LETTERS TO THE EDITOR

TO THE EDITOR: ON OPTIMIZATION BY GEOMETRIC PROGRAMMING

In a recent paper Rijckaert and Martens (1974) used geometric programming to optimize the Williams-Otto process. In presenting their result of 121.54 as the optimal profit, there is an implication that the optimization procedure of Luus and Jaakola (1973) which gave an optimum of 121.53 had not yielded the true optimum for this problem. The purpose of this letter is to clarify this point.

To check the results directly, the computer program given by Jaakola and Luus (1974) can be used directly with only a minor modification involving the performance index. It can be easily seen that the results reported by Rijckaert and Martens are inconsistent with respect to the equality constraints of the problem. If the data of Rijckaert and Martens for T, F_{RC}, F_{RB} and β are used and the other functions evaluated from the equality constraints, a profit of 119.84 results.

By using this as a starting point for optimization, we obtained a maximum profit of 121.534 which is the same as reported by Luus and Jaakola (1973). Other starting conditions also yielded the same result. It is concluded therefore that the optimum profit for this problem is 121.53 and not 121.54.

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2. Luus, R., and T. H. I. Jaakola, "Optimization by Direct Search and Systematic Reduction of the Size of Search Region," *AIChE J.*, **19**, 760 (1973).
3. Rijckaert, M. J., and X. M. Martens, "Analysis and Optimization of the Williams-Otto Process by Geometric Programming," *ibid.*, **20**, 742 (1974).

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REPLY

We would like to add the following three remarks to the letter of R. Luus concerning our paper "Analysis and Optimization of the Williams-Otto Process by Geometric Programming."

1. It was clearly stated in the scope of our paper that our goal was to use G. P. to carry out an analysis of the W.O.-process and that by no means was our intention to put forward a new optimal solution. (The relative difference between the solution reported in our paper and the one obtained by Luus is less than 0.005%.)

2. Since in G.P. the values of the primal variables were derived based on the dual variables and since this operation was performed in single precision—mainly because of the reason stated under—the primal variables will be subject to small rounding errors. To call such a solution inconsistent is at least an overstatement.

3. The value 119.84 was obtained by selecting 4 variables and assuming that they are not contaminated by any error. A value obtained this way will of course depend on the selection of these variables. However, it can be checked easily that if the primal objective function is computed on the basis of all our primal variables, the right optimal value is found (and not 119.84). (Note: An optimization procedure based on an elimination scheme as mentioned by Luus does not in general guarantee the non-negativity of the eliminated variables and might henceforth lead to an infeasible solution.)

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TO THE EDITOR: LABORATORY REACTORS AND THEIR LIMITATIONS

In response to the editor's request for offering constructive suggestions toward improving the Journal, I would like to complement him for publishing the Journal Review article by V. W. Weekman, Jr. I am sure the review will be useful to those who teach reactor design and hopefully will be read by those who are responsible for building pilot plants based on limited reaction rate data.

In view of our energy crisis and this country's abundance of coal, many pilot plants and commercial facilities are being designed and built to make clean fuels from coal. Also in view of some of our safety problems associated with nuclear reactors and the quadrupling of the price of oil during the past year, pressure will be exerted upon the utilities to burn more coal for power generation. This necessitates the removal of sulfur, probably from the stack gases. Efficient design of reactors for these systems calls upon the knowledge of reaction rate data in which one of the reactants is a solid that is consumed by the reaction. For example, in hydrogasification carbon reacts with hydrogen to make methane, in removal of sulfur from stack gases sulfur dioxide and oxygen react with calcium oxide to form sulfates. Such reaction rate studies frequently utilize laboratory reactors not discussed by Dr. Weekman, such as the thermobalance. Like the catalyst deactivation example of Dr. Weekman, these reactions due to the consumption of the solid are always in the transient state. Yet an examination of the literature (Gidaspow, 1972) indicates to this writer that the differential reactor does not deserve the poor rating ascribed to it by Dr. Weekman for transient behavior.

The other problems with the differential reactor pointed out by Dr. Weekman can also be overcome if the catalyst or active solid is made to form part of the wall of a tubular or parallel plate reactor. Thus our experience (Gidaspow and Ellington, 1964; Kulacki and Gidaspow, 1967) shows that high heat release rates for one of the fastest catalytic reactions known—combustion of hydrogen on platinum—are not a problem since surface temperatures can be sectionally controlled. In such reactors which are similar to automobile catalytic converters using monolithic supports channeling is not a problem. We find agreement between differential rate data and integral rate data (Onischak and Gidaspow, 1972, 1973). Finally, a clever suggestion by S. Katz (1959) applied to literature data by the writer (Gidaspow, 1971) can for sufficiently slow reactions even remove the inherent low conversion problem normally associated with a laboratory reactor built to operate as a differential reactor.

Since work with chemical reactions distinguishes chemical engineers from other engineers, I would like to see additional reviews on laboratory reactors. I would also like to suggest to the Directors of AIChE and to the editor that they solicit articles on energy and environmental R & D from

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given by Gentil et al. (p. 473). In addition to considering rather carefully questions of noise correlation and test signals, the authors provide a comparison of the results obtained by different methods, namely least squares, generalized least squares, maximum likelihood, and instrumental variables.

Aircraft and Transportation Systems

Several papers in the proceedings deal with the identification of aircraft dynamics including a survey by Rault (p. 49), a number of sophisticated case studies by Mehra and Tyler (p. 117), and an interesting application to ship dynamics by Åström and Källström (p. 415).

Biological and Economic Systems

A short survey of identification of biological systems is given by Bekey (p. 1123), and several other papers deal with specific systems such as the metabolic, the immune, the lungs, and the cardiovascular. Finally, there are three applications to economic models.

ADAPTIVE CONTROL

Although the IFAC Symposium was devoted to system identification and parameter estimation, it included a limited number of contributions to the closely related subject of adaptive control. Among these we may mention a paper of Peterka and Åström (p. 535) treating the design of self-adjusting regulators using an on-line identification technique, and a paper by Nikiforuk et al. (p. 555) on the control of a nonlinear plant of unknown structure. Finally, Ku and Athans (p. 571) consider a feedforward-feedback suboptimal control for a linear system with randomly varying parameters.

CONCLUDING REMARKS

The proceedings contain material that should be of considerable interest to chemical engineers. The survey papers, especially those which compare various identification methods, give a much needed perspective about what methods are available, how they differ from each other, and under which conditions one method is more suitable than others. One cannot escape the conclusion that further research or applications by chemical engineers should not concentrate in further development of methods but should be focused on a critical evaluation of various assumptions required in applying various methods to specific processes. For example, the statistical nature of random dynamic or measurement errors deserves careful consideration. The design of test signals that do not seriously disturb normal operation, yet provide an adequate excitation, is another. Among various specific applications presented, we recommend a careful study of those directed to power systems because of the serious effort made to utilize theory in a critical way. However, it must also be emphasized that most of this admittedly impressive work deals with linear models required for regulatory control. The modeling of complex nonlinear processes such as a catalytic cracking unit, with the objective of process design and optimization remains a virtually untouched area that will hopefully be taken up in all seriousness by chemical engineers.

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The McGraw-Hill Dictionary of Scientific and Technical Terms, Daniel N. Lapedes, Editor-in-Chief, McGraw-Hill Book Company, New York (1974). $39.50

How does one review a scientific dictionary? Especially one with almost 100,000 definitions and 2,800 illustrations? Spot checking of chemical engineering terms, for example *Marangoni effect, bag filter, Sherwood number,* yielded positive results. The definitions were brief but well-written. *Drag reduction* was not included, but even a book of this size cannot be expected to be all-inclusive.

In fact, the dictionary is a fascinating book in which to browse and learn. Most scientific and engineering fields are covered and my vocabulary was expanded to include *bra vector, Robin Hood's wind, free gold,* among many.

I invited my friends to supply me with terms from their fields and the results were excellent in all cases but one. An orinthologist was outspokenly critical since birds seem to have been somewhat neglected. To make matters worse, worms seem to be well represented (try *Rhynchocoela*). Her retort was, what is a worm without a robin?

The book will be invaluable for libraries and for all companies which must deal with the technical or scientific community. For individuals, it would be a delightful addition to the bookshelf—and in many cases, of real value.

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industrial people such as Dr. Weekman. To allow the editor to print more of such articles, AIChE should give the *Journal* more pages per year.

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ERRATA

In the last column of Table 2b of the article "Computational Methods for Cylindrical Catalyst Particles", [*AIChE J.*, **19**, 969 (1973)], 0.3682 should be 0.2682.

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In "Bisphenol A Synthesis: Kinetics of the Phenol-Acetate Condensation Reaction Catalyzed by Sulfonic Acid Resin" [**20**, 933 (1974)] by R. A. Reinecker and B. C. Gates, in Equation (4) and on the left-hand sides of Equations (5) to (7), the variable C should be replaced by θ, with θ defined as the fraction of sites occupied.

B. C. Gates