EGI – Economia dos processos
PROBLEMAS

1. Vão ser instalados numa fábrica existente, um novo reactor com agitação com um novo permutador de tubos e invólucro e uma nova bomba centrifuga. O reactor tem revestimento vítreo, o seu custo pode ser considerado 3 vezes superior a um reactor em aço carbono. O permutador de calor, a bomba e as tubagens associadas são todas de aço inoxidável de alto teor em crómio (*high-grade*). O equipamento funcionará a pressão e temperatura moderadas. O volume do reactor é 9 m^3, a área de transferência de calor do permutador é 50m^2 e a potência da bomba é de 5kW. Não é necessário nenhum investimento significativo em utilidades, edifícios, infraestruturas de apoio (*off sites*), preparação do local e capital de trabalho. Usando as equações,

$$C_{\mathrm{E}} = C_{\mathrm{B}}\left(\frac{Q}{Q_{\mathrm{B}}}\right)^{M} \qquad \frac{C_1}{C_2} = \frac{I_1}{I_2}$$

$$C_{\mathrm{F}} = \sum_i \left[f_{\mathrm{M}} f_{\mathrm{P}} f_{\mathrm{T}} (1 + f_{\mathrm{PIP}})\right]_i C_{E,i} + \\ + (f_{\mathrm{EP}} + f_{\mathrm{INST}} + f_{\mathrm{ELEC}} + f_{\mathrm{UTIL}} + f_{\mathrm{OS}} + f_{\mathrm{BUILD}} + \\ + f_{\mathrm{SP}} + f_{\mathrm{DEC}} + f_{\mathrm{CONT}} + f_{\mathrm{WC}}) \sum_i C_{E,i}$$

,

a tabela 2.1 (valores correspondentes ao ano de 2000; usar o CEI no gráfico anexo) e as tabelas 2.2 a 2.7, estime o custo do projecto.

2. Uma empresa pondera investir em um de dois projectos A e B. O custo de capital de ambos os projectos é 10^6 €. Os fluxos de caixa anuais estão na tabela 1. Para cada projecto determine:
   a) O tempo de recuperação (“payback time")
   b) O retorno sobre o investimento (“ROI”)
   c) A taxa de retorno sobre o fluxo de caixa descontado (DCFRR- “discounted cash flow rate of return”)

O que concluiria do resultado?

Tabela 1

Ano	Fluxo de caixa /10^3€	
	Projecto A	Projecto B
0	-1000	-1000
1	150	500
2	250	450
3	350	300
4	400	200
5	400	100

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3. Uma companhia avalia dois projectos concorrentes cujo cash flow se apresenta na tabela 2. Para cada projecto determine:
   d) O tempo de recuperação (“payback time")
   e) O valor real actual (NPV- “Net Present value”) com uma taxa de rendimento de 10%.
   f) A taxa de retorno sobre o fluxo de caixa descontado (DCFRR- “discounted cash flow rate of return”)

Com base na comparação destes valores, qual o projecto que deve ser escolhido? Justifique a decisão?

Tabela 2

Ano	Fluxo de caixa /€	
	Projecto A	Projecto B
0	-210000	-50000
1	70000	20000
2	70000	20000
3	70000	20000
4	70000	20000
5	70000	20000

ANEXOS:

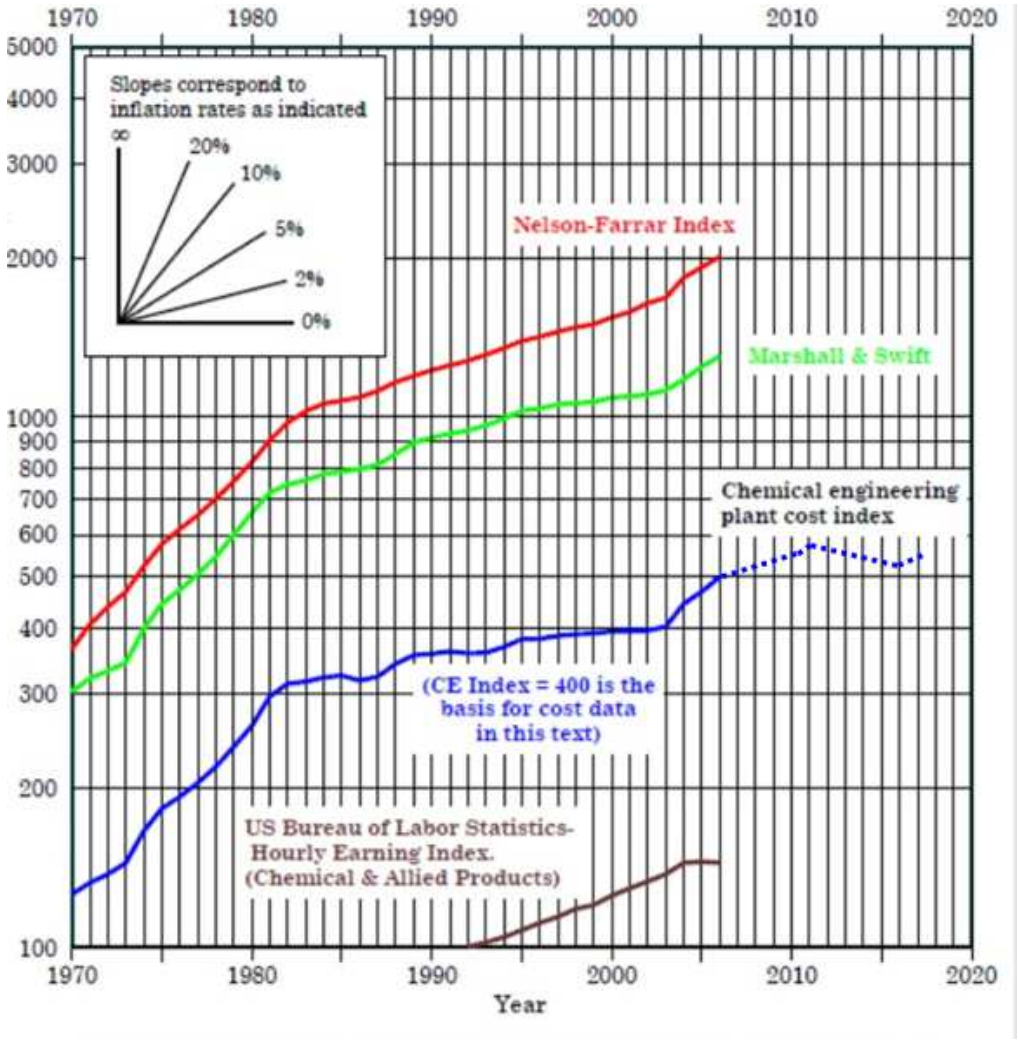

Table 2.1 Typical equipment capacity delivered capital cost correlations.

Equipment	Material of construction	Capacity measure	Base size Q_B	Base cost C_B (\$)	Size range	Cost exponent M
Agitated reactor	CS	Volume (m^3)	1	1.15×10^4	1–50	0.45
Pressure vessel	SS	Mass (t)	6	9.84×10^4	6–100	0.82
Distillation column (Empty shell)	CS	Mass (t)	8	6.56×10^4	8–300	0.89
Sieve trays (10 trays)	CS	Column diameter (m)	0.5	6.56×10^3	0.5–4.0	0.91
Valve trays (10 trays)	CS	Column diameter (m)	0.5	1.80×10^4	0.5–4.0	0.97
Structured packing (5 m height)	SS (low grade)	Column diameter (m)	0.5	1.80×10^4	0.5–4.0	1.70
Scrubber (Including random packing)	SS (low grade)	Volume (m^3)	0.1	4.92×10^3	0.1–20	0.53
Cyclone	CS	Diameter (m)	0.4	1.64×10^3	0.4–3.0	1.20
Vacuum filter	CS	Filter area (m^2)	10	8.36×10^4	10–25	0.49
Dryer	SS (low grade)	Evaporation rate (kg H_2O-h^{-1})	700	2.30×10^5	700–3000	0.65
Shell-and-tube heat exchanger	CS	Heat transfer area (m^2)	80	3.28×10^4	80–4000	0.68
Air-cooled heat exchanger	CS	Plain tube heat transfer area (m^2)	200	1.56×10^5	200–2000	0.89
Centrifugal pump (Small, including motor)	SS (high grade)	Power (kW)	1	1.97×10^3	1–10	0.35
Centrifugal pump (Large, including motor)	CS	Power (kW)	4	9.84×10^3	4–700	0.55
Compressor (Including motor)		Power (kW)	250	9.84×10^4	250–10,000	0.46
Fan (Including motor)	CS	Power (kW)	50	1.23×10^4	50–200	0.76
Vacuum pump (Including motor)	CS	Power (kW)	10	1.10×10^4	10–45	0.44
Electric motor		Power (kW)	10	1.48×10^3	10–150	0.85
Storage tank (Small atmospheric)	SS (low grade)	Volume (m^3)	0.1	3.28×10^3	0.1–20	0.57
Storage tank (Large atmospheric)	CS	Volume (m^3)	5	1.15×10^4	5–200	0.53
Silo	CS	Volume (m^3)	60	1.72×10^4	60–150	0.70
Package steam boiler (Fire-tube boiler)	CS	Steam generation (kg-h^{-1})	50,000	4.64×10^5	50,000–350,000	0.96
Field erected steam boiler (Water-tube boiler)	CS	Steam generation (kg-h^{-1})	20,000	3.28×10^5	10,000–800,000	0.81
Cooling tower (Forced draft)		Water flowrate (m^3-h^{-1})	10	4.43×10^3	10–40	0.63

CS = carbon steel; SS (low grade) = low-grade stainless steel, for example, type 304; SS (high grade) = high-grade stainless steel, for example, type 316

Table 2.2 Typical average equipment materials of construction capital cost factors.

Material	Correction factor f_M
Carbon steel	1.0
Aluminum	1.3
Stainless steel (low grades)	2.4
Stainless steel (high grades)	3.4
Hastelloy C	3.6
Monel	4.1
Nickel and inconel	4.4
Titanium	5.8

Table 2.3 Typical materials of construction capital cost factors for pressure vessels and distillation columns[9,10].

Material	Correction factor f_M
Carbon steel	1.0
Stainless steel (low grades)	2.1
Stainless steel (high grades)	3.2
Monel	3.6
Inconel	3.9
Nickel	5.4
Titanium	7.7

Table 2.4 Typical materials of construction capital cost factors for shell-and-tube heat exchangers[2].

Material	Correction factor f_M
CS shell and tubes	1.0
CS shell, aluminum tubes	1.3
CS shell, monel tubes	2.1
CS shell, SS (low grade) tubes	1.7
SS (low grade) shell and tubes	2.9

Table 2.5 Typical equipment pressure capital cost factors.

Design pressure (bar absolute)	Correction factor f_P
0.01	2.0
0.1	1.3
0.5 to 7	1.0
50	1.5
100	1.9

Table 2.6 Typical equipment temperature capital cost factors.

Design temperature (°C)	Correction factor f_T
0–100	1.0
300	1.6
500	2.1

Table 2.7 Typical factors for capital cost based on delivere equipment costs.

Item	Type of process	
	Fluid processing	Solid processir
Direct costs		
Equipment delivered cost	1	1
Equipment erection, f_{ER}	0.4	0.5
Piping (installed), f_{PIP}	0.7	0.2
Instrumentation & controls (installed), f_{INST}	0.2	0.1
Electrical (installed), f_{ELEC}	0.1	0.1
Utilities, f_{UTIL}	0.5	0.2
Off-sites, f_{OS}	0.2	0.2
Buildings (including services), f_{BUILD}	0.2	0.3
Site preparation, f_{SP}	0.1	0.1
Total capital cost of installed equipment	3.4	2.7
Indirect costs		
Design, engineering and construction, f_{DEC}	1.0	0.8
Contingency (about 10% of fixed capital costs), f_{CONT}	0.4	0.3
Total fixed capital cost	4.8	3.8
Working capital		
Working capital (15% of total capital cost), f_{WC}	0.7	0.6
Total capital cost, f_I	5.8	4.4