To the Editor:

The April 1993 issue contained a review of the book titled *Chemical Process Structures and Information Flows* by Prof. Mah. The reviewer commented that the contents of the book were largely theoretical and used pipeline network design as an example. When this material first appeared in research journals, some 15 years ago, I applied these concepts and principles to the application of two computer programs: one for pressure relief piping networks design and optimization and the other for the design and optimization of gas distribution networks. These programs offered great benefits including the design, and not just the checking, of a network, avoiding the tedious task of specifying the diameters of all branches of the network by hand, and achieving an optimal network design. They were used in the piping network designs of several Italian refineries. Both programs are still working to the full satisfaction of the users.

Ing. Francesco Lorino
Micro Techno
Roma, Italy

To the Editor:

In an R&D note titled "Flow of Yield-Pseudo-Plastic Fluids through a Concentric Annulus" (July, 1992), Gücüyener and Mehmetoğlu discuss the problem of calculating flow rate vs. pressure drop relations for yield-pseudo-plastic fluids flowing axially in a centered annulus, a reference case calculation for, *inter alia*, many oil-well drilling and cementing operations.

In reviewing previous work, this note states that "the axial laminar flow of such (yield pseudo-plastic) fluids in concentric annuli has received very little attention to date" and "this problem was first studied by Hanks (1979)." This is not entirely accurate historically. We dealt systematically with this problem in our article (Fordham et al., 1991), which covered three well-known rheological models (including the Robertson-Stiff), and made comparisons against solutions for the related pipe and infinite plane slot geometries and against experiment. Our own literature search (Fordham et al., 1991) revealed calculations for the case of Casson fluids (a yield-pseudo-plastic rheology) in concentric annuli from at least two sources prior to Hanks (1979): results were published in English by Shul'man in 1973, the Russian original having appeared in 1970. Similar work was the subject of a 1974 MS thesis (Jaisinghani, 1974), summarized in a book form review article in 1980 (Shah). Sources (Shul'man, 1973; Shah, 1980) are included in a 1983 review article (Bird et al., 1983).

In the above-mentioned note, the more awkward problem, "given a flow rate, calculate the pressure drop," is dealt with by a tabular method with interpolations where needed. The operations outlined are fundamentally an iterative solution, for the yield radii $\lambda_{i,o}$, of the two simultaneous Eqs. 9 and 15. Likewise, we found (Fordham et al., 1991) that this is the essence of the computation required (whatever the rheological model) to solve this problem, and we (Fordham et al., 1991) outline a robust algorithm for the numerical solution of the simultaneous equations. Running the Example (Gücüyener and Mehmetoğlu, 1992, Table 2) on our own code, we obtain the result 178.0 $\mathrm{Pa \cdot m^{-1}}$ for the pressure drop. The result 174.8 $\mathrm{Pa \cdot m^{-1}}$ is quoted by Gücüyener and Mehmetoğlu (1992), but the value $\gamma_o = 9.47\ \mathrm{s^{-1}}$ appears to be used in the final stage of the calculation, rather than $\gamma_o = 9.76\ \mathrm{s^{-1}}$ as specified and used elsewhere. If the latter value is used, 177.9 $\mathrm{Pa \cdot m^{-1}}$ is obtained, in close agreement with our own value. We also calculate the velocity profile (Figure 1). Our code is general for yield-pseudo-plastic rheologies, but we (Fordham et al., 1991) overlooked the interesting and ingenious point made by Gücüyener and Mehmetoğlu (1992) that with the Robertson-Stiff model some of the integrals in Eqs. 11 and 14 can be evaluated in closed form, eliminating some numerical integration.

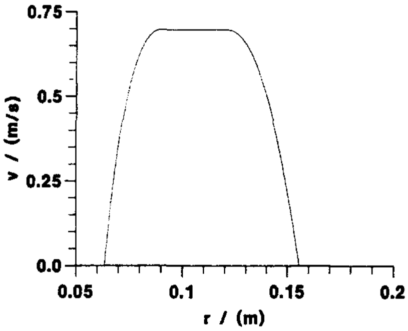

Figure 1.

However, if a tabular or design chart method is sought to solve practical problems, where flow rates and pressure drops are usually the variables of primary interest, it is not clear why Table 1 by Gücüyener and Mehmetoğlu (1992) should be the preferred tabulation. Having obtained values of λ_o (Table 1), explicit evaluation in Eqs. 7, 8 and 15 allows the construction of tables and/or graphs of a nondimensional flow rate $\Omega^* \equiv \Omega / T_o^s = Q/\pi\gamma_o R^3$ vs. a nondimensional pressure drop $(1-\sigma)/T_o = PR(1-\sigma)/2\tau_o$. (The latter group is also the reciprocal of the fractional plug-flow width, which may also be of practical interest.) Because neither dimensionless group suggested mixes Q and P, the solution of *either* type of practical problem (given flow or given pressure drop) is then immediate, apart from small interpolations which may be needed. For slightly different groups, this has indeed been done in Table 2, but only for a small subset of the parameter space spanned by Table 1; extending Table 2 to cover the same range of σ and n might be the more useful tabulation.

Literature cited

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Simon H. Bittleston
Edmund J. Fordham
M. Ahmadi Tehrani
Schlumberger Cambridge Research
Cambridge CB3 0HG, England

Reply:

We would like to thank Bittleson, Fordhan, and Tehrani for their interest in our work. We were aware of their work (Fordham et al., 1991) only after submission of our note. The other references cited by them, however, are limited to a specific rheological model of Casson. Hanks (1979), on the other hand, used a rather flexible and general model (Herschel-Bulkley model) and presented very useful design charts which make practical engineering calculations quite easy. Therefore, Hanks' article still appears to be a pioneering work on this subject.

From Eq. 15 of our note, one can directly calculate the flow rate for a given pressure drop. Pressure drop calculation, however, requires an iterative solution due to the implicit character of Eq. 15 with respect to pressure drop. To simplify the solution of this type of problem, one may construct a design table with the aid of Table 1 and Eq. 15, as illustrated in our example 1. As pointed out by Bittleson et al., Table 2 in our note can be extended to cover the same range of σ and n used in Table 1, which incidentally had been already prepared but was not submitted due to the page limitation. The velocity profile of our example was not also shown for the same reason.

We would also like to thank Bittleson et al. for their correction of the pressure drop which was erroneously calculated in our note as 174.8 $Pa \cdot m^{-1}$, instead of 177.945 $Pa \cdot m^{-1}$, due to the use of the wrong value of 9.47 s^{-1} for γ_o, instead of 9.76 s^{-1}. It is clear that their algorithm gives nearly the same value (178 $Pa \cdot m^{-1}$) as our exact solution.

Literature cited

Fordham, E. J., S. H. Bittleson, and M. A. Tehrani, "Viscoplastic Flow in Centered Annuli, Pipes and Slots," *Ind. Eng. Chem. Res.*, **29**(3), 517 (1991).
Hanks, R. W., "The Axial Laminar Flow of Yield-Pseudoplastic Fluids in a Concentric Annulus," *Ind. Eng. Chem. Process Des. Dev.*, **18**(3), 488 (1979).

Tanju Mehmetoğlu
Hakki Gücüyener
Dept. of Petroleum Engineering
Middle East Technical University
06531 Ankara, Turkey