$Na_2Cr_2O_7$ balance (define as F_c)

$F_c = F_{Co} - (F_{Ao} + R_A)\, X_A\, (c/a) = 2.2 - 2.7\ (2/3)$

$= 0.4$ moles/time $Na_2CR_2O_7$ out in W.

CH_3COOH balance (define as F_D).

$F_D = F_{Do} + (F_{Ao} + R_A)\, X_A\, (d/a) = 0 + 2.7\ (3/3)$

$+ 2.7$ moles/time CH_3COOH out in P.

$Cr_2(SO_4)_3$ balance (define as F_E).

$F_E = F_{Eo} + (F_{Ao} + R_A)\, X_A\, (e/a) = 0 + 2.7\ (2/3)$

$= 1.8$ moles/time $Cr_2(SO_4)_3$ out in W.

Na_2SO_4 balance (define as F_F).

$F_F = F_{Fo} + (F_{Ao} + R_A)\, X_A\, (f/a) = 0 + 2.7\ (2/3)$

$= 1.8$ moles/time Na_2SO_4 out in W.

H_2O balance (define as F_w).

$F_w = F_{wo} + (F_{Ao} + R_A)\, X_A\, (w/a) = 0 + 2.7\ (11/3)$

$= 9.9$ moles/time H_2O out in W.

Recycle stream analysis

$R/F_1 = 1 \rightarrow R = F_1 = 3$ moles/time

$R_A + R_s = R \rightarrow R_s = 3 - 0.176 = 2.824$ moles/time H_2SO_4 in R.

We can now find:

1. Moles of waste stream W out.
   $W = F_A + F_s + F_E + F_F + F_w$
   $W = 0.3 + 2.4 + 0.4 + 1.8 + 1.8 + 9.9 = 16.6$ moles/time of W.
2. Mole % composition of recycle stream.
   % $C_2H_5OH = (0.176/3)\ 100 = 5.9$ mole %
   % $H_2SO_4 = 100 - 5.9 = 94.1$ mole%
3. Over-all conversion of $H_2SO_4 = [(F_{So} - F_S)/F_{So}] = (9.6 - 2.4)/9.6 = 0.75$ or 75%
   Once-through conversion of $H_2SO_4 = [(F_{So} - F_S)/(F_{So} + R_S)] = (9.6 - 2.4)/[9.6 + (3 - 0.176)] = 0.58$ or 58%

A total over-all material balance shows that

$$\left[\frac{\text{moles out}}{\text{time}} - \frac{\text{moles in}}{\text{time}}\right] = (W + P) - (F_1 + F_2)$$

$$= 16.6 + 2.7 - 3\ (2.2 + 9.6) = 4.5$$

Comparing this with the term $[F_{Ao} + R_A)\, X_A\, \Delta n]/a = [(3 + 0.176)(0.85)]\, [(3 + 2 + 2 + 11) - (3 + 2 + 8)]/a = 4.5$

which emphasizes its equality to the change in moles for the over-all process. Also, weight compositions or flow rates are readily obtainable by using the molecular weights of the various species.

CONCLUDING REMARKS

The methodology for handling steady-state recycle calculations presented here is not meant to be a panacea nor a replacement for thinking. However, beginning students often need (and welcome) a clear, consistent approach to solving these kinds of problems. Based on my teaching experience in this area, I have found this approach to be direct and appealing to the students. It incorporates the chemical stoichiometry and the fundamental definition of the once-through degree of conversion of limiting reactant which are repeating elements in the material balance calculations. □

ChE news

KELLY LECTURER NAMED

Dr. Warren E. Stewart of the University of Wisconsin at Madison, has been named the Kelly Lecturer for 1979 by Purdue University. Stewart has been an outstanding contributor to ChE literature and his contributions in the area of approximate methods have had a profound impact on many diverse areas of chemical engineering. He has published, lectured and consulted extensively on transport phenomena, reactor modelling and numerical methods.

DONALD L. KATZ AWARD

The 1979 recipient of the Donald L. Katz Lectureship Award, presented annually by the University of Michigan, is Dr. Robert S. Schechter of the University of Texas at Austin. Dr. Schechter has served in a number of administrative capacities during his career and has authored or co-authored more than 100 technical publications and three books in the areas of applied surface science and irreversible thermodynamics.

ChE conferences

ADVANCED SEMINAR ON DYNAMICS AND MODELLING OF REACTIVE SYSTEMS

• The Mathematics Research Center at the University of Wisconsin-Madison will hold an Advanced Seminar on Dynamics and Modelling of Reactive Systems, October 22-24, 1979. Lecturers will include N. R. Amundson, R. Aris, D. G. Aronson, G. F. Carrier, M. Feinberg, E. D. Gilles, P. S. Gough, L. N. Howard, J. B. Keller, D. Luss, J. Rinzel, R. A. Schmitz, J. H. Seinfeld and F. A. Williams. A detailed program will be available in August. Further information may be obtained from Mrs. Gladys Moran, Mathematics Research Center, Univ. of Wisconsin, 610 Walnut Street, Madison, Wisconsin 53706.

M.I.T.

• July 23 - August 1: **"New Developments in Modeling, Simulation and Optimization of Chemical Processes,"** at Massachusetts Institute of Technology. For further information, contact: Director, Summer Session, M.I.T., Room E19-356, Cambridge, MA 02139.

MICHIGAN

• 1979 Engineering Summer Conferences at the University of Michigan include:

- June 25-29: **"Applied Numerical Methods"**
- July 9-13: **"Physiological Systems for Engineers"**
- July 9-10: **"Solar Energy Measurements and Instrumentation"**

For further information, contact: Continuing Engineering Education, 300 Chrysler Center, North Campus, University of Michigan, Ann Arbor, MI 48109.