Book Review

Advanced Process Control*

W. HARMON RAY

Reviewer: JOHN E. RIJNSDORP

Twente University of Technology, Enschede, The Netherlands.

The road from theory to practice takes many steps, often over or around considerable obstacles. This certainly holds for the process industries, where actual conditions are rather unfavourable for control complexity and sophistication: process behaviour varies significantly and sometimes even qualitatively due to feed and product changes, unavailability of process equipment, lack of manpower for model building and updating, while operator training and motivation often receives insufficient attention.

Still it is worthwhile to explore opportunities for applying modern control theory. Here a necessary step is to present methods in a heuristic way and to demonstrate how they can be numerically worked out for realistic examples.

Harmon Ray has done just that for distributed parameter systems, which are quite common in the process industries. The core of his book is a survey of the present state-of-the-art, to which he and his co-workers have contributed in many respects.

The following topics are covered: processes characterized by ordinary, parabolic and hyperbolic partial differential equations, and as a special case, pure time delays; optimal deterministic control; linear and nonlinear feedback control; deterministic and stochastic state estimation; optimal stochastic control; multivariable Smith predictor; choice of measuring points for distributed parameter processes.

All methods are illustrated by typical processes, such as heat exchangers, steel slab (re)heating, packed-bed and stirred chemical reactors, distillation columns. In most cases, a good compromise has been reached between didactic simplicity and realistic complexity.

The book gives little direct advice to engineers faced with the implementation of advanced control algorithms in industry. The latter requires insight into the sensitivity to changes in process behaviour, the effects of instrumentation failures, recipes for tuning parameters, and guidance for cost/benefit analysis. However, these shortcomings pertain rather generally to the literature as it is now.

In the introduction no distinction is made between measured input disturbances and unmeasured ones. This distinction is important for state estimation and for feed-forward control (which is not discussed either).

The second chapter deals with on-line data acquisition and computer control, which (inevitably) has already been out-paced by the microcomputer revolution in process instrumentation. Too little is told about the latter, and too much about laboratory instrumentation.

Some examples (3.2.1. on page 43; 3.2.8. on page 62) are

too simple compared to the preceding theory. In the discussion of controllability and stabilizability (pp. 59–61) nothing is said about output controllability, which together with stabilizability, is more suitable for practice.

Contrary to what is remarked on page 71, there are usable dynamic measures for interaction, at least for the two-variable case. Noninteracting controller design does not require perfect compensation (page 75) as a little interaction is not harmful.

The chapter on lumped parameter systems and the section on systems with time delays do not indicate the essential limitation to control quality imposed by secondary lags in the control loop (which often can be represented by an equivalent time delay).

In the introduction to optimal deterministic control, the difficulty of constraints on the state variables *alone* is not pointed out (page 86). In fact this section breaks up the sequence of sections dealing with feedback control system design, and so obscures the distinction between finding optimal values of process conditions (off-line or on-line) and implementation of these values in actual process operation (process control in the narrow sense of the word).

On page 107 the importance should be stressed of the positive *semi*-definiteness of the weighting matrix for the state variables in linear/quadratic optimal control. On page 114, more guidance should be given for a correct choice of integral action in this type of control.

The characteristic equation for multivariable Smith predictor control (page 217) is self-evident from the block-diagram, hence it does not require a lengthy derivation.

On page 274, state observers are said to have difficulties with measurement or process noise. In fact, this depends on the choice of the rate of convergence (see page 272). Conservatively designed observers have been applied to chemical processes with good results. Finally, there is no discussion of detectability in the paragraph devoted to observability (page 293).

Notwithstanding these shortcomings, the book is a valuable contribution to the process control field. It can be recommended to students and engineers with a good knowledge of basic control techniques and matrix methods. Only little need be known about partial differential equations as these are well explained in the text.

About the reviewer

Professor John E. Rijnsdorp received his engineering degree from Delft University of Technology in Delft, The Netherlands in 1950. After military service he joined SHELL as a process control engineer. In 1967/1968 he was visiting professor at Polytechnic Institute of Brooklyn in New York. In 1970 he became professor in process control at Twente University of Technology in Enschede, The Netherlands. His main areas of interest are application of modern control theory in process control; structuring of information presentation of VDUs; 'humanized' design of production automation systems.

**Advanced Process Control*, by W. Harmon Ray. Published by McGraw-Hill, New York (1981). 416 pp., U.S. \$29.50.