Optimal Design of Energy Systems

Introduction

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Flow Diagram

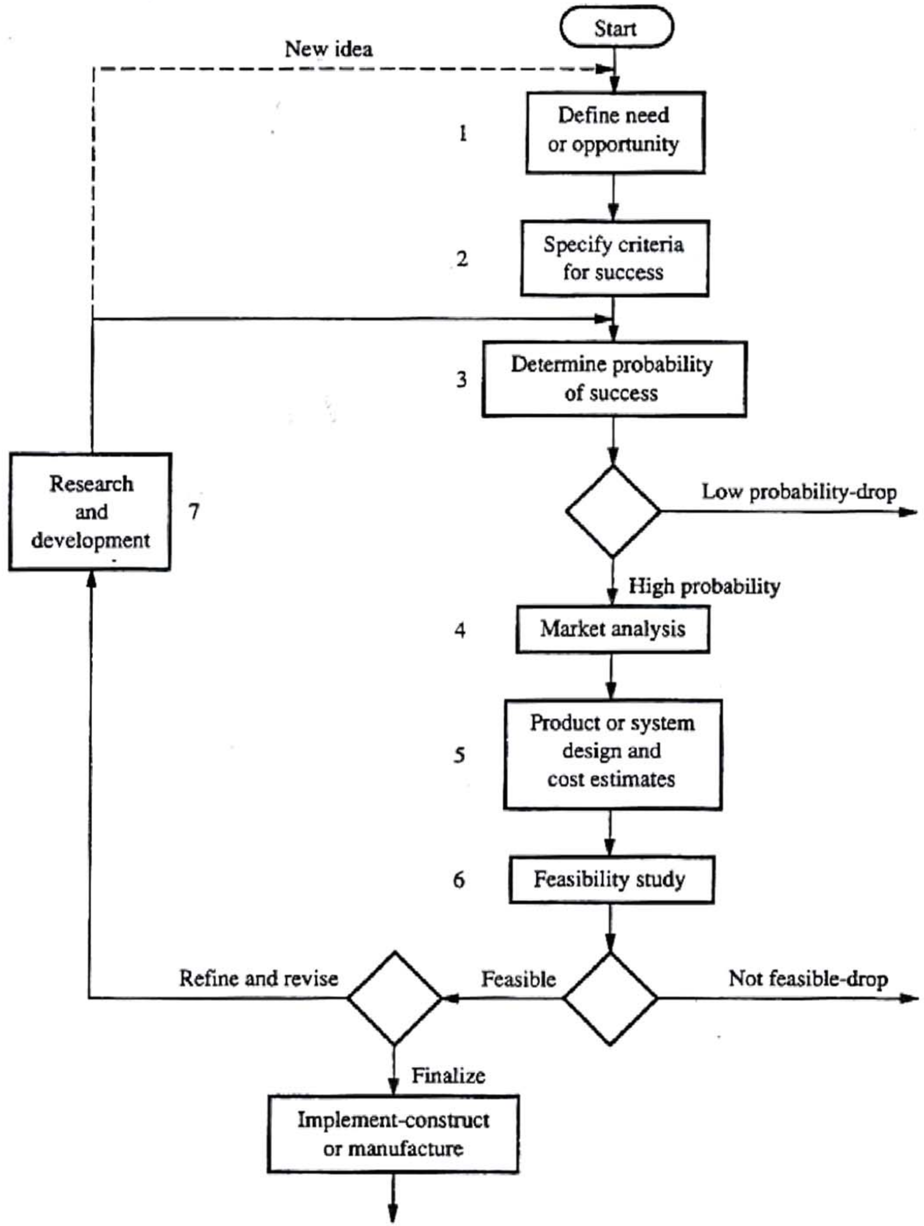

FIGURE 1-1
Possible flow diagram in evaluating and planning an engineering undertaking.

Project Management

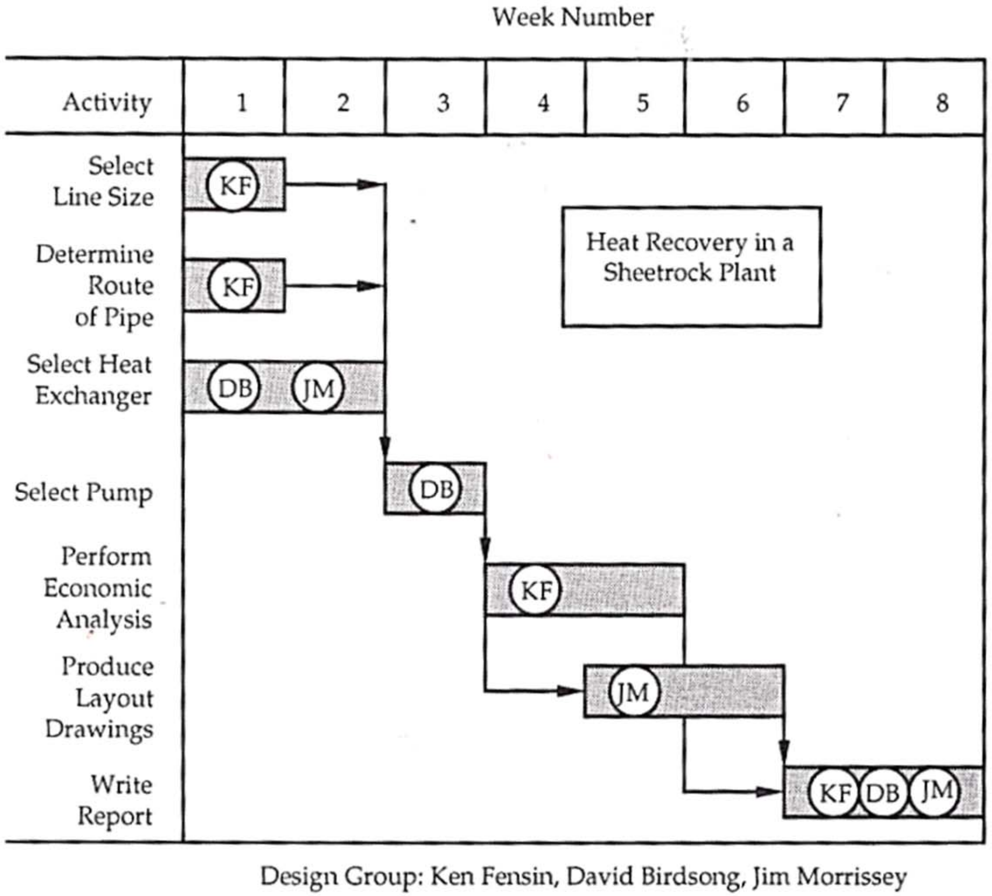

FIGURE 1.7. *Bar chart of smaller jobs to be performed in completing the Heat Recovery Project.*

Project Management

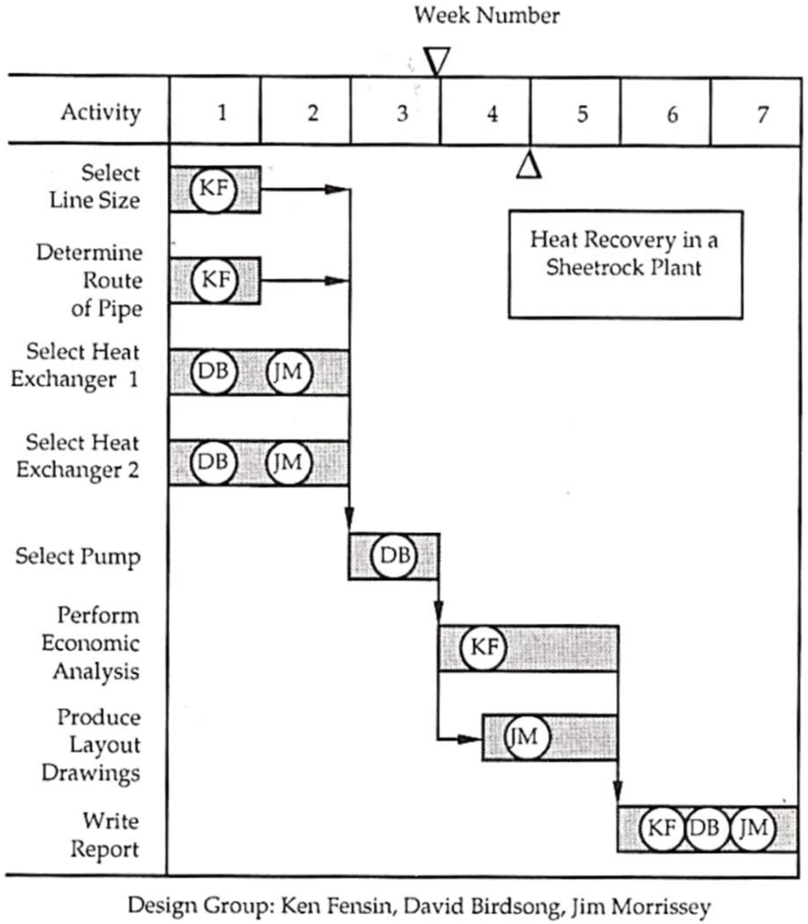

FIGURE 1.8. *Modified bar chart of smaller jobs to be performed in completing the Heat Recovery Project.*

Piping system design example

<Example> Figure 3.7 shows a portion of a piping system used to convey 4.54×10^{-3} m^3/s of ethyl alcohol. The system contains 55 m of commercial steel pipe. All fittings are of the long radius type and are flanged. Calculate the pressure drop over this portion of the pipeline if $z_1=z_2$.

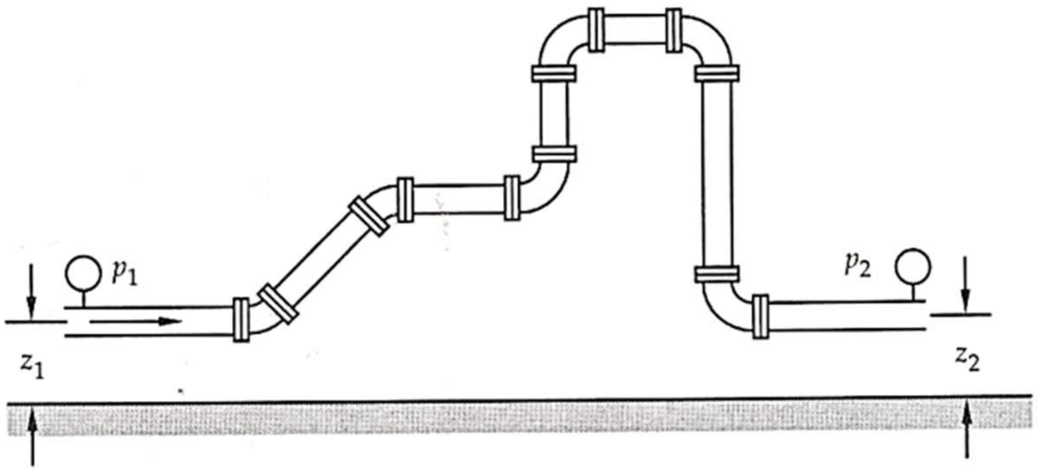

FIGURE 3.7. *The piping system of Example 3.6.*

Piping system design example

<Solution> The control volume we select includes all the liquid in the pipe and extends to each pressure gage. The calculation procedure is as follows.

Ethyl alcohol $\rho = 787\ kg/m^3$ $\mu = 1.10 \times 10^{-3}\ N \cdot s/m^2$

Pipe $D = 0.303\ m$ $A = 0.0722\ m^2$

commercial steel $\varepsilon = 0.00457\ cm$

Flow velocity V=Q/A:

$$Q = 4.54 \times 10^{-3}\ m^3/s \qquad V = 0.629\ m/s$$

Piping system design example

Reynolds number, $\mathrm{Re} = \rho VD / \mu$, relative roughness, and friction factor

$$\mathrm{Re} = \frac{787 \times 0.629 \times 0.303}{1.10 \times 10^{-3}} = 1.36 \times 10^{5}$$

$$\frac{\varepsilon}{D} = \frac{0.00457 \ cm}{0.303 \ m} = 0.000151$$

$f = 0.018$ (Figure 3.3)

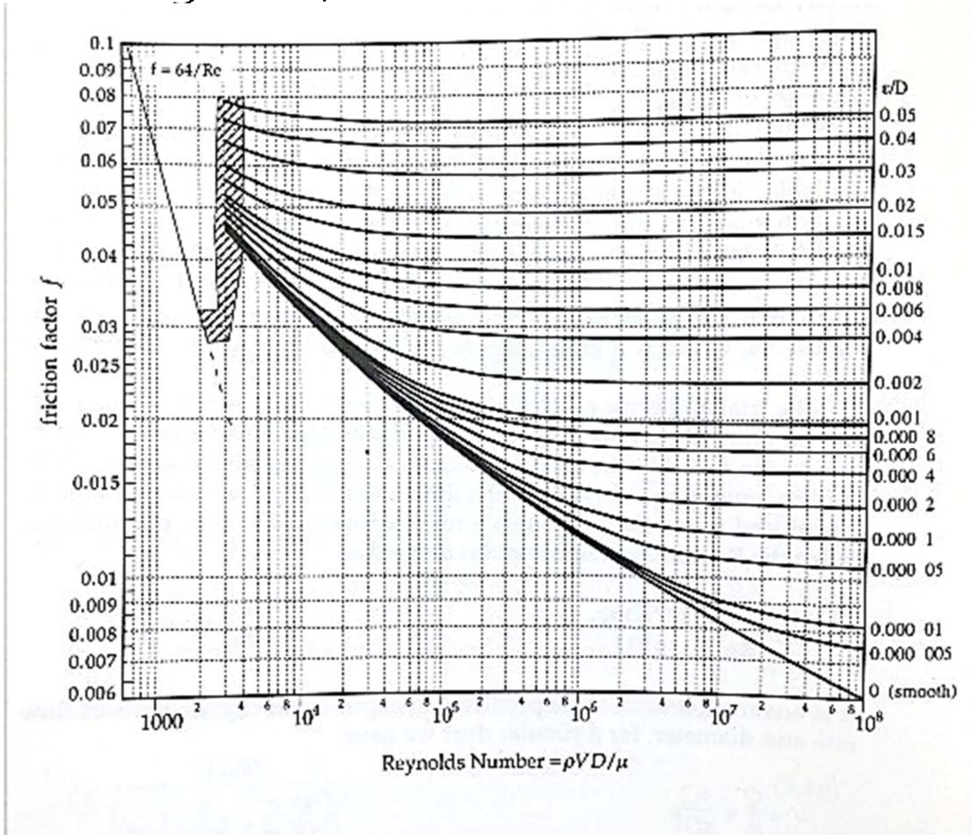

FIGURE 3.3. *Moody Diagram constructed with Chen equation.*

Piping system design example

Modified Bernoulli Equation:

$$\frac{p_1}{\rho g}+\frac{V_1^{\,2}}{2g}+z_1=\frac{p_2}{\rho g}+\frac{V_2^{\,2}}{2g}+z_2+\frac{fL}{D_h}\frac{V^2}{2g}+\sum K\frac{V^2}{2g}$$

Property evaluation:

$$V_1=V_2; \qquad z_1=z_2; \qquad L=55\ m$$

$$\sum K=2K_{45^o\,elbow}+4K_{90^o\,elbow}=2(0.17)+4(0.22)=1.22$$

Equation of motion:

$$\frac{p_1}{\rho g}=\frac{p_2}{\rho g}+\left(\frac{0.018\times 55}{0.303}+1.22\right)\frac{0.629^2}{2g}$$

$$p_1-p_2=698.6\ N/m^2=698.6\ Pa$$

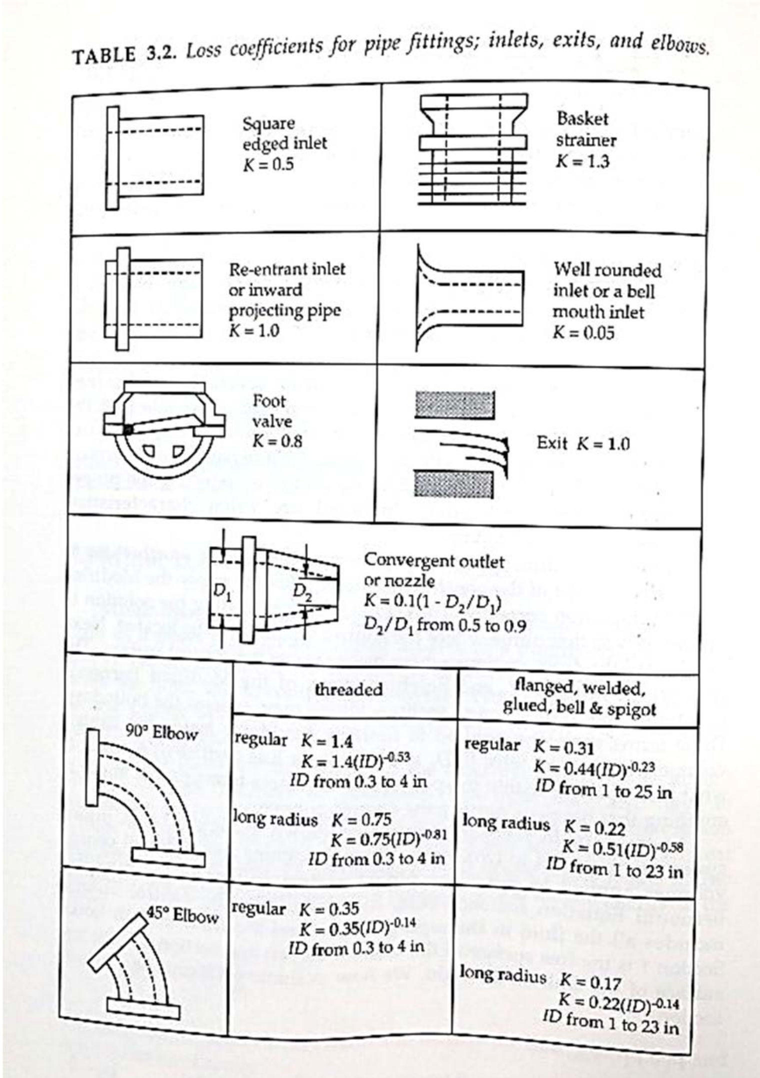

TABLE 3.2. *Loss coefficients for pipe fittings; inlets, exits, and elbows.*

Square edged inlet $K = 0.5$	Basket strainer $K = 1.3$
Re-entrant inlet or inward projecting pipe $K = 1.0$	Well rounded inlet or a bell mouth inlet $K = 0.05$
Foot valve $K = 0.8$	Exit $K = 1.0$
Convergent outlet or nozzle $K = 0.1(1 - D_2/D_1)$; D_2/D_1 from 0.5 to 0.9 (sketch labels: D_1, D_2)	

	threaded	flanged, welded, glued, bell & spigot
90° Elbow	regular $K = 1.4$; $K = 1.4(ID)^{-0.53}$; ID from 0.3 to 4 in long radius $K = 0.75$; $K = 0.75(ID)^{-0.81}$; ID from 0.3 to 4 in	regular $K = 0.31$; $K = 0.44(ID)^{-0.23}$; ID from 1 to 25 in long radius $K = 0.22$; $K = 0.51(ID)^{-0.58}$; ID from 1 to 23 in
45° Elbow	regular $K = 0.35$; $K = 0.35(ID)^{-0.14}$; ID from 0.3 to 4 in	long radius $K = 0.17$; $K = 0.22(ID)^{-0.14}$; ID from 1 to 23 in

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