Figure 3; instead, it follows a curved path given by the locus of the lowest points of the numbered lines in Figure 3 as discussed above.

Normally students conceive of reactions in terms of the microreversibility theorem and would assume that the reverse path following a reversal of the step-change would be the same as the forward path. Figures 5 and 6 show that this is not the case. Thus. microreversibility is inappropriate for describing surface concentrations in this and similar systems.

An exercise that students will find interesting is to calculate the surface composition for a non-reaction system and a reacting one even if the rate constants are very small. Will these compositions be identical?

CONCLUSIONS

Triangular diagrams are useful for teaching steady-state and transient reactor behaviour of catalytic reaction models. Concentrations of surface species, not normally measurable, are particularly easy to reveal and to use to suggest interpretations of transient operation. Similar calculations can, of course, be performed for catalytic reactions with arbitrary mechanisms. In the example presented, the transient reactor behaviour was excited by the step-change of feed composition. Other types of steady-state feed disturbances (*e.g.*, sine, ramp, *etc.*) can be used after proper formulation of the initial conditions.

For systems having more than three components. appropriate subsystems of variables may be chosen. The main advantage of the triangular diagram lies in its power to compress into understandable form a great deal of information about the progress of gas and surface species in catalytic reaction. The FORTRAN programs used in this study are available from the authors.

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REVIEW: Transport Phenomena

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I would like to single out a few papers that are worth extended attention. The keynote lectures all fall into this class, although their coverage varies considerably. They do provide the reader a wealth of information gathered by the authors. In addition, on coherent structures, Blackwelder's short post-conference note is noteworthy. Criminale's contribution offers new insight. Other noteworthy contributions are by Walker and Herzog, and Nishino, *et al.* On wall shear flows, the contributions by Nagano and Tagawa, Usui and Sano, and Ueda *et al.*, should receive more than casual consideration. On free shear flows, I enjoyed reading contributions by Tabatabai *et al.*, Stapountzis, and Kobayashi *et al.* Since I have a special interest in scalar transport, I read all of these. My knowledge of modeling details is more limited; these papers appear to be of interest to one involved in transport modeling, a necessity in our modern engineering society. The numerical simulations of turbulence and transport is a new and budding field; thus contributions rapidly become dated. The two keynote lectures form a good starting place, and the general contributions add to them. Measuring techniques are varied and should receive the researcher's careful attention. The ideas advanced by Bawirzanski *et al.*, Ciccone *et al.*, Akino *et al.*, and Hardalupas *et al.*, are all worthwhile contributions. ☐

BUOYANCY-INDUCED FLOWS AND TRANSPORT

by Benjamin Gebhart, Yogesh Jaluria, Roop L. Mahajan, and Bahgat Sammakia
Hemisphere Publishing Corp., 79 Madison Ave., New York, NY 10016; 1001 pages, $95 (cloth); 971 pages, $49 (paperback); 1988

Reviewed by
J. S. Vrentas
The Pennsylvania State University

With seventeen chapters and more than nine hundred pages, this book deals with a wide range of buoyancy-induced flow problems. The analysis of steady and unsteady laminar external flows driven by both thermal and concentration effects is the focus of the first third of the book. Fluid property variations, turbulence, mixed convection, non-Newtonian effects, and the characteristics of instabilities are considered in subsequent chapters. Buoyancy-driven motions in fluid layers and in enclosures as well as natural convection in porous media are also discussed. Since problems are presented at the end of each chapter, this book can be used not only as a reference source but also as a textbook for a graduate specialty course. A significant part of the book could be covered in a one-semester course at the graduate level.

The authors present their analysis from an engi-

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course on curricular changes in the light of emerging technologies, with the hope of evolving some general guidelines. The following sections outline those guidelines.

Science Courses: The science group, headed by Professor Davis, felt that the science core should be taught by scientists and that the chemical engineering faculty must persuade physical chemists and material scientists to include concepts and examples related to emerging technologies in the core courses. More specifically, examples must include solids, polymers, catalysts, interfaces, colloids, bioreactions, *etc.* They further recommended a course on computational methods after the completion of the core math courses, and that chemical engineering students be allowed to substitute one life science course for one core chemistry course (the most logical option being the second organic chemistry course). No changes were recommended for the physics courses.

Engineering Core Courses: This group, led by Professor Gandhi, outlined the topics to be dealt with in thermodynamics and transport processes. Although their outline showed no changes in the list of topics currently covered in chemical engineering curricula, they suggested that a special effort be made to include new examples from the emerging technologies. Another recommendation was to include discussion of the solid state with respect to deformation, transport of energy and mass, and chemical reaction, with examples of applications to the newer technologies of materials and microelectronic devices.

Chemical Engineering Courses: Arvind Varma (Notre Dame) headed the group which presented observations and recommendations on chemical engineering courses such as chemical reaction engineering, separations, design, control, and laboratory. The group stressed fundamentals with inclusion of examples from both traditional and emerging technologies. Since textbooks on the newer technologies are not yet available, they recommended that examples be commissioned and circulated to chemical engineering departments in a package. They encouraged the use of realistic problems, with liberal use of computer software focusing away from numerical methods. They also recommended that in addition to the two-semester laboratory course, demonstration experiments and video tapes should be used to firm up concepts and even to introduce new course material.

Electives: This group, headed by J. M. Caruthers (Purdue University), classified electives in the new technology areas as microelectronics, biochemical, interfacial, AI, and polymers, and in the traditional technology areas as environmental, petroleum, process metallurgy, and food. A third category was termed "Advanced Core" and included transport, thermodynamics, optimization, and control. The group felt that electives in the new technologies should not eliminate electives in either the traditional technologies or the advanced core. They observed that it is not necessary for each department to offer a complete package in every area.

CONCLUSIONS

The broad conclusions which can be drawn from this four-day seminar are:

1. Chemical engineering must retain its traditional interests, but at the same time must expand its fundamental base to include applications in the new areas of technology. In particular, background in states of matter other than the bulk fluid state (such as solids, thin films, interfaces, microstructured materials, *etc.*) was emphasized.

2. In view of the interdisciplinary nature of the newer areas and the essentially transient nature of technological developments, a fundamental background is necessary to provide a healthy appreciation of the issues involved in the new fields. Thus, chemical engineering expertise on process systems design in such areas must function within the framework of a collaborating team of scientists and engineers of various backgrounds.

3. Curricular modifications must entertain two elements. First, fundamental information must go into the science and engineering core courses, with examples to illustrate the new applications, and chemical engineering courses must be oriented similarly wherever possible (*e.g.*, chemical reaction engineering, separations, control). Second, more detailed involvement with the newer areas of technology must be accomplished through elective courses. □

REVIEW: Buoyancy

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neering science point of view. They focus on the formulation of appropriate forms of the transport equations in the boundary region and on the development of similarity or perturbation solutions. Hence, their book complements the book by Joseph *(Stability of Fluid Motions)* where more mathematical aspects of buoyancy-induced convection are discussed.

This book is clearly written and the material is presented in an orderly fashion. The book should serve as a valuable and comprehensive reference source for anyone interested in the engineering aspects of natural convection. Engineers and scientists doing research in this field will certainly want to own a copy of this book. □