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Optimal control of a continuous flow stirred tank chemical reactor, Javinsky, Martin A., and Robert H. Kadlec, **AIChE Journal, 16,** No. 6, p. 916 (November, 1970).

Key Words: A. Control-8, Nonlinear-0, Optimization-8, Reactor-9, Continuous Stirred Tank Reactor-9, Sodium Hydroxide-1, Ethyl Acetate-1, Sodium Acetate-2, Ethyl Alcohol-2, Saponification-10, Analog Computer-10, Experimental-0, Pontryagin's Method-10.

Abstract: The time optimal control problem for a jacket-cooled CSTR with an exothermic, irreversible, second order, homogeneous liquid phase reaction (the saponification of ethyl acetate) was solved with the maximum principle and phase plane analysis. Both experimental studies and analog computer simulation studies were conducted. The overall performance of the experimental system agreed very well with the performance of the corresponding system simulated on an analog computer.

Withdrawal of flat plates from power law fluids, Tallmadge, John A., **AIChE Journal, 16,** No. 6, p. 925 (November, 1970).

Key Words: A. Entrainment-8, Withdrawal-8, 9, Films-9, Thickness-7, 8, Flow Rate-8, Theoretical-0, Speed-6, Plates-9, Flat-0, Fluids-9, Non-Newtonian-0, Power Law-0, Carbopol-9, Rheology-8.

Abstract: A new one-term withdrawal expression for power law fluids is developed from theoretical equations. Comparison with film thickness data for three carbopol fluids indicates agreement similar to that observed with valid Newtonian theories. The agreement was verified by comparison with independent measurements of entrainment flow rate.

Concentration fluctuations and chemical conversion associated with mixing in some turbulent flows, Torrest, Robert S., and William E. Ranz, **AIChE Journal, 16,** No. 6, p. 930 (November, 1970).

Key Words: A. Measurement-8, Fluctuation-8, 9, Concentration-8, 9, Chemical Reaction-9, Conductivity Probes-10, Mixing-9, Solutions-9, Salts-9, Jets-10, Mass Transfer-8.

Abstract: Microconductivity probes were used for the measurement of point values of mean concentrations and root mean square concentration fluctuations for mixing of salt solutions in turbulent shear flows. Mixing studies covered a range of flow conditions and included ducted turbulent jets, dispersion in turbulent pipe flow, a plane mixing zone, and several multiple injection systems. The results for mixing experiments are compared with available previous work. Reaction product concentrations for a rapid, second order, irreversible reaction in multiple injection systems, the plane jet, and the mixing zone were also obtained.

Optimal probability partial control of linear inventory systems, Kim, S. M., and Douglas J. Wilde, **AIChE Journal, 16,** No. 6, p. 943 (November, 1970).

Key Words: A. Control-8, Partial Controllability-8, Process-9, Inventory-9, Level-9, Tank-9, Mathematical Model-10.

Abstract: Most processes have more storage levels to control than there are production rates for changing inventories, a situation known as "partial controllability." Necessary and sufficient conditions under which all levels can be held within predetermined limits are presented. A control law maximizing the probability of satisfactory operation is developed, together with the computational steps required for its implementation. A simple numerical example is given.

The purification of helium gas by physical adsorption at 76°K., Kidnay, A. J., and M. J. Hiza, **AIChE Journal, 16,** No. 6, p. 949 (November, 1970).

Key Words: A. Adsorption-8, 10, Purification-8, Helium-9, Charcoal-5, Methane-3, Nitrogen-3, Mixtures-9, Breakthrough Time-8, Mass Transfer Coefficient-8.

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Applied Numerical Methods, B. Carnahan, H. A. Luther, and J. O. Wilkes, John Wiley and Sons, New York (1969).

Recent years have seen the availability and use of digital computers expand to the point where many practical problems of engineering and science are readily solved on such machines. Since a digital computer performs only arithmetic operations, it is necessary to approximate the many mathematical operations which arise by using numerical methods. Carnahan, Luther, and Wilkes have written a book which presents most of the presently available numerical methods, stressing their application to practical problems using a digital computer. It concentrates on the use of each method, with many examples, plus a thorough discussion of the magnitude and type of errors to be expected.

The book should be of particular value as a text in a senior-level computer applications course, since it contains a number of completely worked computer examples. Its emphasis on the use of the computer to get numerical answers to real problems should complement the mathematical approach now so well presented to engineering undergraduates. In addition, the book should be of real value to the practicing engineer, as a source of information regarding newer mathematical topics and their application to practical problems.

The first chapter presents a good summary of the various polynomial forms for interpolation and approximation of functions. It includes a consideration of the less commonly encountered Chebyshev polynomials, especially useful for minimizing the maximum error for the polynomial representation of a given function. Next, the authors give an excellent presentation of techniques for numerical integration, beginning with conventional equal-interval procedures and following with methods applicable to unequally spaced base points. Numerical differentiation is touched on only briefly. The third chapter considers numerical approaches to the determination of the roots of algebraic equations. Emphasis is placed on the solution of polynomial equations, but several of the techniques considered can also be applied to transcendental equations.

The next section summarizes the basic background information concerning the nomenclature of matrices and the operations possible with them. A number of good examples illustrate the

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Abstract: The physical adsorption isotherms for three methane-helium mixtures, two nitrogen-helium mixtures, and one methane-nitrogen-helium mixture were measured at 76°K. and pressures of 2 to 65 atm. on a coconut shell charcoal. The adsorption isotherms of the pure components were also determined over the appropriate pressure ranges. The concentration versus time or breakthrough curves were also measured for both the binary and ternary mixtures at a number of different flow rates. Mass transfer coefficients for both the gas phase and the adsorbed phase were obtained from these breakthrough curves.

The mechanism of heat transfer in a spray column heat exchanger: II. Dense Packing of Drops, Letan, Ruth, and Ephraim Kehat, **AIChE Journal, 16,** No. 6, p. 955 (November, 1970).

Key Words: A. Heat Transfer-7, 8, Temperature-8, Water-9, Spray Column-9, Packing-10, Dense-0, Kerosene-5, Velocity-6, Wakes-6, 7, Mathematical Model-10.

Abstract: Temperature profiles of water in a spray column heat exchanger operating with a dense packing of kerosene drops were measured. The physical picture of heat transfer is similar to that for dispersed packings of drops and emphasizes the dominant role of wakes in the heat transfer mechanism. The mathematical equations for dispersed packings of drops were modified to take into account the reduction of wake size at the interface of the two packings and the difference in the mixing patterns at the top of the column.

Laminar flow in the entrance region of a cylindrical tube, Part I: Newtonian Fluids; Part II: Non-Newtonian Fluids, Sylvester, N. D., and S. L. Rosen, **AIChE Journal, 16,** No. 6, p. 964 (Pt. I), p. 967 (Pt. II) (November, 1970).

Key Words: A. Flow-8, Fluids-9, Entrance-9, Tubes-9, Cylindrical-0, Newtonian-0, Non-Newtonian-0, Glycerine-9, Water-9, Polymers-9, Pressure Loss-7, 8, Reynolds Number-6.

Abstract: Pressure losses at the entrance to a cylindrical tube were investigated in these studies. Part I is a study of Newtonian fluids, namely, glycerine-water solutions; and Part II is a study of non-Newtonian fluids, namely, aqueous polymer solutions. In laminar, fully developed, steady tube flow, elastic and inelastic fluids are indistinguishable. Viscoelastic fluids exhibited much higher entrance pressure losses than did inelastic fluids with comparable viscous properties. A method has been developed for separating the elastic portion of the overall entrance loss and shows that in some cases the elastic contribution represents as much as 80% of the total. An analysis is also presented which allows calculation of the elastic entrance loss in terms of a Hookean shear modulus.

The effect on conversion of flow rate variations in a heterogeneous catalytic reactor, Denis, G. H., and R. L. Kabel, **AIChE Journal, 16,** No. 6, p. 972 (November, 1970).

Key Words: A. Rate-6, Flow-9, Conversion-7, Reactor-10, Heterogeneous-0, Tubular-0, Catalyst-10, Ion Exchange Resin-10, Mathematical Model-10, Composition-7, Product-9, Production-7, Ethanol-1, Water-2, Ethyl Ether-2.

Abstract: The unsteady state behavior of a tubular heterogeneous catalytic reactor, in which significant adsorption effects occur, has been investigated theoretically and experimentally. Transient responses of conversion to step increases and decreases of flow rate as well as to periodic variations in flow rate are considered. To evaluate the model, experiments were performed on the vapor phase dehydration of ethanol to diethyl ether as catalyzed by ion exchange resin in the acid form.

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mechanical steps associated with the various matrix procedures. This leads directly into a presentation of methods available for the solution of systems of simultaneous linear equations, with some extension to nonlinear equations. Both direct and iterative techniques are given, with the former useful for systems of the order of forty or fewer equations and the latter appropriate when dealing with larger systems. A in previous chapters, completely worked examples are given to illustrate the utility of each of the methods described.

The next two chapters summarize the many available approaches to the numerical solution of differential equations, both ordinary and partial. Emphasis is on the solution of initial condition problems, with careful analysis of the expected error and its propagation. Boundary-value problems are also considered, but only in a limited manner. Partial differential equation solution procedures are also presented, again with emphasis on specific examples worked out in detail. Although the examples given are relatively simple, the basic approaches can be applied to a wide variety of more complex situations, several of which are outlined in the text.

The concluding chapter emphasizes the need for statistical methods in the analysis and use of data from real physical situations. The basic ideas of statistical analysis are presented, and a number of statistical procedures are described. The practicing engineer with little statistics background should find the summary quite useful, but more thorough grounding in statistical analysis will be necessary to be able to apply the various procedures to more complex situations.

In summary, "Applied Numerical Methods" is an unusually well-written book. Its emphasis on the inclusion of carefully documented and completely worked out computer examples makes it of considerable value both to undergraduate engineering students and to practicing engineers. It should be in the library of every engineer who uses, or hopes to use, the digital computer as a tool in the numerical solution of practical engineering problems.

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