CH402 Chemical Engineering Process Design

Class Notes L16

Plant Cost Scaling and Breakeven

Quiz 1 - paper

In-class problem in Canvas

L15 lookback: Estimating capital cost for an industrial facility

Method 1 – scaling against a known price

- Method 1a – scaling equipment
- Method 1b – scaling entire facilities (problems 6-9 and 6-10)

Method 2 – percentage method

- Method 2a – percentage of FCI – Example 6-1
- Method 2b – percentage of PEC – Colorful worksheet
- Need to differentiate between capital investment and purchased equipment cost.
- Need to understand the different components of capital investment.
- *Key - Each of these components has a well-known percentage of the total FCI.*
- To illustrate, we will looked closely at Example 6-1 and problem 6-8 in Lesson 15.
- We also discussed Method 2c – Lang Factors in Lesson 15.

FE Ref. Manual pages 257

Objectives for Lesson 16:

1. Estimate capital costs using scaling factors.
2. Estimate capital costs based on turnover ratio.
3. Determine breakeven point given production data.

Plant Costs - Methods A-G

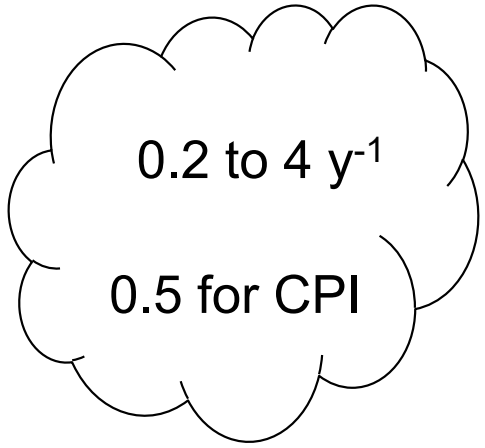
- A - Detailed item estimate
- B - Unit cost estimate – based on records
- C - Percentage of delivered-equipment cost
- D - Lang factors
- E - Power factors with plant/capacity ratio
- F - Cost per unit capacity
- G - Turnover ratio

Method G: Turnover Ratio

Similar to what we have been doing for single pieces of equipment.

$$\text{Turnover Ratio} = \frac{\text{gross annual sales}}{\text{fixed capital investment}}$$

Eq. 6-11, p. 258



± 30 % accuracy.

Problem 6-9.

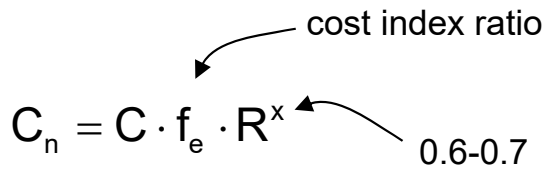
Estimate by the turnover ratio method the fixed-capital investment required in 2000 for a proposed sulfuric acid plant (battery-limit) which has an annual capacity of 1.3×10^8 kg/yr of 100% sulfuric acid (contact catalytic process), using the data from Table 6-11, when the selling price of sulfuric acid is $86 per metric ton. The plant will operate 325 days/year. Repeat the calculation, using the cost capacity exponent (scaling) method with data from Table 6-11

Problem 6-9.

Estimate by the turnover ratio method the fixed-capital investment required in 2000 for a proposed sulfuric acid plant (battery-limit) which has an annual capacity of 1.3×10^8 kg/yr of 100% sulfuric acid (contact catalytic process), using the data from Table 6-11, when the selling price of sulfuric acid is $86 per metric ton. The plant will operate 325 days/year. Repeat the calculation, using the cost capacity exponent (scaling) method with data from Table 6-11

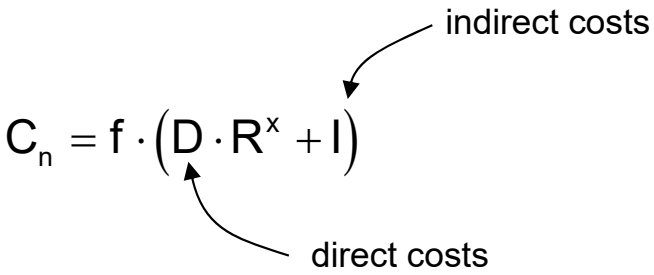
Method E: Power Factors and Plant Capacity Ratio

Similar to what we have been doing for single pieces of equipment.



Eq. 6-9, p. 254

Table 6-11, p. 255



Eq. 6-10

± 20 % accuracy.

$$\text{Cost of Plant A} = \text{Cost of Plant B} \cdot \left(\frac{\text{Capacity of Plant A}}{\text{Capacity of Plant B}} \right)^n$$

FEE p. 258

Problem 6-10.

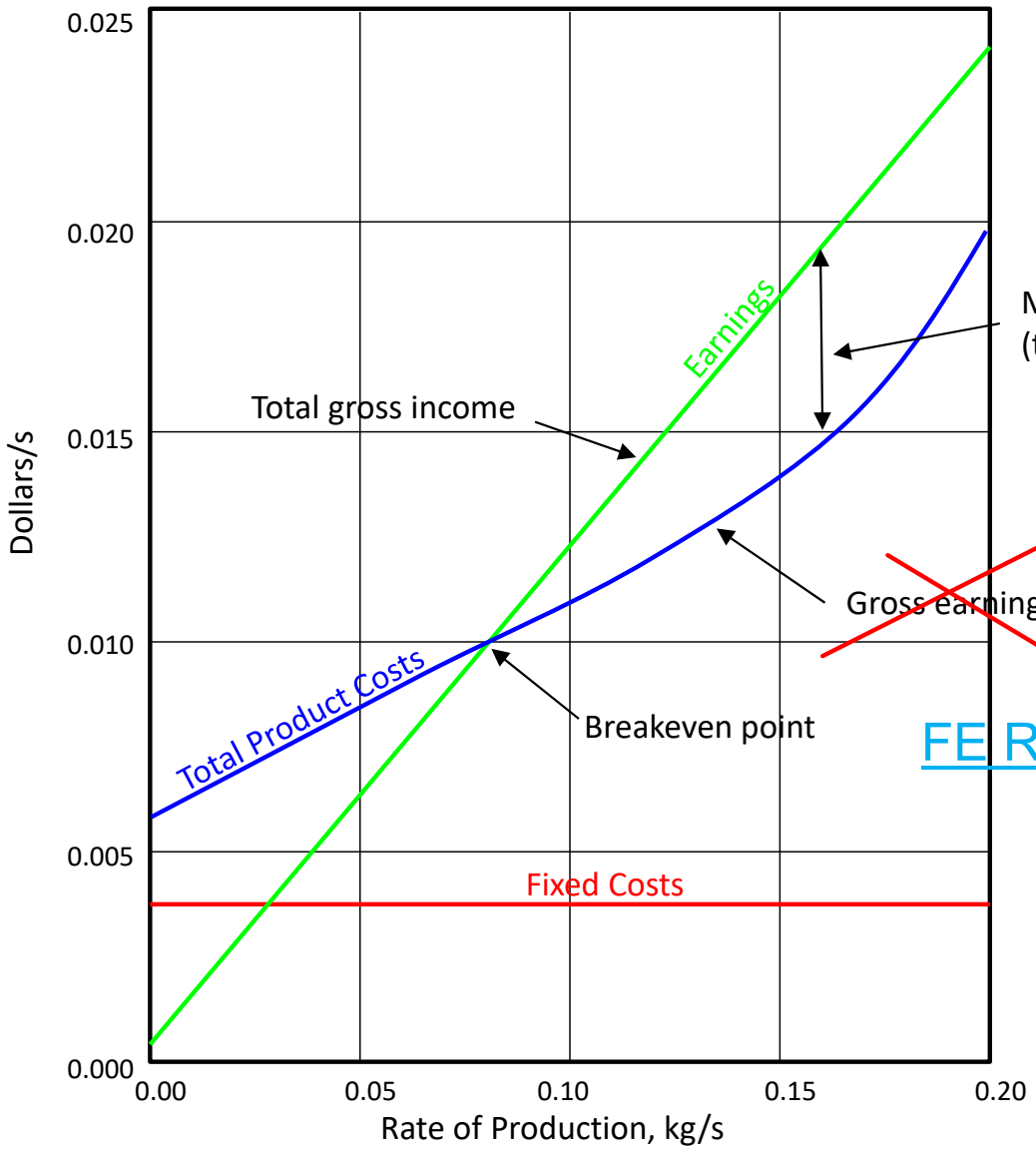
The total capital investment for a chemical plant is $1 million, and the working capital is $100,000. If the plant can produce an average of 8000 kg of final product per day during a 365-day year, what selling price in dollars per kilogram of product would be necessary to give a turnover ratio of 1.0?

FEE Manual v10.3 page 231

Break-Even Analysis – ICP

Figure 6-3; FEE p. 231; equation: gross earnings – variable costs – fixed costs

apply this equation



FE Ref. Manual pages 231

The authors no not state that fixed costs are included in total product costs. Normally they are not (as in ICP).

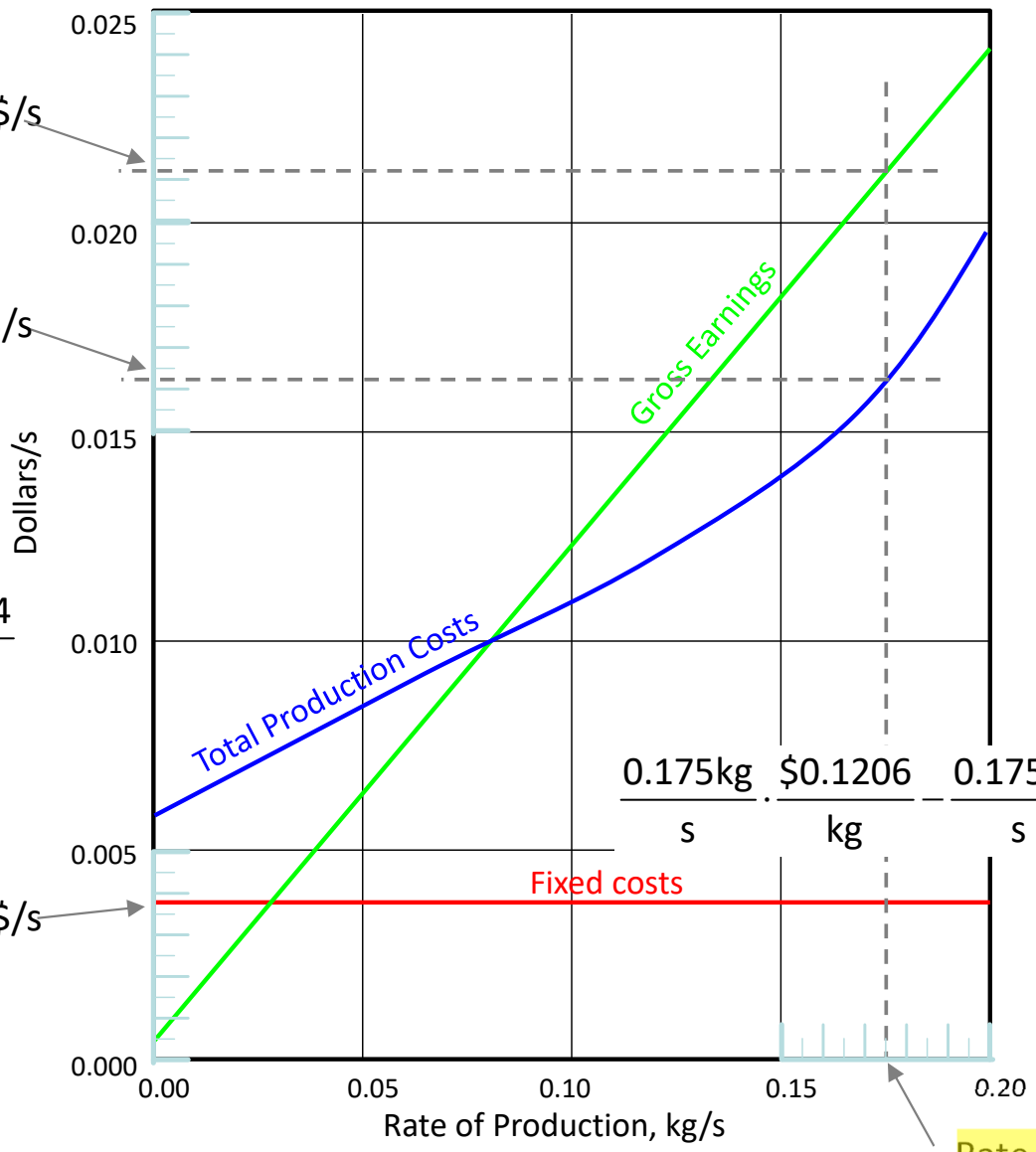
Breakeven point is at the indicated point if total product costs include fixed costs.

FEE Manual v10.3 page 231

Break-Even Analysis – Ex1

Figure 6-3; FEE p. 231; equation: gross earnings – variable costs – fixed costs

apply this equation



Gross Earnings = 0.0211 $/s

Total Prod. Cost = 0.0162 $/s

Variable Costs:

$$0.0162 - 0.0038 = \frac{\$0.0124}{s}$$

Fixed Costs = 0.0038 $/s

market price, $/kg:

$$\frac{0.175\text{kg}}{s} \cdot x = \frac{\$0.0211}{s}$$

$$x = \frac{\$0.1206}{\text{kg}}$$

variable production cost, $/kg:

$$\frac{0.175\text{kg}}{s} \cdot y = \frac{\$0.0124}{s}$$

$$y = \frac{\$0.0709}{\text{kg}}$$

$$\frac{0.175\text{kg}}{s} \cdot \frac{\$0.1206}{\text{kg}} - \frac{0.175\text{kg}}{s} \cdot \frac{\$0.0709}{\text{kg}} - \frac{\$0.0038}{s} = \frac{\$0.0049}{s}$$

Operating at a profit

Rate of production = 0.175 kg/s

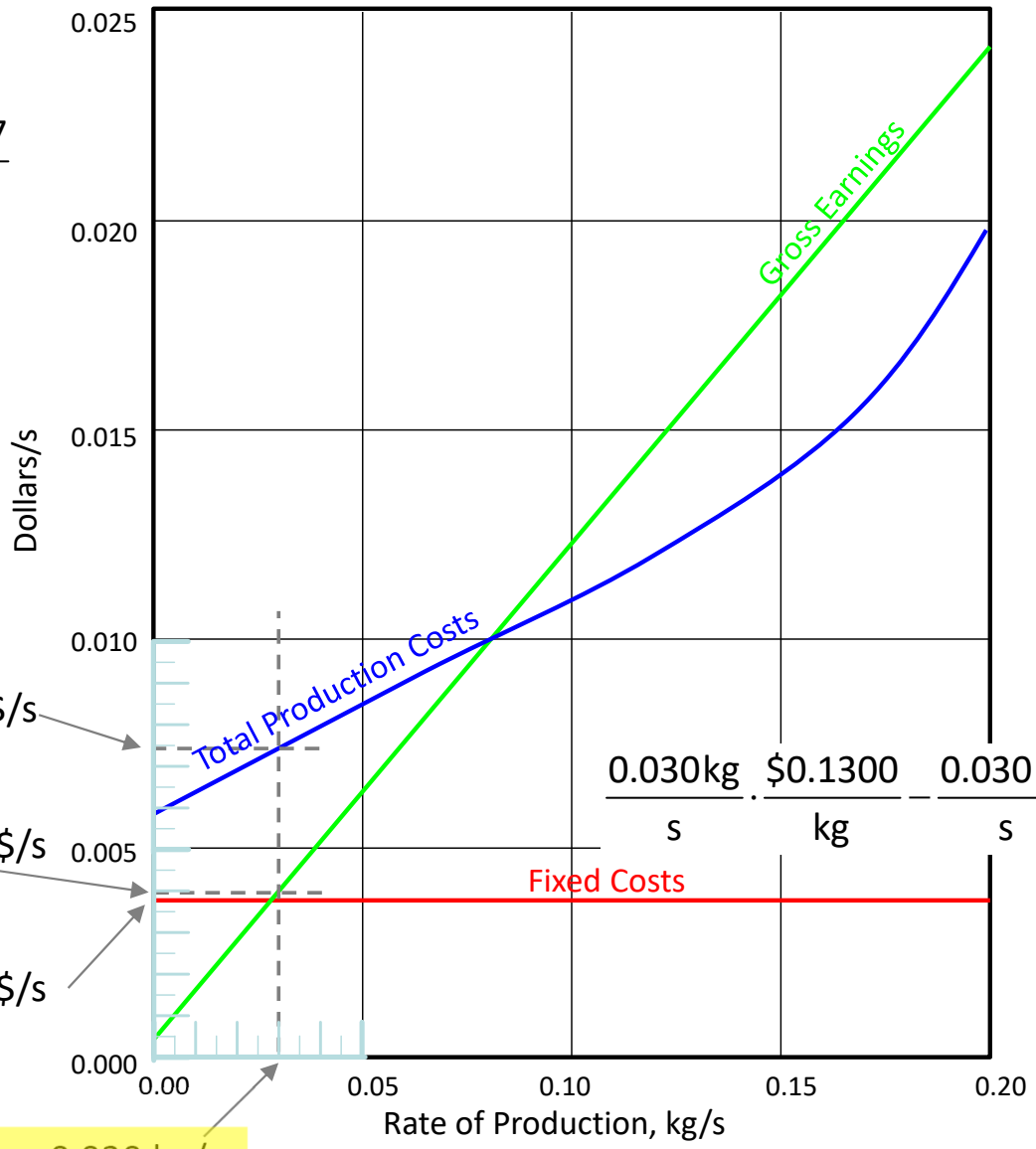
Break-Even Analysis – Ex2

Figure 6-3; FEE p. 231; equation: gross earnings – variable costs – fixed costs

apply this equation

Variable Costs, $/s:

$$0.0075 - 0.0038 = \frac{\$0.0037}{s}$$



Total Prod. Cost = 0.0075 $/s

Gross Earnings = 0.0039 $/s

Fixed Costs = 0.0038 $/s

Rate of production = 0.030 kg/s

market price, $/kg:

$$\frac{0.030\text{kg}}{s} \cdot x = \frac{\$0.0039}{s}$$

$$x = \frac{\$0.1300}{\text{kg}}$$

variable production cost, $/kg:

$$\frac{0.030\text{kg}}{s} \cdot y = \frac{\$0.0037}{s}$$

$$y = \frac{\$0.1233}{\text{kg}}$$

$$\frac{0.030\text{kg}}{s} \cdot \frac{\$0.1300}{\text{kg}} - \frac{0.030\text{kg}}{s} \cdot \frac{\$0.1233}{\text{kg}} - \frac{\$0.0038}{s} = -\frac{\$0.0036}{s}$$

Operating at loss

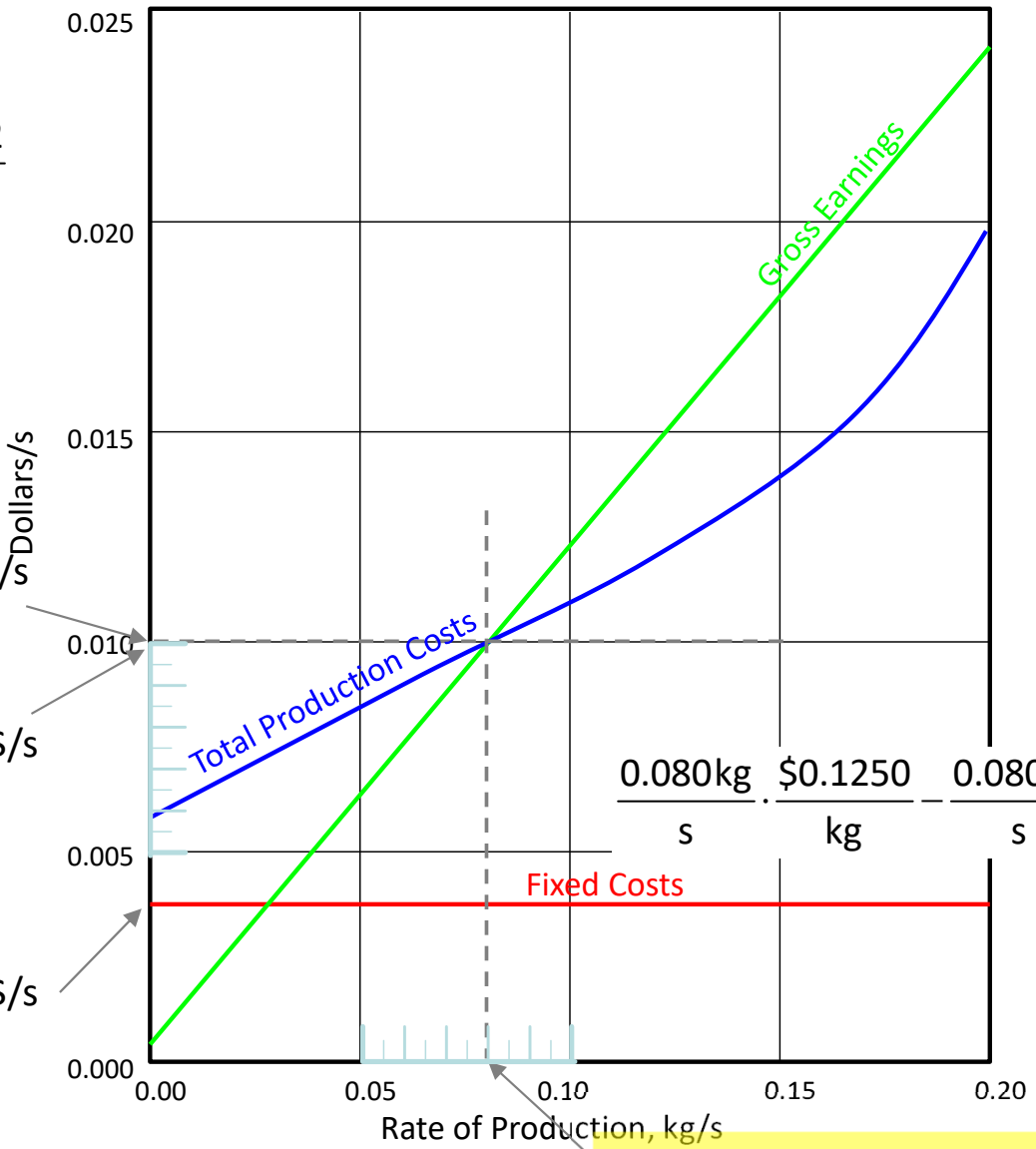
Break-Even Analysis – Ex3

Figure 6-3; FEE p. 231; equation: gross earnings – variable costs – fixed costs

apply this equation

Variable Costs, $/s:

$$0.0100 - 0.0038 = \frac{\$0.0062}{s}$$



Total Prod. Cost = 0.0100 $/s

Gross Earnings = 0.0100 $/s

Fixed Costs = 0.0038 $/s

market price, $/kg:

$$\frac{0.080\text{kg}}{s} \cdot x = \frac{\$0.0100}{s}$$

$$x = \frac{\$0.1250}{\text{kg}}$$

variable production cost, $/kg:

$$\frac{0.080\text{kg}}{s} \cdot y = \frac{\$0.0062}{s}$$

$$y = \frac{\$0.0775}{\text{kg}}$$

$$\frac{0.080\text{kg}}{s} \cdot \frac{\$0.1250}{\text{kg}} - \frac{0.080\text{kg}}{s} \cdot \frac{\$0.0775}{\text{kg}} - \frac{\$0.0038}{s} = \frac{\$0.0000}{s}$$

“Breakeven”

Questions?