ends" the authors toss out to interested researchers as projects worthy of effort to firm up the foundations and to broaden the features of their approach. Indeed, it is the researchers who will be the most interested in this volume. Its value to them lies not merely with the proposed control system design method but also with the articulation of point of view and descriptions of the types of process operations problems now faced by the processing industries. Rarely have these been so clearly and forcefully presented in recent times by colleagues in industrial practice.

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Solid-Liquid Separation

Edited by Ladislav Svarovski, 3rd ed., Butterworths, Stoneham, MA, 1990, 716 pp., $95.

This book is remarkably and, in some cases, formidably comprehensive. In encyclopedic format, it deals with every solid-liquid separation method ever mentioned in the chemical engineering literature.

As its editor succinctly describes in the foreword, "The book comprises chapters on basic fundamentals, on principles and on equipment, as well as on various important aspects of solid-liquid separations such as filter aids, washing, flocculation, etc. The emphasis is on the use of equipment rather than on its design, although the latter is not ignored; consequently, the book will probably be most useful to chemical engineers and process engineers, particularly those in plant operation, plant design, or equipment testing and commissioning. I hope we have managed to strike a good balance between practical and academic considerations as both are equally important and cannot be separated."

In addition to the above-mentioned topics, the editor manages to include to a remarkable extent such subjects as flotation, membrane separations, high gradient magnetic separation, and the thermodynamics of solid-liquid separation.

Ten of the 23 chapters are written by the editor, Svarovski, who is an internationally recognized authority on the broad field of solid-liquid separation. He has a particular research interest in hydrocyclones, but is probably best known for his books and for the seminars or short courses he has been giving on solid-liquid separations for perhaps the last 30 years. The rest of the chapters are written by a mix of academics and industrialists. All are recognized experts in the specific fields covered. Professor Ives, for example, who wrote the chapter on deep bed filtration, has been recognized as the preeminent authority on the subject for as long as this reviewer can remember.

As might be expected in a book written by many authors, there are some different viewpoints and emphases in the various chapters. Academic authors tend to place more emphasis on elaborating theories and mathematical models, while industrial practitioners tend to go further into engineering and process aspects. Also there are some differences in the skill with which the subjects are organized and presented. However, all are reasonably well written, and most are very well written indeed. All are comprehensive and clearly authoritative.

At this point comments will be made on a couple of local items in the book.

Sedimentation devices act as classifiers when the feed solids are not flocculent. Some fractions of fines below a cut-off size do not settle into the underflow and thus escape into the overflow. Hydrocyclones, DSM screens, and, to a considerable extent, solid bowl centrifuges deflocculate solids and act as classifiers even on flocculated feeds. Classification theory, although not named as such, is covered in a chapter titled "Efficiency of Separation of Particles from Fluids." In it certain separation processes are described using combinations of separators. One combination, however, is given special attention in a separate chapter.

A combination often encountered in practice is the use of a solid bowl centrifuge to further dewater the underflow from a gravity thickener. The overflow from the solid bowl, which contains escaping fines, is returned to the thickener feed. This recirculation of fines can, and in practice too often does, lead to disaster. Fines build up in the circuit until the thickener becomes overloaded. This problem is treated at length in a chapter titled "Problems with Fine Particle Recirculation." Every process designer should be aware and mindful of this problem, but, to the best of the reviewer's knowledge, it is not covered elsewhere in the literature. Its treatment here is an indication of how comprehensive the coverage of the field is in the book.

Overall, the book is so strong and well written that it seems like nitpicking to focus on weakness in one part of a chapter. The review of the theory in the chapter on gravity thickening (which is the reviewer's field of interest) contains several misconceptions, some of which are inherited from the literature. These misconceptions regarding theory do not detract from the bulk of the chapter, dealing with test procedures for determining thickener specifications, with thickener designs, and with applications. In these more practical aspects, the chapter is remarkably sound and comprehensive.

To justify criticism of the theoretical treatment the following misconceptions and/or shortcomings are noted. The description of the zones that form in batch settling derives from the speculations of Comings et al. (1954). It is inconsistent with flux theories, notably that of Kynch (1952), which have since been developed. The well-known "first decreasing rate" segment of a settling plot is now conceived to result from successive arrival at the suspension-supernatant interface of free-settling Kynch zones having ever increasing concentrations and ever decreasing settling rates. The effect of initial concentration on the shape of settling plots is also now explained on the basis of the flux theory.

Contrary to what is asserted, the work by Coe and Clevenger did not concern "the settlement of noncolloidal particles as initially discrete units." Their method would not be relevant to such classifying suspensions, and their experimental work was done with strongly flocculating materials.

It is also asserted on the basis of one paper in the literature that "although the Coe-Clevenger and Talmage-Fitch methods for designing thickener dimensions from batch settling tests provide a useful tool for obtaining acceptable estimates, they are not nearly concise or precise enough for continuous thickener design." This is true enough. There is at this time *no* theoretically sound and empirically completely-reliable procedure for designing thickeners. All currently used mathematical models have theoretical shortcomings, and empirically the behavior of thickening suspensions can deviate widely from that predicted by the models. The author then goes on to present the flux theory as represented in geometric constructions introduced by Yoshioka et al., presumably more precise. However, the first Yoshioka diagram (their Figure 5.17), is simply a graph of the Coe and Clevenger equation for thickener flux as a function of concentration. Except that graphical procedures permit interpolation between data points, it gives no more precise information than the Coe and Clevenger procedure. The Talmage and Fitch construction is essentially a mathematical transform of the second Yoshioka construction, and as such is no less precise.

The operating lines in a Yoshioka diagram are not obtained by means of tests, as asserted. They are constructed on a Kynch plot by first choosing a value for c_u and then drawing the highest line from this value on the concentration axis that does not pass above the Kynch plot at any point between the initial concentration and c_u. The intercept of this line on the flux axis directly gives the maximum flux the thickener will handle. The particular advantage of the second Yoshioka construction is that operating lines for different values of underflow concentration can all be constructed on the same Kynch plot, without further tests.

Kynch theory, although mentioned, is not elaborated. Flux theory for determining compression zone behavior and depth, which has been presented in a number of papers, is mentioned only to note that such theories exist. Purely from the standpoint of practice, the latter omission is not unreasonable, since flux theories of compression have not yet been applied in practice. Kynch theory, on the other hand, is a basis for almost all modern thickening theories. From a theoretical standpoint, both theories are significant. It would have been desirable to have both theories treated the same way as other subjects to make the chapter more useful to those intending to do research.

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