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A theory of laminar flow stability, Hanks, Richard W., **AIChE Journal, 15,** p. 25 (January, 1969).

Key Words: A. Flow Stability-9, Stability Parameter-2, 9, Transition-9, Analysis-8, Angular Momemtum-1, Linear Momentum-1, Drag-1, Turbulence-2.

Abstract: In this paper an analysis of laminar flow stability is presented which leads naturally to the parameter in a much different manner than originally proposed. The stability parameter is seen to represent the coupling ratio between the rate of change of angular momentum of a deforming fluid element and its rate of loss of momentum by frictional drag. At a certain critical value of this coupling ratio, the element becomes unstable to rotational disturbances. If such disturbances are present, the basic nonlinearity of the momentum transfer process guarantees rapid amplification and generation of a turbulent eddy. The consequences of the theory are examined for two special fixed boundary classes of motion. The physical interpretation of the parameter is compared with conventional interpretations of the Reynolds number and found to be more fundamentally sound. The application of the theory to moving boundary flows, such as the Couette viscometer, is also discussed and an important physical difference is pointed out.

Graphical calculation of multiple steady states and effectiveness factors for porous catalysts, Stewart, Warren E., and John V. Villadsen, **AIChE Journal, 15,** p. 28 (January, 1969).

Key Words: A. Calculation-8, Reaction Rates-9, Diffusion-9, Heat Conduction-9, Multiple Steady States-9, Particle Stability-9, Porous Catalysts-5, Effectiveness Factor-7, Particle Size-6, Particle Shape-6, Reaction Kinetics-6, Variable Fluid Properties-6, Asymptotic Solutions-10, Polynomial Approximation-10, Orthogonal Collocation-10, Nonisothermal-0, Nonlinear-0.

Abstract: Simple graphical methods are given for predicting the effectiveness factors of single reactions in particles of various shapes. A collection procedure was used for small particles, and the known asymptotic solution was used for large particles. Multiple steady states and variable fluid properties can be handled directly. Examples are given for several nonlinear reaction rate laws.

On the particle size distribution function and the attrition of cracking catalysts, Gwyn, J. E., **AIChE Journal, 15,** p. 35 (January, 1969).

Key Words: A. Attrition-8, Cracking Catalyst-9, 1, Fluidization-10, Elutriation-10, Retention-4, Loss-4, 7, Time-6, Particle Size-6, Attritability-6, Rate-7, Fines-3, Air-5, Gas-5. B. Attrition-8, Cracking Catalyst-9, Particle Size Distribution-9, 1, 2, 6, 7, Mathematical Analyses-10, Loss-7, 4, Integral Rate-2, Fines-3, Primary-0.

Abstract: The rate of attrition of a catalyst sample of a single particle size can be expressed by a simple function of initial diameter and of time. The initial rate is a function of initial diameter, whereas the decrease in attrition rate of a catalyst of a given size as the catalyst ages depends only on time.

The attrition equation for a single size of particles is introduced into the particle size distribution function and, through mathematical analyses, yields a relationship for the attrition of a full size-range catalyst. The form of this relationship, which includes terms for attritability and severity of attrition conditions, is verified by laboratory and commercial attrition data on two full-range catalysts. The size distribution of an attrited sample is not expressible in simple analytical form, but is readily obtained by numerical analysis.

An approximate solution for countercurrent heat exchangers, Tien, Chi, and Seshadri Srinivasan, **AIChE Journal, 15,** p. 39 (January, 1969).

Key Words: A. Heat Exchanger-4, Counter Flow-8, Heat Transfer-8, Multistream Forced Convection-8, Integral Method-10.

Abstract: An approximate solution is presented for the countercurrent parallel plate exchanger with laminar flow. Using the integral method, the problem is reduced to one of solving a pair of first-order differential equations in a straightforward manner. Comparisons between the results of this work and those obtained from a more elaborate orthogonal expansion technique are found to be excellent.

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State, which are used rather extensively in preference to others.

It appears that students using this book might acquire a speaking knowledge of microscopic and the macroscopic postulates of thermodynamics but it is doubtful that they will acquire a working knowledge of thermodynamics. Without the latter, the student cannot make the necessary thermodynamic calculations that arise in other engineering problems.

This compromise between statistical and classical thermodynamics is a good book for the library but is not a suitable text for third year students in Chemical Engineering.

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Mass Transfer Operations, Second Edition, Robert E. Treybal, McGraw-Hill, New York (1968). 717 pages. $15.75.

In the thirteen years which have elapsed since the first edition of this excellent text, numerous changes in the training of chemical engineers have taken place. Consequently a revised treatment of this important subject is most welcome.

The general format and arrangement of subject matter has been retained while, at the same time, the design approach so successful in the past, is still emphasized. The number of chapters and chapter headings remain the same. The most significant changes appear in the first five chapters, devoted to the underlying principles of diffusion and mass transfer where the influence of the more recent approach to the theory of the transport processes is apparent. The basic features, for example, of the film, penetration, surface-renewal, and combined film-surface-renewal theories are compactly treated as are also the several transport analogies.

The chapter on gas-liquid contacting equipment has been updated and the list of references reflecting current design practices greatly expanded. The use of enthalpy-concentration methods is now included in the chapter on distillation and quantitative methods for handling multicomponent systems in absorption and distillation are given. Unfortunately, as in the first edition, treatment of phase equilibria, particularly of nonideal systems, is still sketchy. Limitations of space, however, preclude an adequate treatment of this complicated field.

The numerous illustrative problems have been revised and made more comprehensive. They form an integral part of the text. The number of ref-

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erences at the end of each chapter, particularly of the more recent literature, has been increased. Many new problems have been added and occasionally answers are given. These problems appear to be lengthier and more difficult than those of the first edition but do not require a mathematical facility beyond undergraduate calculus.

The author has retained the clarity of expression characteristic of the previous volume and the typography is excellent throughout. This volume should prove most useful not only to the chemical engineering student but to the practicing engineer desiring to bring himself up-to-date on the state of the art of the several mass-transfer operations.

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Analysis and Simulation of Multiport Systems, Dean Karnopp and Ronald C. Rosenberg, Massachusetts Institute of Technology Press, Cambridge (1968). 221 pages. $10.00.

Dynamic systems have been represented by several methods. The most used method is through differential equations. Other methods that are used are circuit graphs, signal flow diagrams, block diagrams, etc. Each of these have their advantages and disadvantages and are useful for specific types of systems.

The authors introduce a new method, the bond graph, first introduced by Henry M. Paynter in 1961. The authors state that "In order to make the analysis of a large system tractable, the models of the component parts must be rather simple, and it is usually the simpler models within fields of specialization that turn out to be closely analogous to models in other fields. These observations lead one to seek a uniform way to describe dynamic models of physical systems that traditionally fall into specialized categories but do not have a great deal in common". They present the bond graph to accomplish this objective.

To quote again "The mechanism for the convenient and rigorous system of power flow is the bond graph, and the main purpose of this study will be to present rules and methods for working with bond graphs". The concepts and notation are new and therefore the Theory of bond graphs is not as complete as that of more developed theories.

The authors list the goals of bond graph methods, which briefly are:

1. Provide a uniform mechanism for

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Mass transfer driving forces in packed and fluidized beds, Wilkins, George S., and George Thodos, **AIChE Journal, 15,** p. 47 (January, 1969).

Key Words: A. Celite Particles-1, Reactor Bed-1, Actual Driving Force-4, Carrier Gas-5, *n*-Decane-5, Hydrocarbon-6, Bed Height-6, Concentration Gradient-7, Driving Force-8, Packed Bed-9, Fluidized Bed-9, Hydrocarbon Analyzer-10, Steady State-10.

Abstract: The evaporation of *n*-decane into air from the surface of Celite particles has been used for the establishment of mass transfer factors for both packed and fluidized bed systems. For these calculations log-mean partial pressure differences were used. Actual concentration profiles of the transferable component were also experimentally measured by monitoring, at different bed heights, the concentration of *n*-decane vapor present in air used as the carrier gas. This was made possible through the use of an extremely sensitive hydrocarbon analyzer. The resulting profiles were used to obtain by graphical integration the actual driving force prevailing each run. A nearly one-to-one correspondence was found to exist between the actual driving force and the corresponding log-mean value for both packed and fluidized bed runs.

Liquid film flow rates in two-phase flow of steam and water at 1000 lb./sq.in.abs., Singh, Kuldip, W. A. Crago, E. O. Moeck, and C. C. St. Pierre, **AIChE Journal, 15,** p. 51 (January, 1969).

Key Words: A. Two-Phase-8, Annular Flow-8, Porous Sinter-10, Steam-Water-8, Tube-10, Burnout-4, Entrainment-4, Mass Flux-6, Quality-6, Sinter Length-6, Film Flow Rates-7, High Pressure-5, Adiabatic-5.

Abstract: A knowledge of liquid film flow-rates is important for design purposes when accurate predictions are required of the conditions under which dryout heat flux occurs in nuclear reactors and boilers. Liquid film flow-rates were measured for a steam-water mixture in cocurrent, upward annular flow in a tube at a pressure of 1,000 lb./sq.in.abs. Sinters located at the test section exit were used to extract the liquid film after the method of the Harwell group. Sinter lengths of 2, 1, and ½ in. were employed to investigate the effect of length on the extracted liquid flow rates. The test section was a stainless steel pipe I.D. 0.493 in., approximately 200 diam. in length. The total mass flux ranged from 0.2 to 0.7×10^6 lb.m/hr.sq.ft. and the quality varied from 0.3 to 0.92.

The experimental film flow rates were found to increase with decreasing quality. In the range of parameters investigated, the curves of film flow rate at constant quality vs. mass flux showed a maximum at a fixed value of steam velocity. At the same total mass flux and quality the film flow from the ½ in. sinter was lowest suggesting that the crests of high amplitude roll waves overshot the sinter. Film flow-rates were consistently higher than the theoretical predictions using Levy's model. About one-third of the measured flow rates were twice as high as predicted.

Sensitivity of a class of distributed parameter control systems, Sienfeld, John H., **AIChE Journal, 15,** p. 57 (January, 1969).

Key Words: A. Sensitivity-8, Control-8, Distributed Parameter Systems-8, Parameter Variations-8, Algorithm-10, Optimization-9.

Abstract: A sensitivity matrix is defined as a measure of trajectory deviations to small parameter variations of both open and closed-loop controlled nonlinear parabolic and first-order hyperbolic systems. In general the parameters may enter through the system equations or the boundary conditions and may be time or spatially dependent. The introduction of a positive measure of the sensitivity, the norm of the sensitivity matrix, into the performance index is shown to be effective in limiting the trajectory deviations due to the parameter variations. The open and closed loop control of a double pipe heat exchanger is analyzed with the open-loop problem solved by an approximate procedure. The sensitivity reformulation is successful in reducing trajectory sensitivity, however at the cost of decreased overall performance.

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