is oxidized and the cell population increases. Lastly, hydroxide is steadily consumed as acid is produced by the process.

ACKNOWLEDGEMENT

The author wishes to express his appreciation for the technical assistance of Dr. Marion Woolsey. Research upon which this experiment is based was funded by Combustion Engineering, Inc. of Stamford, Connecticut.

REFERENCES

1. Baalsrud, K., and K. S. Baalsrud, "Studies on *Thiobacillus denitrificans*," *Arch. Mikrobiol.*, **20**, 34-62 (1954)
2. Sublette, K. L., and N. D. Sylvester, "Oxidation of Hydrogen Sulfide by *Thiobacillus denitrificans:* Desulfurization of Natural Gas," *Biotech. and Bioeng.*, **29** 249-257 (1987)
3. Sublette, K. L., and N. D. Sylvester, "Oxidation of Hydrogen Sulfide by Continuous Cultures of *Thiobacillus denitrificans*," *Biotech. and Bioeng.*, **29**, 753-758 (1987)
4. Sublette, K. L., and N. D. Sylvester, "Oxidation of Hydrogen Sulfide by Mixed Cultures of *Thiobacillus denitrificans* and Heterotrophs," *Biotech. and Bioeng.*, **29**, 759-761 (1987)
5. Suzuki, I., "Mechanisms of Inorganic Oxidation and Energy Coupling," *Ann. Rev. Micro.*, **28**, 85-101 (1974)
6. American Public Health Association, *Standard Methods for the Examination of Water and Wastewater,* 14th Ed., APHA, New York (1976)
7. Meites, L., Ed., *Handbook of Analytical Chemistry,* McGraw-Hill Book Co., New York (1963)
8. Schedel, M., and H. G. Truper, "Anaerobic Oxidation of Thiosulfate and Elemental Sulfur in *Thiobacillus denitrificans*," *Arch. Mikrobiol.*, **124**, 205-210 (1980)
9. Folin, O., and V. Ciocalteau, "On Tyrosine and Tryptophan Determinations in Proteins," *J. Biol. Chem.*, **73**, 627-649 (1927)
10. Lowry, O. H., N. J. Rosebrough, A. L. Farr, and R. J. Randall, "Protein Measurement with the Folinphenol Reagent," *J. Biol. Chem.*, **193**, 265-275 (1951) ❐

ChE book reviews

ADVANCES IN DRYING,
Volume 4
Edited by Arun A. Mujumdar
Hemisphere Publishing Corporation,
79 Madison Avenue, New York, NY 10016
421 Pages, $97.50

Reviewed by
E. Johansen Crosby
University of Wisconsin

The drying of solids is probably one of the oldest unit operations practiced by man. In the past, this process generally was considered to mean the removal of moisture from matter when the amount of same was relatively small. However, in the chemical processing industry of today, feedstocks to be dried may contain as much as ninety percent moisture, and that moisture many times may be nonaqueous and multicomponent. Moisture removal can be effected by (i) condensed-phase separation, (ii) chemical decomposition, (iii) chemical precipitation, (iv) absorption, (v) adsorption, (vi) expression and (vii) vaporization. Convection drying, *i.e.*, moisture removal by vaporization with the drying medium being both the energy source and moisture sink, is by far the most common method used. The materials-handling considerations resulting from many different feedstock and product requirements inevitably resulted in the development of many types of equipment—each with its own operation idiosyncrasies.

In recent years, the number of monographs, handbooks, journals, proceedings and research reports devoted to this subject has increased markedly with the series entitled *Advances in Drying* which was initiated in 1980. In the preface of Volume 4, the editor indicates that this ". . . series is designed to allow individuals concerned with (various) aspects of drying to access relevant information in a carefully reviewed form with minimal time and effort." Like its predecessors, this work consists of a number of reviews, updates, and developments concerning theory, design, and practice in connection with moisture transfer through and/or removal from solids. Eight individual topics are addressed from various viewpoints by contributors from seven countries.

Computer-aided design of convection dryers is discussed in Chapter 1. The classification of mathematical models according to contact zones and flow patterns, the systematic application of the overall mass and energy balances, and the simplification of drying mechanisms is presented. Most of the chapter is devoted to examples of recommended calculation procedures for different types of dryers with the coverage of spray and rotary dryers being especially minimal. Chapter 2 deals with recent advances in the drying of wood. A review of drying theory and modeling is followed by a good summary of recent developments in lumber and veneer drying. Recommendations for future work are presented. Chapter 3 contains a condensed theoretical review of the drying of porous solids with stress on the internal mechanism of moisture and energy transfer. Coupled heat and moisture transfer in soil is reviewed in Chapter 4. Written from

Continued on page 43.

modified and used by laboratories in Mechanical and Chemical Engineering and Engineering Technology at Texas Tech. It contains a descriptive five-item scale on each of eight team and technology performance attributes. It also has a section for other comments. I will compile the evaluation data, use that to assign a team member grade, and share the compiled results with the team member. There are several advantages to such an approach. Student leaders can check off attributes without the bias that grading carries and, consequently, may produce a more accurate measure of their team member's performance. Additionally, discussion of the compiled data with each individual may aid coaching for improved performance. Initial feedback is positive.

The second negative evaluation concerned the variable difficulty of the projects, and a typical comment was, "How do you grade a hard program compared to an easy project?" ". . . all projects should be either programs or reports." "Don't compare apples and oranges." Students perceive that the computer projects are more difficult than the technology reports. Considering the level of computer programming expertise of our juniors, I must agree. Perhaps two-thirds of the class have forgotten both the programming language and the systematic approach to programming learned in their freshman course. They tend to write the entire program at once (without having performed hand calculations for familiarity with the procedure), then become extremely frustrated as they debug simultaneous and interconnected syntax and logic erors. Although I preview this, it remains a problem, and I plan to reducing my expectations on the computer assignment scope and strengthening my message to the computer simulator project leaders.

SUMMARY

In an attempt to integrate project management and interpersonal skills development into a junior level transport course, student project exercises were structured with one accountable leader who plans, coordinates, and grades the work of three team members. The exercise structure achieves its objectives and is received well by the students. The course professor must be prepared for the degree of subjectivity introduced and be able to manage personnel problems. Student-to-student evaluations may improve with a non-grade rating form.

REFERENCES

1. Everett, Gayle L., "The Transition From Student To Engineer," *TECHnology MAGAZINE*, (a student engineering publication of Texas Tech University, PO Box 4200, Lubbock, TX, 79409), 1986/87, pp. 10-12. □

REVIEW: Advances in Drying

Continued from page 37.

the viewpoint of the soil scientist, the equations of change for mass and energy transport, formulation of the relevant mass fluxes, consideration of the transport properties, and choice of boundary conditions are covered. Experimental measurement of the transport properties also is considered and the drying of soils by buried heat sources is discussed. A mathematical model for convective drying with the incorporation of sorption isotherms is presented in Chapter 5. This chapter is not a review but rather a research paper concerned with the drying of a porous capillary body and accompanied by a very limited bibliography. Chapter 6 is primarily a descriptive review of the solar drying of crops. After a brief discussion of drying principles, the status of solar drying technology together with equipment description is presented. This is followed by a discussion of the design features and typical performance characteristics of solar heaters for air. A very brief consideration of the relevant economics concludes the review. Certain principles of operation and design considerations for spouted-bed drying are presented in Chapter 7. Emphasis is placed on the selection of a spouted-bed system and its fluid-mechanical characteristics. Three previously published models for describing the performance of this type of dryer are summarized and compared. Chapter 8 is a nontheoretical review of press drying. The principles of operation are summarized and performance data are presented. The mechanical features of existing pilot machines and proposals for full-scale dryers as well as alternatives for improved paper densification are given.

Those persons interested in drying should find the individual contributions to this volume to be of some interest. The authors of most of the chapters are generally recognized authorities in their field. Unfortunately, much of the material seems to have been edited and/or proofread very rapidly and/or poorly as there are a number of instances of quite awkward grammar, misspelling and, something especially disconcerting, incomplete nomenclature. The text is type-set and production is good except for those few figures which are reproduced by direct photocopy. As with similar publications of this type, the price is high. Because of its restricted technical content, this volume should be perused prior to purchase. □