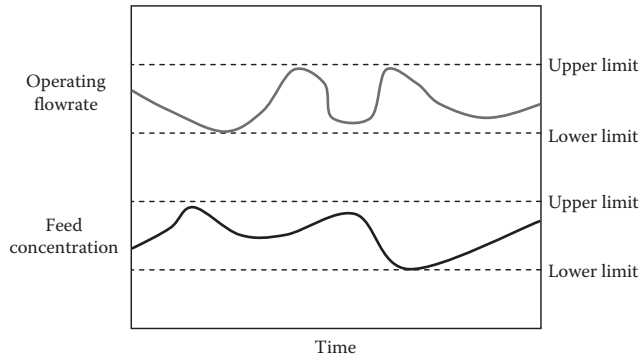


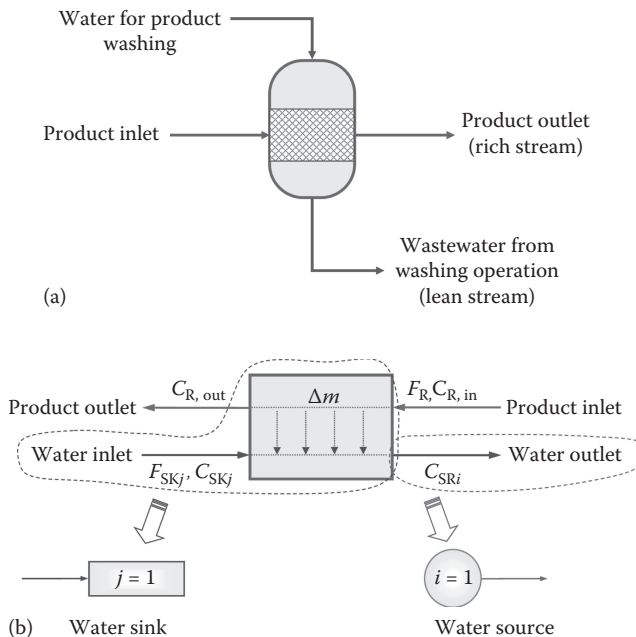
**Figure 2.1**

PFD for AN production. (From El-Halwagi, M.M., *Pollution Prevention through Process Integration: Systematic Design Tools*, Academic Press, San Diego, CA, 1997, p. 87. With permission.)



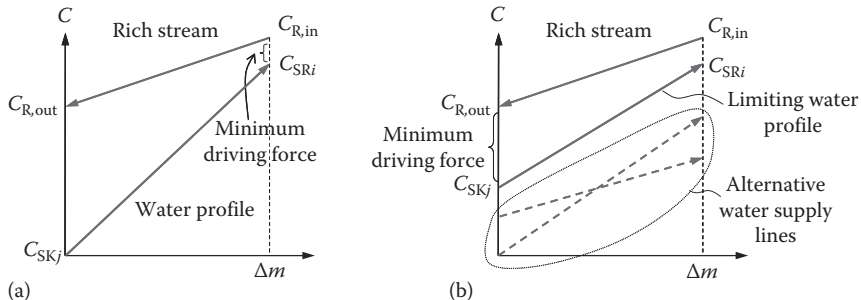
**Figure 2.2**

Historical data for plant operation. (From El-Halwagi, M.M., *Process Integration*, Academic Press, San Diego, CA, 2006, p. 42. With permission.)



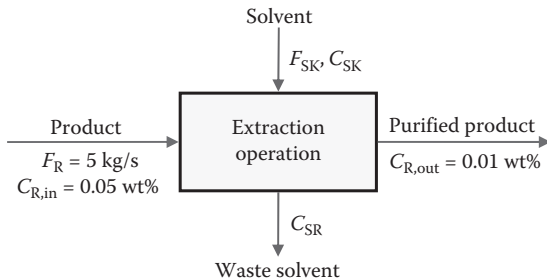
**Figure 2.3**

A product washing operation (a) for the above and (b) for the below.

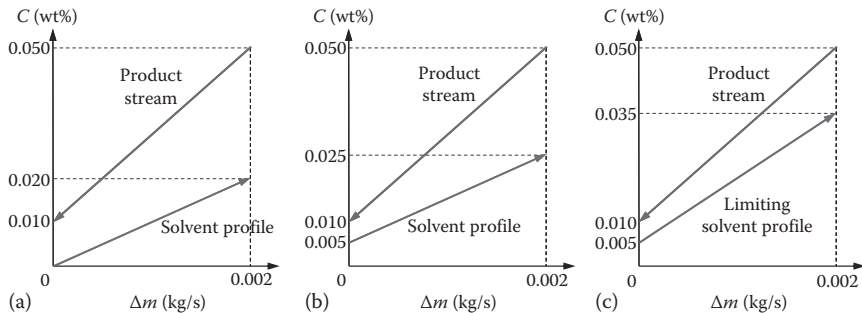


**Figure 2.4**

A product washing operation represented in concentration versus load diagram. (From *Chem. Eng. Sci.*, 49, Wang, Y.P. and Smith, R., Wastewater minimisation, 981–1006, 1994. Copyright 1994, with permission from Elsevier.)

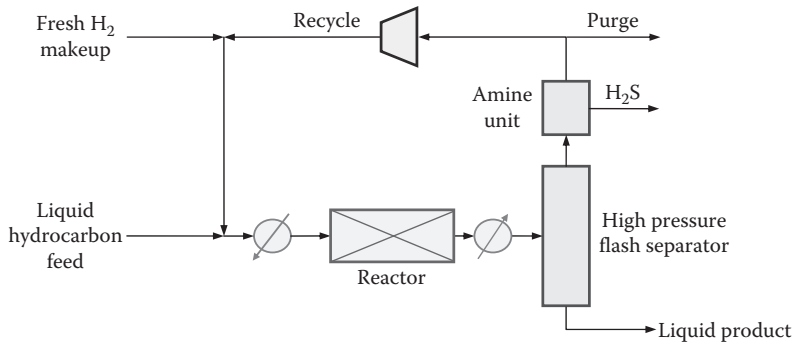


**Figure 2.5**  
An extraction operation.



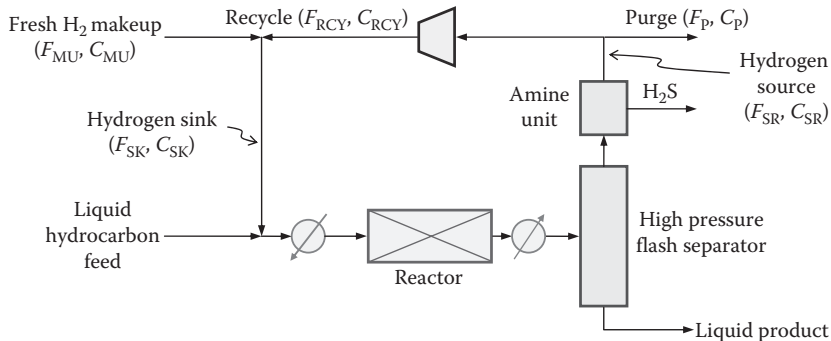
**Figure 2.6**

Concentration versus load diagrams for Example 2.3: (a) Scenario 1, (b) Scenario 2, and (c) Scenario 3—limiting solvent profile.



**Figure 2.7**

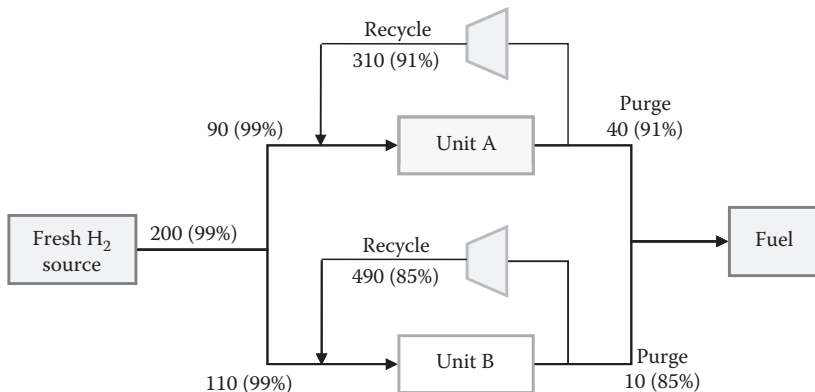
A simplified PFD for a hydrogen-consuming unit. (Reprinted with permission from Alves, J.J. and Towler, G.P., Analysis of refinery hydrogen distribution systems, *Ind. Eng. Chem. Res.*, 41, 5759–5769, 2002. Copyright 2002 American Chemical Society.)



**Figure 2.8**

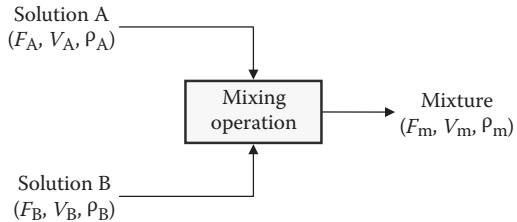
Identification of hydrogen sink and source. (From *Adv. Environ. Res.*, 6, Hallale, N. and Liu, F., Refinery hydrogen management for clean fuels production, 81–98, 2001. Copyright 2001, with permission from Elsevier.)





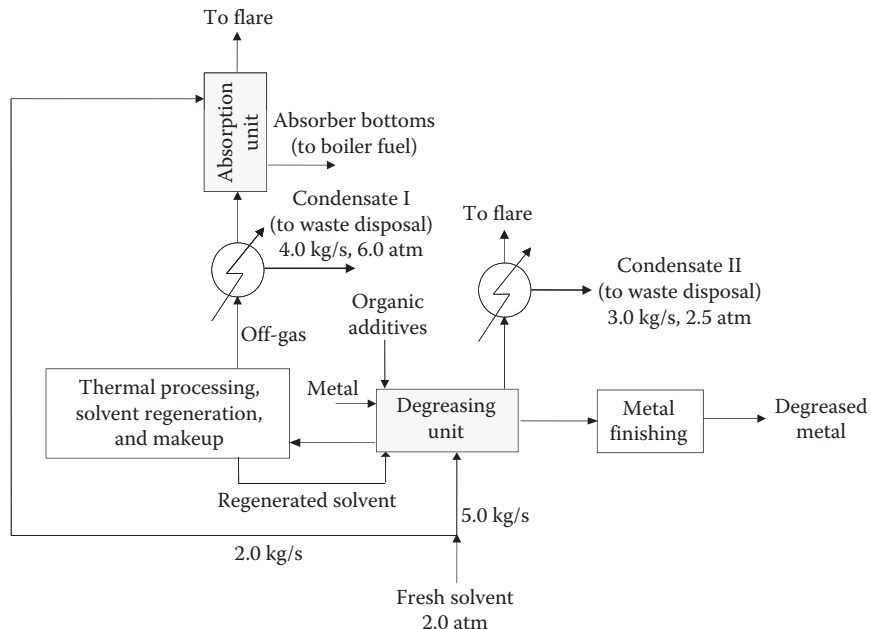
**Figure 2.9**

PFD of a refinery hydrogen network (stream flowrate given in million standard cubic feet/day—MMscfd; its hydrogen purity is given in parenthesis). (From *Adv. Environ. Res.*, 6, Hallale, N. and Liu, F., Refinery hydrogen management for clean fuels production, 81–98, 2001. Copyright 2001, with permission from Elsevier.)



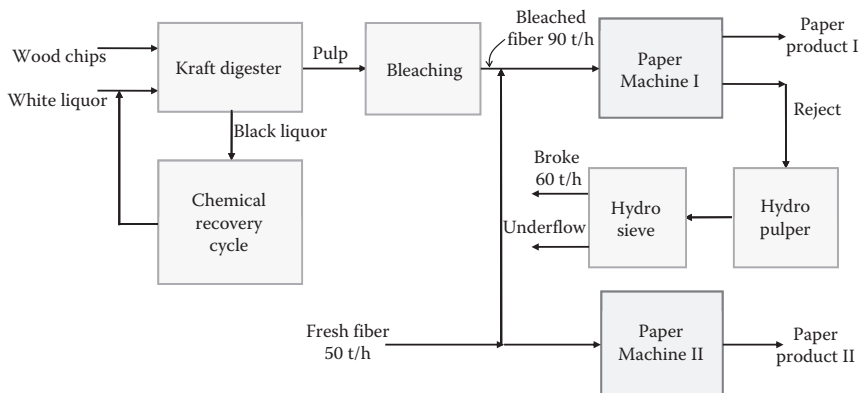
**Figure 2.10**

Mixing of solutions with different density.



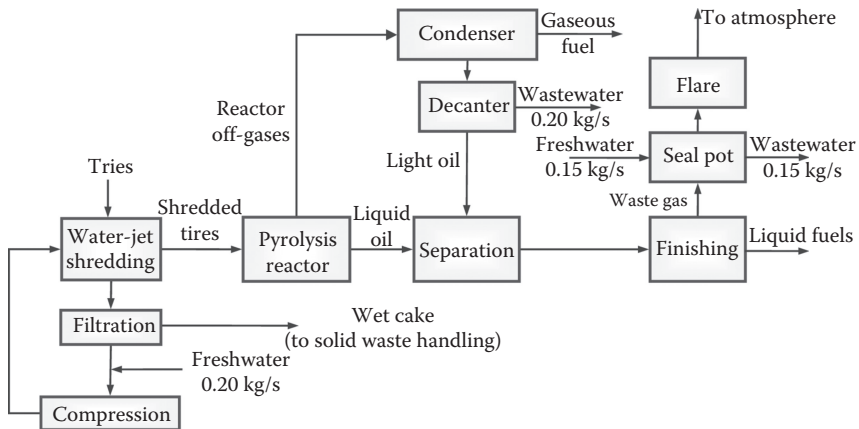
**Figure 2.11**

PFD of a metal degreasing process. (Reproduced from Kazantzi, V. and El-Halwagi, M.M., *Chem. Eng. Prog.*, 101(8), 28, 2005. With permission. Copyright 2005 American Institute of Chemical Engineers (AIChE).)



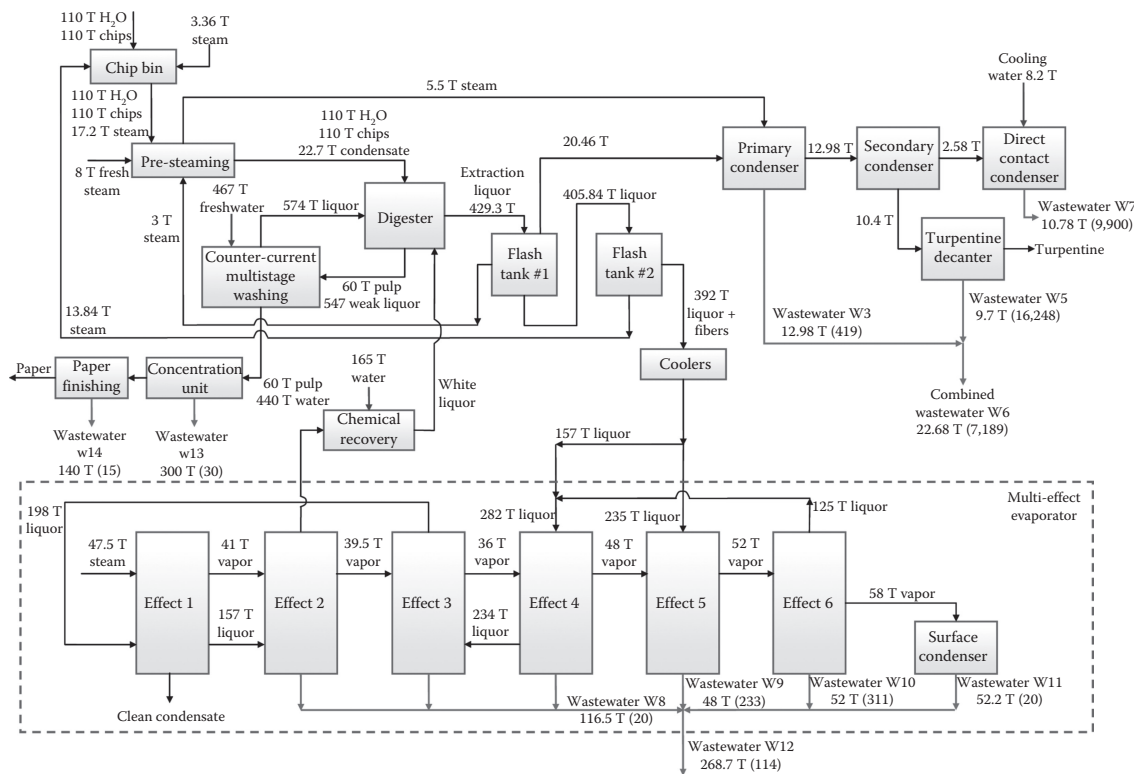
**Figure 2.12**

PFD of a papermaking process. (Reproduced from Kazantzi, V. and El-Halwagi, M.M., *Chem. Eng. Prog.*, 101(8), 28, 2005. With permission. Copyright 2005 American Institute of Chemical Engineers (AIChE).)



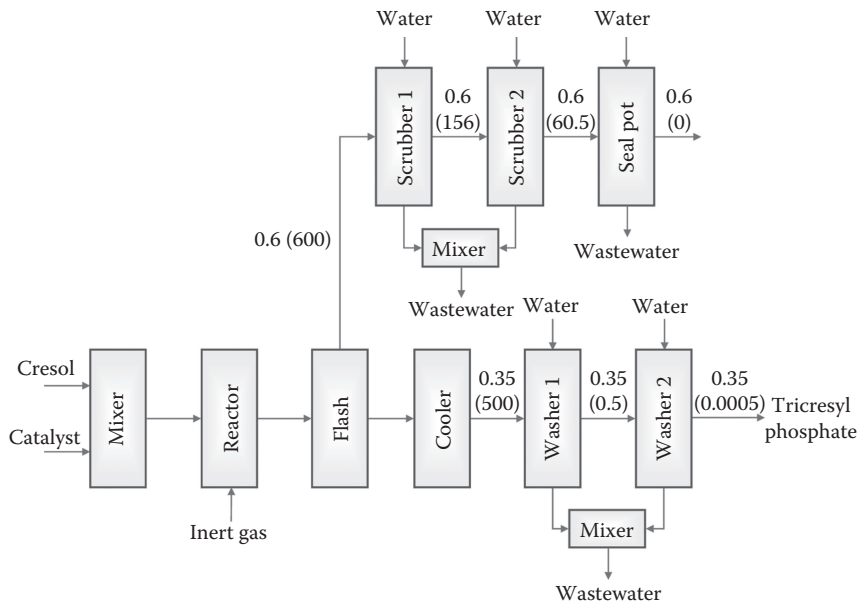
**Figure 2.13**

Tire-to-fuel process. (From El-Halwagi, M.M., *Pollution Prevention through Process Integration: Systematic Design Tools*, Academic Press, San Diego, CA, 1997, p. 97. With permission.)



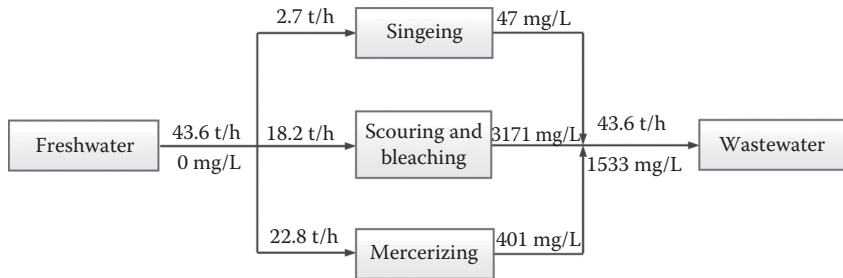
**Figure 2.14**

A Kraft pulping process (basis: 1 h; T refers to ton; values in parenthesis indicate methanol concentration in ppm). (From Hamad, A.A. et al., Systematic integration of source reduction and recycle reuse for cost-effective compliance with the cluster rules, in *AIChE Annual Meeting*, Miami, FL, 1995. With permission.)



**Figure 2.15**

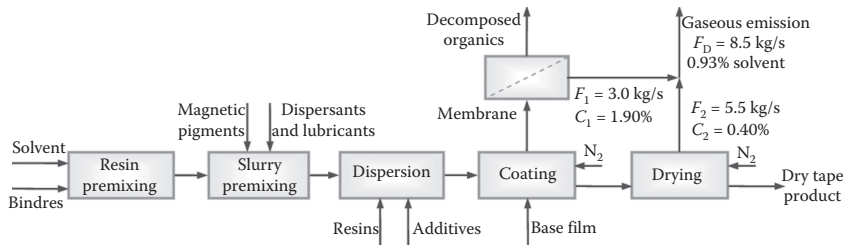
Tricresyl phosphate manufacturing process (stream flowrates given in kg/s; values in parenthesis indicate cresol concentration in ppm). (From Hamad, A.A. et al., Optimal design of hybrid separation systems for in-plant waste reduction, in *Proceedings of the Fifth World Congress of Chemical Engineering*, San Diego, CA, Vol. III, pp. 453–458, 1996. With permission.)



**Figure 2.16**

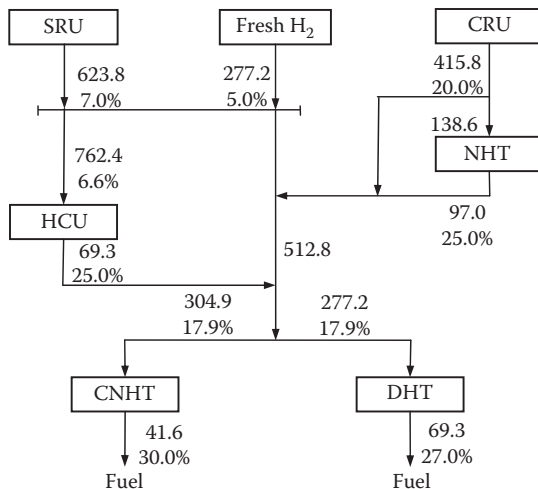
Water-using scheme for the bleaching section in a textile plant. (From Ujang, Z. et al., *Water Sci. Technol.*, 46, 77, 2002. With permission.)





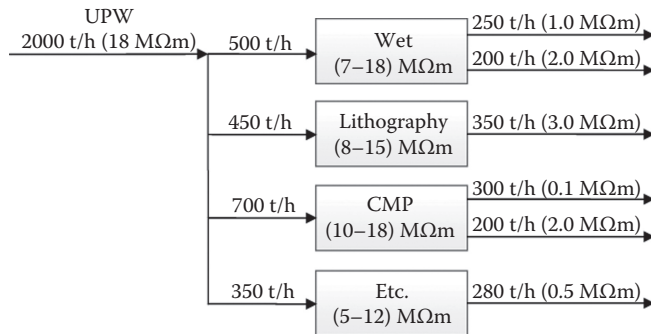
**Figure 2.17**

A magnetic tape process. (From Dunn, R.F. et al., Selection of organic solvent blends for environmental compliance in the coating industries, in Griffith, E.D., Kahn, H., and Cousins, M.C. eds., *Proceedings of the First International Plant Operations and Design Conference*, Vol. III, pp. 83–107, AIChE, New York, 1995. With permission.)



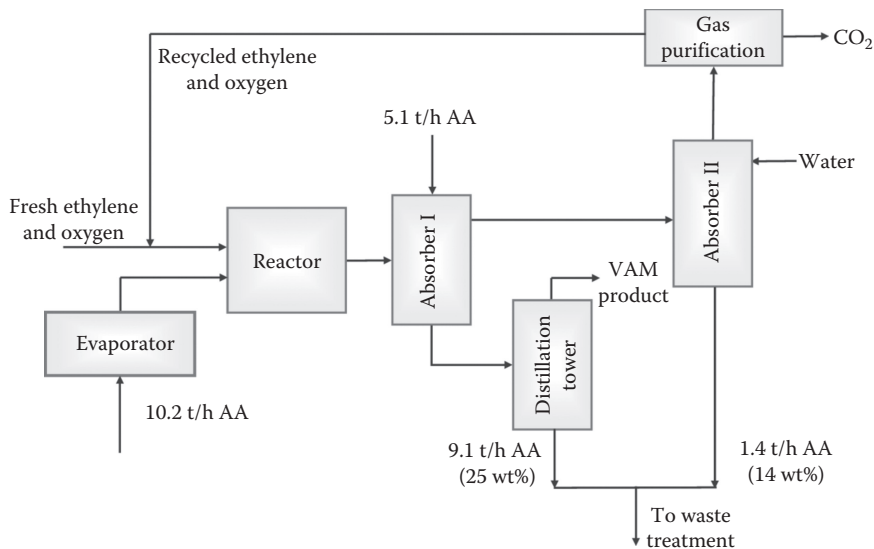
**Figure 2.18**

A refinery hydrogen network (numbers represent the total gas flowrate in mol/s and impurity concentration in mol%). (Reprinted with permission from Alves, J.J. and Towler, G.P., Analysis of refinery hydrogen distribution systems, *Ind. Eng. Chem. Res.*, 41, 5759, 2002. Copyright 2002 American Chemical Society.)



**Figure 2.19**

Usage of UPW in a wafer fabrication process.



**Figure 2.20**

Vinyl acetate manufacturing process (numbers represent AA stream flowrate; values in parenthesis represent water concentrations in AA streams). (From El-Halwagi, M.M., *Process Integration*, Academic Press, San Diego, CA, 2006, p. 56. With permission.)