Solution To Test 1

Problem 1

Using 6/10 rule we get

$$C_A = C_B \cdot (A/B)^{0.6}$$

$$= \$20 \text{ mil} \times \left(\frac{200 \times 10^6 \text{ lbs/yr}}{100 \times 10^6 \text{ lbs/yr}} \right)^{0.6}$$

$$= \$20 \text{ mill} \times 2^{0.6} = \underline{\underline{\$30.31}} \text{ mill}$$

This is 1994 cost.

C.E. Cost Index (1994) = 368.1

" " (2000) = 394.5

$$\therefore C_{A,2000} = \$30.31 \text{ million} \times \frac{394.1}{368.1}$$

$$= \underline{\underline{\$32.45}} \text{ millions}$$

$$\approx 32 \text{ million}$$

Note:

Keep in mind that this is an order-of-magnitude type estimate. Hence error is ±40% to −20%. Thus one should round-off the answer. It is incorrect to give the answer as \$32, xxx, xxx.xx which is misleading w.r.t. accuracy.

Problem 2

Total # of operators Required

Item	Operators/shift
T-101, Tower	0.35
E-106, Heat Exchanger	0.1
P-102A/B Pump	0.
E-104, Heat Exchanger	.1
V-102, Vessel	0
	.55

No of shifts/year = 365 × 3 = 1095 shifts/year

No of shifts/operator = ~~1 operator~~ × 49 $\frac{\text{weeks}}{\text{yr}}$ × 5 $\frac{\text{shifts-op}}{\text{week}}$

= 245 shifts/~~operator~~/yr/man

∴ No of people required

$$= \frac{0.55 \text{ op/shift} \times \frac{1095 \text{ shifts}}{\text{yr}}}{245 \text{ shift-op/yr/man}}$$

Even though this represents a fractional operator, we will keep it that way. In practice, operators will be shared with other plants/facilities in the location.

= 2.458 men-years

Note: Do not round-off this number.

Cost, yearly = 2.458 × \$42,000

= \$103,242.86 /yr

rounding off = \$103,000/yr

Correction for year (use CEPCI as an initial guess)

$$= \$103{,}000 \times \frac{CEPCI_{2000}}{CEPCI_{1996}} \left(\frac{394.5}{381.7}\right)$$

= \$106,000

Problem 3.

Using ~~Yearly~~ Equivalent Annual operating Cost method

Air-cooled :

$$YAOC = \$23{,}000 \cdot f(A/P, i, n) + \$2{,}000$$

$$f(A/P, 0.08, 12) = \frac{(1+i)^n \cdot i}{(1+i)^n - 1} = \frac{(1.08)^{12} \times (.08)}{(1.08)^{12} - 1}$$

$$= 0.132695$$

$$\therefore YAOC_{air\text{-}cooled} = \$23{,}000 \times .132695 + \$1{,}200.00$$

$$= \$\,\cancel{5052.00}\ 4251.00$$

$$YAOC_{water\text{-}cooled} = \$12{,}000 \times .132695 + 3300$$

$$= \$\,\cancel{3459.00}\ \$4892.34$$

Water is significantly ~~cheaper~~ more expensive

$$\Delta(YAOC) = \$640.00\ /\text{year}$$

This is equivalent to a $\Delta(NPV) = \frac{640}{.132695} =$

$$= \$4823.00$$

Using NPV method :

$$NPV(\text{air-cooled}) = \$23{,}000 + \$1200\,\frac{(1+i)^n - 1}{i(1+i)^n} = \$32{,}043$$

$$NPV(\text{Water-cooled}) = \$12000 + \$3300 \cdot \text{''} = \$36{,}869$$

$$\therefore \Delta NPV = \$4826.00$$

Problem 5

Economic Potential

$= \text{Cost of } \cancel{\text{Raw Material}} \text{ Product} - \text{Cost of Raw material}$

Product = 8.478 lbmol/hr

Recycle = 1.216 "

Feed = 9.984 lbmole/hr

Assume Product can be sold as cyclohexanone. It does not have to be 100% pure.

∴ Feed consumed = (9.984 ~~...~~

= ~~8.768~~ lbmole/hr

$$\hat{EP} = 8.478 \times \$125 - \cancel{8.768}\ 9.984 \times \$\cancel{125}\ 59$$

$$= \$\cancel{542.43}/hr\ \$470.69/hr.$$

EP per lbmole of feed = 542.43 / 8.768

= $61.86 / lbmole of ~~feed~~

(b) Value of matls lost in the gas stream

$$= \cancel{0.015}\ .0062 \frac{lbmol\ A}{hr} \times \frac{\$59}{lbmol} + .0491 \times \frac{\$125}{lbm}$$

$= \$6.50/hr$

Not significant compared to $542/hr above.

Problem 5.c

Waste Stream Economic Value

$$= .1064 \frac{\text{lbmol}}{\text{hr}} \frac{\$59}{\text{lbmol}} + .4452 \times \frac{\$125}{\text{lbmol}}$$

$$= \$61.92/\text{hr}.$$

This is significant. Reduce by changing the waste seperator design

Problem 5d

Maximum EP achievable is when all of the feed is converted to B.

$$\text{Max EP} = (\$125 - \$59)\left(9.984 \frac{\text{lbmol}}{\text{h}}\right)$$

$$= \$658.94/\text{hr}$$

This means we are far from optimum.

Problem 5e.

1. Change design of waste sep column to recover more product and increase mole % of high boiler in waste stream.
2. Change reactor operating conditions to reduce production of C.