as depreciation remains constant. Notice the negative NPV for both of these cases. This is because the actual IRR is less than the 20% rate of return used to calculate the NPV. The obvious advantage of debt financing in this problem is due to the low interest rate on the loan (10%). Finally, comparison of cases 7 and 8 shows that inflation has no effect on the before-tax return when there is no loan. This is because all of the remaining cash flow items are assumed to inflate at the same rate. Depreciation has no effect on the before-tax returns.

The effect of the depreciation method on the IRR and on the NPV is shown in Table 5. Both double-declining balance and sum-of-the-years' digits produce similar results and are superior to the straight line method. This is because the depreciation allowance is accelerated in the early years of the project reducing taxes and shifting after-tax income to the early years where it counts more. The double-declining balance method used by the program switches automatically to straight-line in the later years of the project as allowed by the rules of the Internal Revenue Service.

TABLE 5
Effect of Method of Depreciation on the Rate of Return and the Net Present Value

Depreciation Method	IRR, %	NPV @ 20% k$
Straight-line	34.22	3,300
Double-declining balance	38.19	3,890
Sum-of-the-years' digits	38.30	3,943

Percent debt: 70%
Tax Rate: 48%
Inflation Rate: 8%

CONCLUSIONS

Two computer programs have been developed which are suitable for use by students in process design courses. The equipment cost estimation program is flexible, easy to use and based on the latest cost correlations available, those from project ASPEN. The economic evaluation program frees the student from the tedious trial-and-error calculations which are involved in the determination of the internal rate of return. The program is realistic as it accounts for depreciation, income taxes and inflation. □

ACKNOWLEDGMENT

The authors wish to express their appreciation to the staff of project ASPEN, MIT Energy Laboratory, for the cost correlations used in the equipment cost estimation program, and to Banco Central de Reserva de El Salvador for the support of Mr. Kuri.

REFERENCES

1. Bussey, L. E., *The Economic Analysis of Industrial Projects*, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1978.
2. Evans, L. B., et al., "Computer-Aided Industrial Process Design," The ASPEN Project, Eleventh Quarterly Progress Report, Massachusetts Institute of Technology, Cambridge, MA, March 15, 1979.
3. Evans, L. B., et al., "Computer-Aided Industrial Process Design," The ASPEN Project, Thirteenth Quarterly Progress Report, Massachusetts Institute of Technology, Cambridge, MA, September 15, 1979.
4. Evans, L. B., et al., "Computer-Aided Industrial Process Design," The ASPEN Project, Fourteenth Quarterly Progress Report, Massachusetts Institute of Technology, Cambridge, MA, December 15, 1979.
5. Kohn, Philip M., "CE Cost Indexes Maintain 13-year Ascent," *Chemical Engineering*, Vol. 85, No. 10, May 8, 1978, pp. 189-192.
6. Kuri, C. J., "Process Equipment Cost Estimation and Economic Evaluation," M.S. Thesis, Department of Chemical Engineering, Louisiana State University, Baton Rouge, Louisiana, 1980.
7. Peters, M. S., and K. D. Timmerhaus, *Plant Design and Economics for Chemical Engineers*, 3rd. ed., McGraw-Hill, New York, 1980.
8. Pikulik, A., and H. E. Diaz, "Cost Estimating for Major Process Equipment," *Chemical Engineering*, Vol. 84, No. 22, Oct. 10, 1977, pp. 106-122.
9. Richardson Engineering Services, *Process Plant Construction Estimating Standards*, Vol. 4, Solana Beach, CA, 1979-80.
10. Seader, J. D., W. D. Seider, and A. C. Pauls, *FLOWTRAN Simulation-An Introduction*, 2nd Ed., CACHE Corporation, Cambridge, MA, 1977.
11. Soni, Y., M. K. Sood, and G. V. Reklaitis, *PCOST Costing Program*, Purdue University, W. Lafayette, Indiana, May 1979.

ChE books received

"Flame-Retardant Polymeric Materials," edited by Menachem Lewin, S. M. Atlas, and Eli M. Pearce; Plenum Publishing Corp., New York, 10013; 238 pages, $35.00 (1982)

"Advances in Cryogenic Engineering," R. W. Fast, Editor; Plenum Publishing Corp., New York 10013; 1224 pages, $95.00 (1982)

"Surface Chemistry of Froth Flotation," Jan Leja; Plenum Publishing Corp., New York 10013; 758 pages, $69.50 (1982)

"Flat and Corrugated Diaphragm Design Handbook," Mario Di Giovanni; Marcel Dekker, Inc., New York 10016; 424 pages, $55.00 (1982)