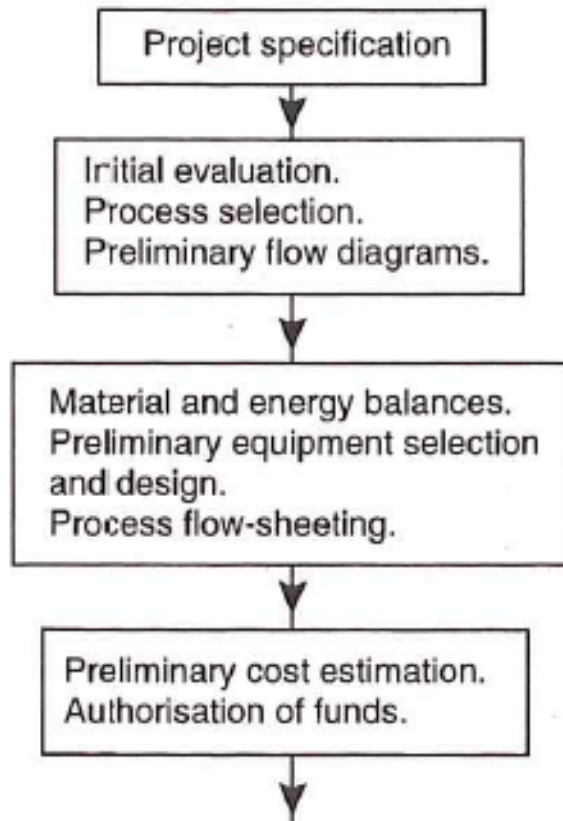


Basics in Process Design

Project cost estimation





- ✗ Block flow diagrams
- ✗ Calculate flows from mass and energy balances
- ✗ Rough sizing of equipment for
 - storage
 - preprocessing
 - reaction
 - separation,
 - heat exchange
 - transport
- (■ Instrumentation
- ■ Cost estimates

Cost

- Capital cost = cost of building the process plant (planning, equipment, construction ...)
 - Operating cost = cost of running the process plant (raw materials, energy, waste handling, salaries ...)
 - Profit = Income from sales – capital costs – operating costs
-

Reading

- The methods and data described are taken from chapter 6 in Chemical Engineering Design by R. K. Sinnott (vol. 6 in Coulson&Richardsons Chemical engineering).
- <http://site.ebrary.com/lib/abo/docDetail.action?docID=10186190>



Time value of money

- Changes in cost
 - Measured as inflation
 - Interest on loans
 - Cost indexes
 - Cost index as a function of time
 - Cost of equipment of same type but different size
 - Cost estimates
-

Plant cost index

Chemical Engineering,

http://www.che.com/Assets/File/CEPCI_I_01-2002.pdf

Economic Indicators

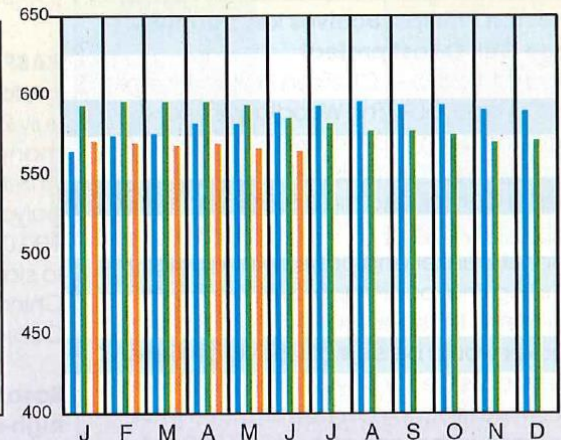
2011  2012  2013 

DOWNLOAD THE **CEPCI** TWO WEEKS SOONER AT **WWW.CHE.COM/PCI**

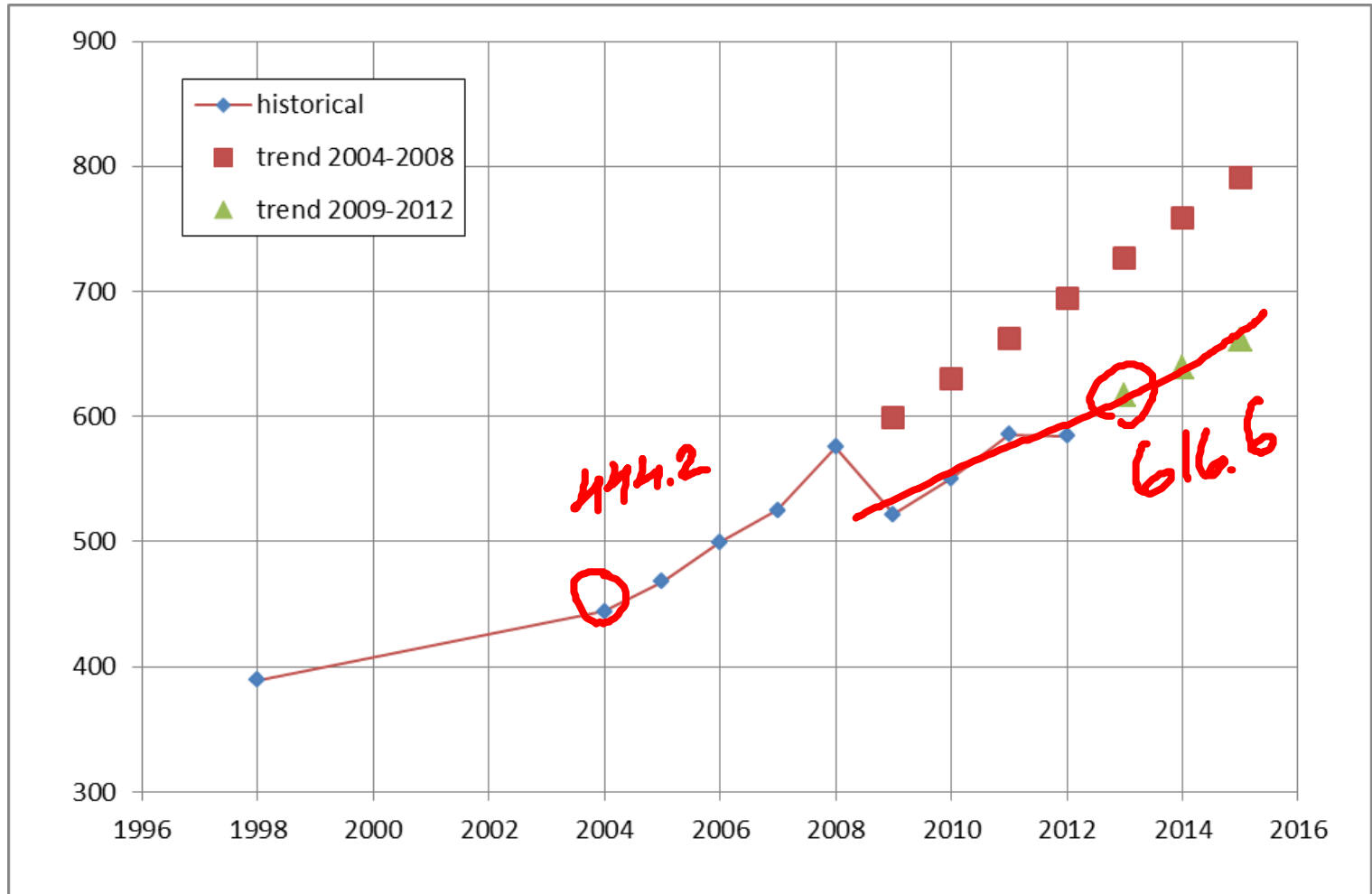
CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

(1957-59 = 100)	Jun.'13 Prelim.	May'13 Final	Jun.'12 Final
CE Index	564.9	566.5	585.6
Equipment	684.1	685.4	713.9
Heat exchangers & tanks	626.7	624.3	661.4
Process machinery	654.4	655.1	666.5
Pipe, valves & fittings	859.3	863.4	917.7
Process instruments	410.2	410.6	425.1
Pumps & compressors	919.2	919.3	927.0
Electrical equipment	512.7	513.1	513.7
Structural supports & misc	730.9	741.7	759.9
Construction labor	317.6	319.7	322.6
Buildings	530.8	534.0	527.1
Engineering & supervision	324.4	325.5	327.9

**Annual
Index:**
2005 = 468.2
2006 = 499.6
2007 = 525.4
2008 = 575.4
2009 = 521.9
2010 = 550.8
2011 = 585.7
2012 = 584.6



Plant cost index



Plant size

- Estimate of capital cost related to plant capacity

$$C_2 = C_1 \left(\frac{S_2}{S_1} \right)^n$$

- C_2 cost of plant with capacity S_2
 - C_1 cost of plant with capacity S_1
 - $n = 0.6$
-

Cost estimation

- Factorial method
 - Estimate total cost of major equipment (PCE or C_e)
 - Estimate total fixed capital cost using Lang factor (value depends on type of process)

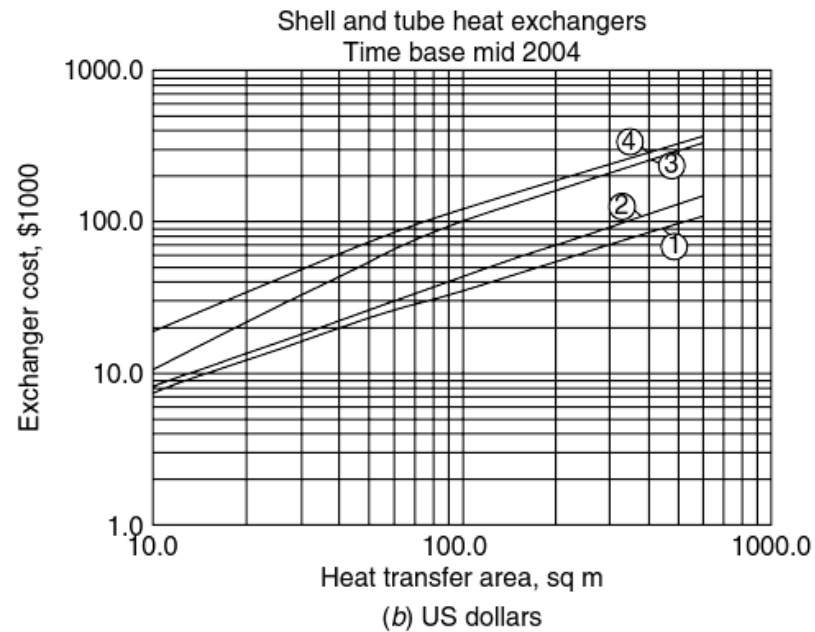
$$C_f = f_L \cdot C_e$$

C_f = total fixed capital cost

C_e = total cost of major equipment cost

f_L = Lang factor

Equipment cost



Materials		Pressure factors		Type factors	
Shell	Tubes				
① Carbon steel	Carbon steel	1–10 bar	× 1.0	Floating head	× 1.0
② C.S.	Brass	10–20	× 1.1	Fixed tube sheet	× 0.8
③ C.S.	Stainless steel	20–30	× 1.25	U tube	× 0.85
④ S.S.	S.S.	30–50	× 1.3	Kettle	× 1.3
		50–70	× 1.5		

Figure 6.3a, b. Shell and tube heat exchangers. Time base mid-2004
Purchased cost = (bare cost from figure) × Type factor × Pressure factor

Ancilliary equipment

$$\text{Cost} = C \cdot S^n$$

Table 6.2. Purchase cost of miscellaneous equipment, cost factors for use in equation 6.7. Cost basis mid 2004

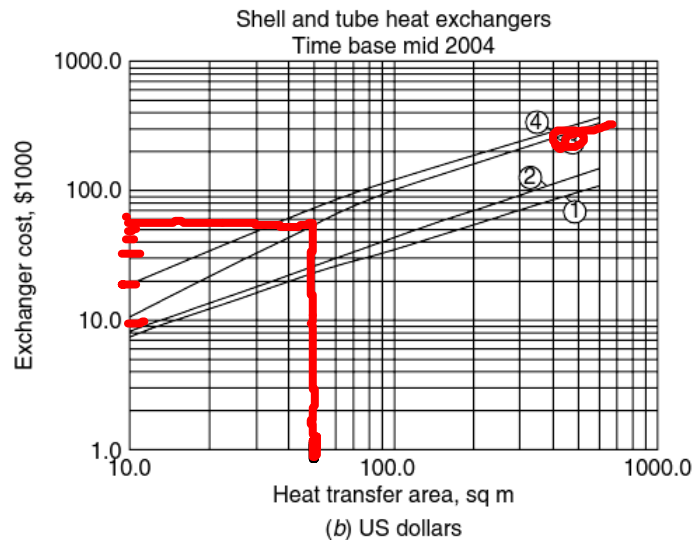
Equipment	Size unit, S	Size range	Constant C,£	C,\$	Index n	Comment
Agitators						
Propeller	driver	5–75	1200	1900	0.5	
Turbine	power, kW		1800	3000	0.5	
Boilers						
Packaged						oil or gas fired
up to 10 bar	kg/h steam	$(5-50) \times 10^3$	70	120	0.8	
10 to 60 bar			60	100	0.8	
Centrifuges						
Horizontal basket	dia. m	0.5–1.0	35,000	58,000	1.3	carbon steel
Vertical basket			35,000	58,000	1.0	×1.7 for ss
Compressors						
Centrifugal	driver power, kW	20–500	1160	1920	0.8	electric, max. press. 50 bar
Reciprocating			1600	2700	0.8	
Conveyors						
Belt	length m	2–40				
0.5 m wide			1200	1900	0.75	
1.0 m wide			1800	2900	0.75	
Crushers						
Cone	t/h	20–200	2300	3800	0.85	
Pulverisers	kg/h		2000	3400	0.35	

Example

Estimate the cost of the following equipment 2014 using data from 2004:

1. A shell and tube heat exchanger, heat transfer area 50 m^2 , floating head type, carbon steel shell, stainless steel tubes, operating pressure 25 bar.
 2. A horizontal, cylindrical storage tank, 3 m diameter, 12 m long, used for liquid chlorine at 10 bar, material carbon steel.
 3. Turbine agitator, 20 kW drive.
-

Heat exchanger



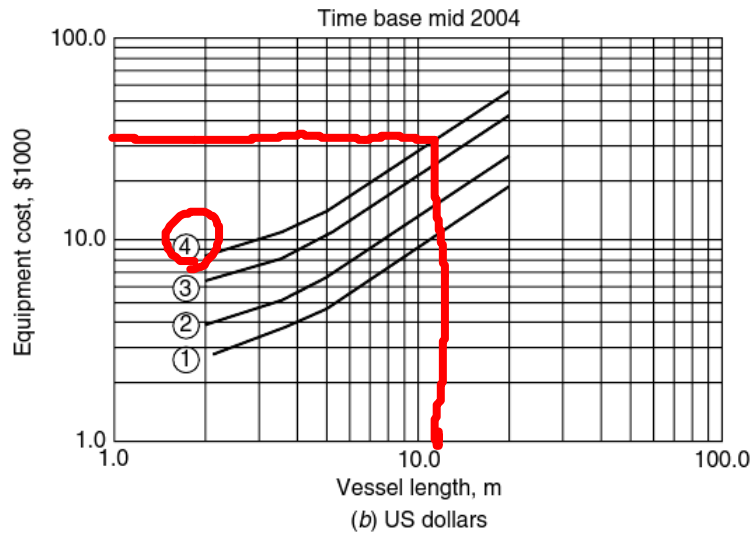
$$\text{Cost} = 55 \cdot 10^3 \$ \cdot 1.25 \cdot 1.0$$

$$= 68750 \$$$

Materials		Pressure factors		Type factors	
Shell	Tubes				
① Carbon steel	Carbon steel	1-10 bar	× 1.0	Floating head	× 1.0
② C.S.	Brass	10-20	× 1.1	Fixed tube sheet	× 0.8
③ C.S.	Stainless steel	20-30	× 1.25	U tube	× 0.85
④ S.S.	S.S.	30-50	× 1.3	Kettle	× 1.3
		50-70	× 1.5		

Figure 6.3a, b. Shell and tube heat exchangers. Time base mid-2004
Purchased cost = (bare cost from figure) × Type factor × Pressure factor

Pressure vessel



Diameter, m		Material factors	Pressure factors
①—0.5	②—2.0	C.S. × 1.0	1–5 bar × 1.0
②—1.0	④—3.0	S.S. × 2.0	5–10 × 1.1
		Monel × 3.4	10–20 × 1.2
		S.S. clad × 1.5	20–30 × 1.4
		Monel × 2.1	30–40 × 1.6
		clad	40–50 × 1.8
			50–60 × 2.2

Temperature up to 300°C

Figure 6.6a, b. Horizontal pressure vessels. Time base mid-2004.
Purchase cost = (bare cost from figure) × Material factor × Pressure factor

$$\text{Cost} = 33 \cdot 10^3 \$ \cdot 1.0 \cdot 1.2$$

$$= 39600 \$$$

Turbine agitator

Table 6.2. Purchase cost of miscellaneous equipment, cost factors for use in equation 6.7. Cost basis mid 2004

Equipment	Size unit, S	Size range	Constant C,£	C,\$	Index n	Comment
<i>Agitators</i>						
Propeller	driver	5–75	1200	1900	0.5	
Turbine	power, kW	5–75	1800	3000	0.5	
<i>Boilers</i>						
Packaged						oil or gas fired
up to 10 bar	kg/h steam	$(5-50) \times 10^3$	70	120	0.8	
10 to 60 bar			60	100	0.8	

$$\text{Cost} = 3000\$ \cdot 20^{0.5}$$

$$= 13416\$$$

Total

68750

39600

13416

121766 \$

2004

Cost in 2013 = 121766 \$ $\frac{616.6}{444.2}$

= 169025 \$

≈ 170000 \$

Questions?

