, can provide an opportunity to explore new process conditions and control strategies. The rest of the book details modeling techniques for bio processes that can be used to develop virtual plants.

First principle models begin with mass and energy balances. The heat and kinetics for reactions and the vapor-liquid equilibrium further enhance the model. Virtual plants can be constructed using reusable modules that can be embedded within the control system. In the final chapters the models are extended to artificial neural networks (ANNs) that use operating data to build multivariable non-linear correlations of complex processes. Another set of technologies for complex processes, particularly suited to biological processes, are principle component analysis (PCA) and multivariable process control. In PCA, many variables are mapped to fewer orthogonal dimensions.

Boudreau and McMillan have assembled a single book that introduces the readers to the basics of control and the basics of bioprocesses, the dynamics of these processes, and then much more. For those in the bio-industry, this insight is truly valuable. That makes *New Directions in Bioprocess Modeling and Control*, well worth buying for those in the bio industry and well worth reading, or borrowing (BBB), for those that work in other industries. It is available for \$82 (member price) at ISA.org.