is in charge of the department's process control computer laboratory. This facility includes a GE-312 digital process control computer and peripheral equipment which was a competitive gift awarded by Dow Chemical Co., Midland, Mich., on the basis of a proposal submitted by the department. The laboratory also contains a TR-48/DES-30 analog/digital logic package which was granted by the National Science Foundation.

During his seven years at Clemson, Dr. Bruley has had 18 articles published or accepted for publication and filled 35 speaking engagements, including an invitation to the University of Goteburg, Sweden, in June, 1968.

Dr. Bruley is a member of the AIChE, Tau Beta Pi, Sigma Xi, the Simulation Council, and is a registered professional engineer in South Carolina. A native of Chippewa Falls, Wis., Dr. Bruley is an honor graduate of the University of Wisconsin, receiving a BS degree in chemical engineering in 1956. While there, he held a Universal Oil Products scholarship.

He then attended the Oak Ridge School of Reactor Technology, Oak Ridge, Tenn., as a special fellow in a one-year graduate nuclear engineering program. Dr. Bruley later attended Stanford University on an Atomic Energy Commission fellowship and was graduated in 1959 with an MS in mechanical engineering.

At the University of Tennessee, Dr. Bruley held Shell and Texaco foundation scholarships while pursuing his PhD in chemical engineering and serving as a graduate teaching assistant.

Dr. Bruley's wife is the former Suzanne Bigler. They have three sons: Scott, 6, Randy, 5, and Mark, 2.

ChE book reviews

Design Studies in the Manufacture of Ethylene by Pyrolysis of Naphtha, D. B. Tolmie (Ed.), The University of Sydney, New South Wales, (Australia), Department of Chemical Engineering, (1967), $10.

This is a bound report of some 285 typed and mimeographed legal-size pages. It covers the efforts of 26 senior chemical engineering students in the class of 1967 at The University of Sydney. As the title suggests, the class project dealt with the design and economic evaluation of an ethylene plant. The plant capacity is 120,000 long tons per year of polymer-grade (99.9% pure) ethylene; because of the naphtha feedstock this entails a considerable production of ethylene co-products such as propylene, butylenes, and gasoline.

The report is divided into 12 chapters, each covering the work of two students. Introductory material is provided by Professors T. G. Hunter and D. B. Tolmie and includes some treatment of project scheduling and control. Chapters by the students cover the following titles in sequence:

> Economics and Technology
> Storage and Transportation
> Naphtha and Ethane Pyrolysis Furnaces
> Scrubbing and Compressing Pyrolysis Gases
> Heat and Power Economy, Utilities and
>   Effluent Disposal
> Acid Gas Removal
> Drying of Cracked Gases
> Refrigeration System
> Acetylene Conversion
> Distillation
> Plant and Services Layout
> Optimizing Process Conditions

Each chapter includes a brief treatment of technology, a summary of detailed calculations, and a list of references. In total, the report contains a considerable amount of collected material on the general subject of ethylene technology.

The contents of the report reflect industrial practice to some extent, since the material was reviewed and criticized by practitioners. It extends beyond conventional process design and includes such details as locations of fire hydrants and first aid stations. It suffers from the time constraints of students who are not able to consider many of the alternate solutions to the problems at hand. However, the amount of work done by the students and by the editor is indeed impressive, and one wonders whether there was

compound system cannot attain state 2* either.

Inspection of Table 2 and Figure 3 reveals that the state where $\triangle S = 0$ corresponds to state 2* in Figure 2. Over the range of possible V_2' values ($A \leq V_2' \leq B$) the function $\triangle S' + \triangle S''$ is monotonically increasing and it reaches its maximum value where $\triangle S'' = 0$. It was shown earlier, however that both $\triangle S'$ and $\triangle S''$ must be > 0 when separated by an adiabatic wall, and so the possibility of the compound system ever attaining this state can be dismissed. In short, for the initial conditions selected, the entropy of the compound system did not maximize in the presence of an internal adiabatic constraint. The compound system was not able to reach state 2*. An infinity of initial states having this property exist. The author has shown[4], however, that another infinity of initial states also exist for which we may not make that statement. There are initial states for which we may not exclude the compound system from attaining the state of maximum entropy. One such state is to use the initial pressures and temperatures given in Table 1 but to let $V_1' = 2$ cu. ft. and $V_1'' = 14$ cu. ft. This set of initial conditions will give equilibrium values whereby both $\triangle S'$ and $\triangle S''$ are > 0 *even* with a diathermal separating wall.

What statement can be made concerning the final equilibrium state of the compound system shown in Figure 1? Certainly the entropy of the compound system does increase when the mechanical constraint is removed. In general, however, the entropy does not reach its global maximum (state e) nor does the compound system maximize the entropy subject to the adiabatic constraint (state 2*). Just how much the entropy does increase cannot at present be determined by the tools of classical thermodynamics.

CONCLUSIONS

The key point in our discussion has been the following — the presence of an adiabatic internal wall represents a constraint on thermal equilibrium and a system in constrained equilibrium need NOT be in the state of maximum entropy. Thus the characteristics of the dividing wall, which may at first appear to be an unimportant element, are critical for the prediction of the final equilibrium state.

NOTATION

n — number of moles, lb. moles
p — pressure, psia

R — ideal gas constant, psia-ft³/lb mole — °R
S — entropy, e.u.
T — absolute temperature, °R
V — volume, cu. ft.
$\triangle$ — refers to change in value of a thermodynamic property

Subscripts

1, 2 refer to equilibrium state with adiabatic separating wall

Superscripts

prime, double prime — used to designate subsystems

REFERENCES

1. Landsberg, P. T., Thermodynamics, pp. 6-12, Interscience Publishers, New York (1961).
2. Wilson, A. H., Thermodynamics and Statistical Mechanics, pp. 65-67, Cambridge University Press, Cambridge, England (1966).
3. Buchdahl, H. A., The Concepts of Classical Thermodynamics, pp. 13-14, Cambridge University Press, Cambridge, England (1966).
4. Brainard, Alan J., *Il Nuovo Cimento*, Series X, 62B, 88-94, (1969).
5. Tisza, Laszlo, Generalized Thermodynamics, p. 89, MIT Press, Cambridge, Massachusetts (1966).
6. Callen, Herbert B., Thermodynamics, pp. 321-323, John Wiley & Sons, Inc., New York (1965).
7. Ibid, 24.
8. Reference 1, p. 149.
9. Hatsopoulos, George N., and Joseph H. Keenan, Principles of General Thermodynamics, pp. 393-396, John Wiley & Sons, Inc., New York (1965).

BOOK REVIEW   (Continued from page 61)

very much time left for other university work during the senior year.

This report should be of value to teachers of chemical engineering design who are willing to bite off a rather formidable chunk of a large and involved process. Some pitfalls are that naphtha is not a representative feedstock for U. S. ethylene manufacture, that the economics must be adapted to U. S. circumstances, and that the information is only that which has been gleaned from the open literature. The counsel of practitioners engaged in the ethylene business would be advisable. Perhaps the best use of the report would be in providing material for short design studies. Example sections amenable to adaptation would be cracked gas drying, acid gas sweetening, and acetylene removal by hydronation.

In summary, this is a collection of design problem solutions that in whole, or in part, can be of value to the teacher of chemical engineering design. *Reviewed by Dr. James R. Fair, Monsanto Company, St. Louis, Mo.*

[Please—a little self analysis: How many teachers "inspired" you as a student? Where? In the classroom? Or in their offices? Motivation may be necessary at the high-school level but at the college level? Can't the coop plan supply this motivation? What about the graduate level?]

A-2. "Many (most) of my students need to be prodded by being forced to go to class, or to turn in homework, or to have me (the teacher) review the material three times a week."

[Can we afford to accept such a condition at the college level? Isn't this statement an indictment of present educational methods?]

A-3. "I bring to class the latest developments in the literature (or from my research) and so illustrate and extend the textbook as well as the subject."

[A fair answer, *if* we are discussing high-level graduate seminars for the PhD degree; even here a Xerox copy of a Ditto statement of the "new" material could save a good deal of chatter.]

A-4. "The students are not exposed to the presence of other students, and to the questions of other students which may be novel to them, and to the reactions of the students."

[True, but need it be 3 times a week times 5 to 7 subjects? The experienced teacher finds few novel questions, and these should be anticipated in the course printed material.]

Q. Isn't the graduate student (or the professor) overworked in answering the phone (one 2-hour period during the week)?

A. Surprisingly, the phone load is very light *except* for a night or two before an examination. (And therefore we call the phone service a psychological crutch.)

BOOK REVIEWS   (Continued from page 93)

Mass Transfer in Heterogeneous Catalysis
Charles N. Satterfield
267 pages, M.I.T. Press, (1970)
Cambridge, Mass.

This book is a sequel to the 1963 volume 'The Role of Diffusion in Catalysis" written by Professors Satterfield and Sherwood. The arrangement of the material and the point of view are the same as in the earlier work. The new volume retains the objective of emphasizing the practical, problem-solving approach.

The first chapter treats diffusion in gases and liquids in a brief way and then presents in detail mass transport in porous catalysts. Binary mixtures are used almost exclusively to illustrate diffusion phenomena and little attention is given to the molecular theory of diffusivities. However, rather complete up-to-date data are presented for liquid and gaseous, binary systems. Models of pore structure applicable to diffusion calculations are discussed along with a reasonably complete summary of data on tortuosity factors. From a historical viewpoint, Rothfield's work [AIChE Journal *9* 19 (1963)] might have been given credit, along with the other two groups mentioned, for deriving the accepted relations for diffusion at constant pressure in a pore where both Knudsen and bulk transport are significant.

Chapter 2 treats transport resistances between fluids and solid particles and includes a summary of available information for fluidized beds and slurries.

The major share of the book is devoted to the interaction of diffusion and heat transfer and reaction in influencing the effectiveness of porous catalysts. The conventional isothermal problem is considered first (Chapter 3), and then intraparticle temperature effects are introduced. Methods of *predicting* the effective thermal conductivity are mentioned only in passing in order to present the available experimental data. Considerable space is given to the effect of the form of the rate equation on the effectiveness factor, a subject in which the author has done considerable work.

The final chapter describes the effects of poisoning on rates and selectivity and the related subject of regeneration of coked catalysts. Poisoning is analyzed using the Wheeler classification [A. Wheeler, Advances in Catalysis III, p. 249 (1951)]. The data on carbon gasefication is summarized with the objective of presenting working equations for the rate of burnoff. For the high-temperature case of diffusion-controlled burnoff (the shell model) data are given, but the theory is not included. In general, the concepts of gas-solid non-catalytic reactions are not discussed. As the title indicates, the treatment is limited to catalytic reactions.

The book presents a convenient source of data (much of it recent) on transport effects in solid-catalytic reactions and as such will be a most valuable addition to the literature. The material is presented clearly and the data abstracted from the literature are reproduced and analyzed with sufficient detail and care to be useful.

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