ments. These courses can be taken as the fourth elective or as overload courses.

Industrial response to our process control program has been positive and encouraging. Industrial representatives have helped us to choose the material to be presented and have helped with financial support for our computer facility. Positive feedback from instrument and control system vendors and from manufacturing companies, especially pulp and paper companies, has consisted not only of verbal approval but also the ultimate test: They need, want, and hire the graduates of the program. □

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ChE book reviews

ADVANCED PROCESS CONTROL

By W. H. Ray
McGraw Hill, NY, 1981

Reviewed by John C. Friedly
University of Rochester

There are few available books suitable for a graduate-level course in chemical process control, although there are a number of more general as well as a number of more specialized advanced control texts. That fact alone would make this text a useful addition to the literature. However, this book has more to appeal to students and practitioners alike.

The book covers nearly all of the most used ideas of modern process control, from multivariable control, through optimal control, to state estimation. Ray tries to present a balanced coverage of control of both lumped and distributed parameter systems, linear and nonlinear systems, theory and practice. From the large literature available, choice of the basic principles has been skillfully made. As in most of Ray's work the concepts are illustrated with a wealth of rather detailed examples, all pertinent to chemical engineering. In addition, there is a summary of several more elaborate case studies taken from the literature. The only noticeable omissions are parameter estimation and adaptive control.

The style is mainly expository with approaches to solving the problems stressed rather than an axiomatically rigorous mathematical treatment. As should be expected, vectors and matrices are used throughout and the manipulative skills of linear algebra are essential. For the most part, mathematical methods are introduced where needed as unobtrusive digressions in the text. The prose is eminently readable and the typescript is free of obvious errors.

The bulk of the material is jammed like meat on a delicatessen sandwich into just three rather long chapters. The advanced control concepts are first introduced in Chapter 3 on control of lumped parameter systems. Multivariable control, non-interactive control, modal control and optimal control are all covered in some detail. Both the theoretical basis and the more practical implementation of the control is discussed, including computation and approximation problems. The following chapter attempts to give the same type of coverage for control of distributed parameter systems. This is done to the extent possible and the distinctive problems associated with the more complex distributed systems are covered well. The coverage of optimal filters and observers in Chapter 5 is complete, but the concepts of stochastic control are only paid lipservice. In the same chapter both lumped and distributed, linear and nonlinear systems are included. These meatier chapters are contained between two which, while appropriate, suggest that the sandwich could well have been served open-faced. Chapter 2 gives an overview of the hardware and practical details of the use of minicomputers for process control and is virtually not referred to again in the text. The final chapter reviews several case studies from the literature that use many of the concepts covered earlier, but is also somewhat disconnected from the rest of the material in the text.

The text is not without its faults however. In using many parts of the text for a course in process control, students found that it contained a

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tion may be used. The fourth reaction involves combustion of the carbon to carbon dioxide. Complete combustion of other product gases also occurs in the presence of oxygen at these temperatures. The equilibrium constants for these reactions are very large; similarly, rate data which was presented in class indicated that the rate constants for reactions between carbon and oxygen were very large. The fourth reaction might be excluded from consideration since the presence of excess oxygen at specific regions in the bed would likely lead to complete combustion products. The heat derived from such reactions, of course, is necessary to balance the endothermic reactions involved in the production of high Btu gas.

The composition of the product gas may be determined by thermodynamic calculations. At 700 K, the equilibrium constants are $K_1 = 22.6$, $K_2 = 1.60 \times 10^{-3}$ and $K_3 = 7.31$. The corresponding gas phase composition is $y_{CH_4} = 0.20$, $y_{H_2O} = 0.44$, $y_{CO_2} = 0.25$, $y_{H_2} = 0.094$, and $y_{CO} = 0.0074$.

The results of the calculation indicate that the heat required due to the overall endothermic nature of the gasification reactions is relatively low. Substantial amounts of energy are required to heat the coal to 700 K and vaporize the moisture in the coal bed. Students are also capable of providing a rough estimate of the heat loss to the surrounding environment. The effect of approximating the coal composition is relatively small. The results of the calculations vary as a result of the particular assumptions made, but roughly 15-20% of the coal would have to be burned. □

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curious mixture of brevity and detail. A great deal of straightforward algebraic detail is given in many places while in others mastery of far more difficult concepts is assumed. For example, knowledge of eigenvalues and eigenvectors of matrices is assumed in the earlier part of Chapter 3, but is reviewed in some detail later in the same chapter. Far more background in stochastic processes is assumed than the typical chemical engineer has. Although little theory of stochastic processes is actually needed, the jargon is used extensively. The reader is not given enough background for even a clear physical interpretation of the results. Such a commonly used concept as the expected value of a stochastic variable is never even defined. Notation is also a problem in places, with the same symbols being used for different quantities or different symbols used for the same quantities within the same chapter.

In spite of some shortcomings Ray's latest book is highly recommended. It is by far the best book available for a graduate-level level course in modern chemical process control. □

DESIGN OF INDUSTRIAL CHEMICAL REACTORS FROM LABORATORY DATA

By J. Horak & J. Pasek
Heyden & Son, Philadelphia, PA

Reviewed by Moin Ahmed
Union Carbide Corporation

This book is an addition to a large number of books on the design of chemical reactors. However, this book differs from many other text books by emphasizing the practical aspects, sometimes at the expense of needed theory. The book touches some subjects like analytical methods and statistical methods of data evaluation which most books on reactor design do not address.

The book delves into useful qualitative discussion of many design principles, design methods and reactor descriptions. However, in a number of places a more mathematical and less empirical approach would have been useful. Most of the examples are of a qualitative nature, and there are very few examples which emphasize more than one principle at a time. At least on one occasion the book is misleading, referring to free energy of reaction as enthalpy of reaction. The translator has often used terms that are not familiar to American readers (like technological properties of a reactor).

The book is not well organized and is divided into too few chapters. After an introductory chapter, there is a chapter on Reactions in Solutions which is actually a chapter on homogeneous reactions. This chapter is followed by a chapter titled, Types of Reactors. In addition to the title, it describes data collection, treatment and regression of data, determination of specific heats and heats of reaction, and a very good description of scale-up techniques referred to by the authors as Data Transfer. Chapter 4 deals with the catalytic reactors. This chapter also presents the trickle bed reactors, heat transfer media and construction of heat transfer loops—subjects very useful to practicing which are neglected by most re-