A Course on

DOCTORAL LEVEL CHEMICAL ENGINEERING ECONOMICS

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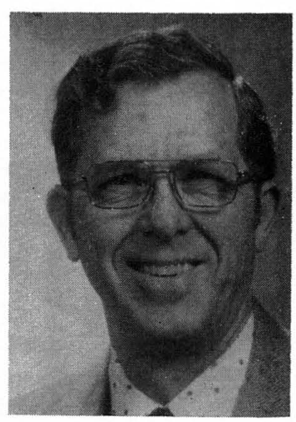
IT HAS BEEN SAID THAT . . . "The central activity of engineering, as distinguished from science, is the design of new devices, processes and systems which create economic resources at the expense of thermodynamic availability, time, space and other natural resources" (Tribus, 1969). Chemical engineering curricula do not always reflect the key roles of design and economics in achieving the distinction between engineering and science.

The Engineers Council for Professional Development has in recent years been exerting pressure by means of accreditation procedures upon engineering departments to offer a modicum of design content in their curricula. This has resulted in some increase of attention to design at the undergraduate level, but design instruction at the graduate level remains relatively untouched. The anomaly is much worse with respect to economics. Many departments (including that of the author) do not require a course in engineering economics at the undergraduate level. Some economics may be incidental to design courses, and an elective may be available for a course in the subject. But sadly, many B.S. ChE's come out of school with little or no understanding of this vital material. Again, as in the case of design, the situation is much worse at the graduate level. The author has no firm data, but surmises that very few chemical engineering departments require a course in chemical engineering economics in the core for graduate work. It would be interesting to survey the departments to see what the situation actually is.

Incidentally, the course in "Engineering Economy" classically taught by industrial engineers and frequently used by chemical engineering students falls short of what these students really need.

At The University of Tennessee, there are two graduate-level courses in chemical engineering economics, both of which are elective. One of these, "Chemical Process Industry Economics," is intended for M.S. students, and the other, "Venture Analysis in the Process Industries," is intended primarily for Ph.D. students. The former is prerequisite to the latter. Our University operates a strong off-campus program for engineers in industry by means of videotape. The fact that some 80 percent of the students in these two courses are off-campus engineers must be a commentary on the status of education in economics and on the importance that economics has in the real world.

The M.S. level course is probably not much different from such courses at other institutions. The "Venture Analysis" course may, however, be somewhat novel. It assumes that the student has a



Oran L. Culberson received his B.S. degree from Texas A & M. After serving as an infantry officer in World War II, he obtained M.S. and Ph.D. degrees at the University of Texas. He was with Gulf Research and Development Company for 3 years in process design and economics, and with Celanese Corporation for 12 years in process design and economics, and in the management of computer and operations research departments. Culberson joined the University of Tennessee in 1965, and was selected as Alumni Association Outstanding Teacher in 1978. He is a fellow of AIChE, in which he has served as chairman of two local sections and two national committees.

working understanding of capital costs, manufacturing costs, measures of economic merit, distribution considerations, raw material and product markets, marketing aspects, the time-value-of-money and some notions about the need to optimize among all these factors. The student is expected to apply this knowledge in a role-playing development of an answer to a tough question.

The question posed at the last offering of the course was (in condensed form): "We are a major producer of ethylene. We are thinking of increasing our ethylene capacity by one billion pounds per year. When should we have this capacity come on stream (if at all!), and what size and feedstock should the plant(s) take?" Persons familiar with the ethylene situation will recognize that the question is fraught with difficulties about uncertainties in the growth of demand, what the other producers are going to do, about relative merits and availabilities of alternate feedstocks, about the trade-off between plant size and manufacturing cost, etc. An answer to the question is developed by two-person teams, each of which assumes the identity of a major corporate producer. This relating of a team to a company, e.g. Exxon, enables the team to develop a feel for the team's position and attitude.

All of the work in the quarter is devoted to the preparation of a report which contains the team's analysis and recommendation. There are no quizzes or homework. Suggested readings and sources of information are provided to the students, but the burden of the development and analysis of information is on the team. Between the first and last weeks, student-teacher contact consists of weekly sessions with the individual teams in which the instructor helps the students in their worries about where they are and where they need to go. At the beginning of the project the teams are advised, but not required, to divide the responsibility into a manufacturing/technical role and a marketplace role.

Two very useful documents were provided to the students. One of these was a paper which admirably summarizes ethylene manufacturing technology in terms of processes, feedstocks, products, and capital and manufacturing costs (Baba and J. Kennedy, 1976). The teams were not expected to get involved in details of design; any scaling up or down of plant size and capital cost was to be satisfactorily handled by an exponential relationship. The other vital document was material from a major chemical company's procedures for evaluating projects proposed for capital appropriation. Those procedures require in part the development of ten-year forecasts of sales volume, unit selling price, cash flow and return on investment, and of the compilation of information for checklists for each of marketing, technical and manufacturing/engineering areas. Typical of the numerous items from the checklists are—for marketing: "characteristics of major end use markets (growing, static or declining; seasonal or cyclical nature; individual requirements as to quality, package, technology, service or price; vulnerability to substitution by competitive products, etc.)"; for technical: "Degree of technical risk: highlight modifications planned in construction and differences over demonstrated technology, scale-up uncertainties, raw material differences, etc."; and for manufacturing/engineering: "For the capital cost estimate, give the source, degree of accuracy and basis for the estimate, and the expenditure schedule."

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The final class meeting consisted of all the teams assembling on campus for an all-day oral presentation of the information in the teams' written reports. Each team used about one-half hour to summarize its analysis and conclusions, followed by a discussion of these. The critique of a team's work focused on the substance of its information, analysis and reasoning. Obviously, it would have been foolish for the instructor to tell a team: "Your decision to go/not go with the expansion was wrong." The companies actually in the business are at least (!) as capable as the instructor, and they are by no means unanimous in the decisions they are taking on this same question. Only time will tell who is right and wrong.

We were extremely fortunate to have Mr. Robert E. Kennedy of the Gulf Oil Chemicals Company participate in the course. His position as Marketing Manager for Olefin Derivatives enabled him to provide data to the students on suppliers and markets for ethylene. His presence at the presentation did very much to hang flesh on the bones of what was taking place. Perhaps the greatest value of his participation was characterized in a comment of a student to me: "I really busted a gut on the project so as not to embarrass the Department and you in the eyes of Mr. Kennedy."

Educators are always deeply appreciative of a willingness by people from industry to get involved in working with students. The author particularly valued this investment by Mr. Kennedy and Gulf toward instruction in a subject so foreign to universities. □

REFERENCES

Baba, T. R. and Kennedy, J. R., "Ethylene and Its Co-products: The New Economics," *Chem. Engr.*, V83, No. 1, 116-128 (1976).

Tribus, M., "Rational Descriptions, Decisions and Designs," Pergammon Press, Elmsford, New York, 1969, p. xv.

ChE book reviews

FILTRATION: PRINCIPLES AND PRACTICES (TWO PARTS),

Part I. Chemical Processing and Engineering Series, Volume 10

Clyde Orr, Ed.
Marcel Dekker, 1977. 544 pp. $45.00
Reviewed by Max S. Willis
University of Akron

Filtration is one of the most neglected areas of chemical engineering. This is the consequence of the fact that it is not based on a sound theoretical basis and is an art rather than a science. Other areas, such as heat and mass transfer, receive much more attention because of their sound theoretical basis.

Although this book attempts "to cover theory as well as the practical considerations that enter into actual applications," it does not achieve its purpose. It also suffers a lack of careful organization, common nomenclature and format.

In Chapter 1, Gas Filtration Theory is covered extensively with numerous references (462 to be exact!). Contrary to the other chapters of the book, it does not have a notation section at the end. It is possible to combine this Chapter with Chapter 4, Industrial Gas Filtration.

Chapter 2, Liquid Filtration Theory and Filtration Pretreatment, and Chapter 5, Filtration in the Chemical Process Industry, basically cover the same area and most of the equations are repeated twice. Notation is not consistent, for example, mass fraction of solids in the slurry is denoted by c and s in Chapters 2 and 5, respectively. From the reader's point of view, some statements are contradictory. For example, in Chapter 2, the value of B is claimed to vary between 0 to 0.25 (p. 189) but in Table 7 (p. 400) of Chapter 5, the general range of B is given to be 0.1 and 0.5. Also the flow direction in Figure 21 of Chapter 5 is not correct.

In Chapter 2, which is attributed to Professor Tiller, the basic flow equation for compressible sludges (Eq. 41) is discussed and the Kozeny-Carman equation is substituted for the permeability term. This latter substitution is subject to conjecture since in a recent article [Filt. & Sep., *14*, 122 (1977)] Professor Tiller claims that the Kozeny-Carman Equation cannot be used to describe compressible cakes behavior.

In Chapters 2 and 5, the solids movement within the filter cake is neglected in order to avoid the use of a "sophisticated" form of Darcy's law for the development of filtration theory. If the solids velocity is zero, then, according to the equation of continuity, porosity at any point is independent of time and the superficial liquid velocity is constant throughout the filter cake at any instant. But, according to Equation (72) of Chapter 5, which was derived on the basis of no solids velocity in the filter cake, porosity at any point is a function of time which is, of course, a contradiction.

Recently, it has been observed that there are a number of serious problems in the compression-permeability test cell (CPTC) methodology which leads one to question the ability of this device to accurately and, more importantly, to uniquely simulate a constant pressure filtration. In one of his articles [AIChEJ *15*, 405 (1969)], Professor Shirato stated that ". . . most data found in the literature have not taken wall friction into account and consequently do not yield strictly accurate values." Although almost all the figures in Chapter 5 are from data based on CPTC observations from the papers of Professor Tiller and Professor Shirato published over the past two decades, the problem with compression-permeability test cell data is never mentioned.

The rest of the book deals with the Filter Media, Chapter 3, and Ultrifiltration, Chapter 6.

The price of the book is far too expensive! □