Exam No. 1 **ChE 473K** **Fall 2002**

Key

Problem No. 1 (FCI) - 50 pts

Sylvanite is a naturally occurring mixture of KCl and NaCl found in deposits near Carlsbad, New Mexico. You are an engineer for Acme Chemical Company which produces KCl for sale. You have developed the attached process for the recovery of KCl for the sylvanite:

The sylvanite is 56.6 wt percent NaCl and 43.4 wt percent KCl. It is fed to the dissolver as a solid by an existing conveyer. Design production of KCl is 10 ton / stream day and the unit will operate 24 hours per day, 330 days per year.

The circulating brine flow is 3.84 lbs per lb of sylvanite. The dissolver is a jacketed, agitated, reactor with a 3 hour residence time based on the flow of the circulating brine. The solid NaCl is removed from the dissolver by existing equipment.

Saturated brine is pumped to the crystallizer which is maintained at 77 F by refrigeration coils. The crystallizer is a forced circulation evaporator type. Removal of the solid KCl is by existing equipment. Cold brine at 77 F discharges the crystallizer and is heated by saturated 300 F steam to 220 F in a shell-and-tube heater.

Specific heat of the brine may be assumed constant at 0.8 BTU/ lb F and the specific gravity may be assumed constant at 1.20 at all locations in the process loop.

Assume a project start up of Jan. 1 , 2005, The CE Equipment Cost Index was 357 in 1990 and is projected to be 420 in 2005.

- Determine the FCI based on the Lang method.

Problem No. 2 (IRR) - 50 pts

You are employed as a engineer in a refinery / petrochemical complex with primary responsibility for projects in the catalytic reforming area. Currently your unit is producing 8000 barrels per day (1 barrel = 42 gallons) of reformate which is blended into gasoline. Reformate value in the gasoline pool is $ 0.75 / gallon. A proposed project will not only increase the production of reformate, but it will also upgrade its quality so that it may be used as a feedstock to your chemicals plant for the production of solvents. Data for the proposed process improvement project are:

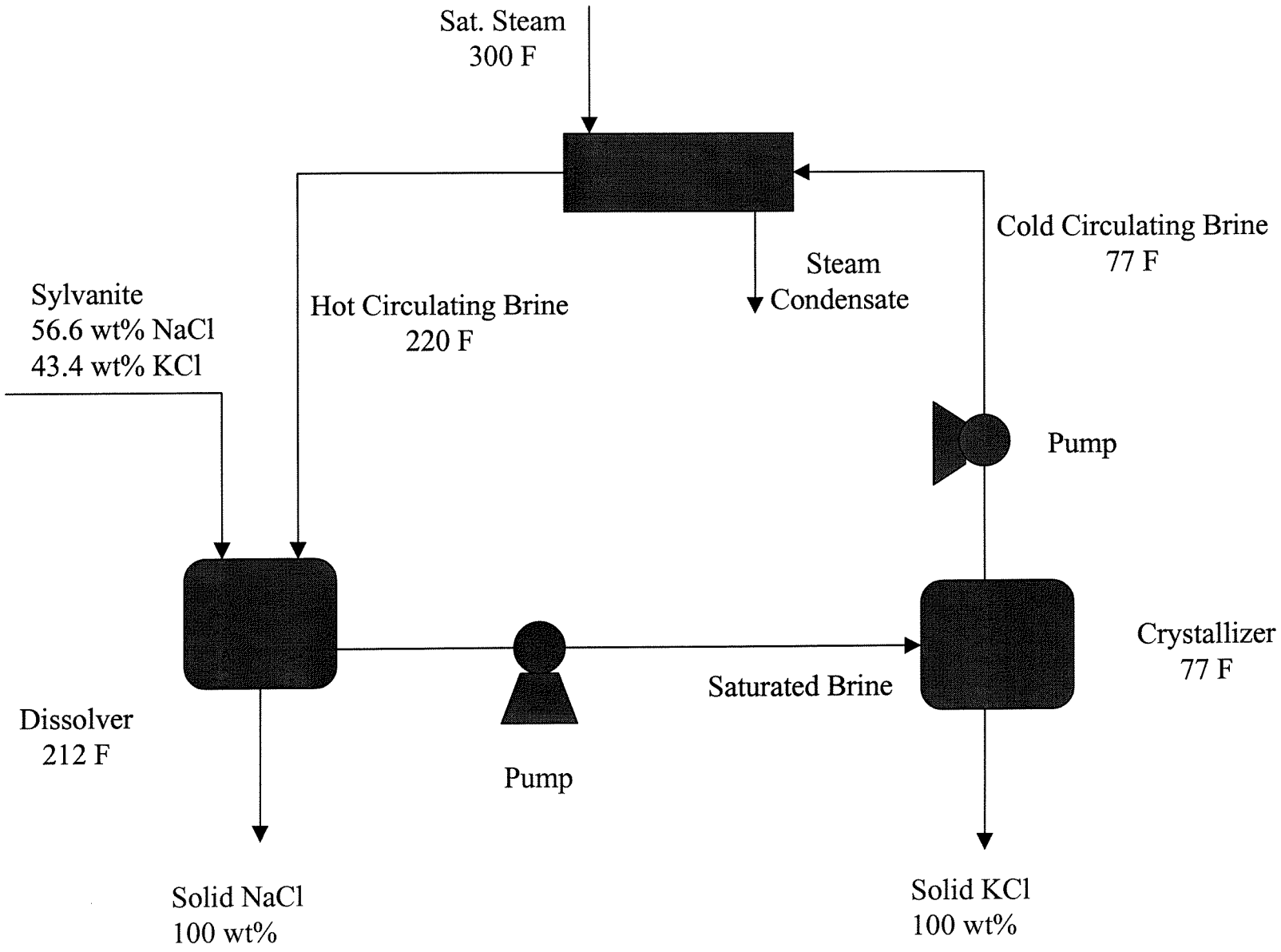
Fixed capital investment = $ 30 mm
Construction period = 1 yr
Project life = 3 years
Tax rate = 50 percent
Stream time = 330 day / yr
Depreciation = 3 years straight line

New Project Information

Year	Production	Value of Reformate		Operating expenses (not including depreciation)	
	B/D	Gasoline	Solvent	Current process	Revised Process
1	9000	$ 0.75	$ 1.00	$ 40mm	$ 50 mm
2	10000	$ 0.75	$ 1.05	$ 40 mm	$ 52 mm
3	11000	$ 0.80	$ 1.10	$ 40 mm	$ 54 mm

- Determine the profitability (IRR) for the proposed process improvement project.
- What is your recommendation ?

Problem No. 1


Sat. Steam
300 F
Cold Circulating Brine
77 F
Steam
Condensate
Sylvanite
56.6 wt% NaCl
43.4 wt% KCl
Hot Circulating Brine
220 F
Pump
Crystallizer
77 F
Saturated Brine
Dissolver
212 F
Pump
Solid NaCl
100 wt%
Solid KCl
100 wt%

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Problem No. 1

Material Balance (1 day of operation basis)

Sylvanite 10 $\frac{\text{Ton KCl}}{\text{sd}}\left(\frac{2000\text{ lb}}{\text{Ton}}\right)\left(\frac{1\text{ lb Sylvanite}}{0.454\text{ lb KCl}}\right) = 46,083\ \frac{\text{lb}}{\text{SD}}$ 1920 lb/hr

Circ. Brine Flow = 3.84 (46083) = 176959 $\frac{\text{lb}}{\text{SD}}$ 7373 $\frac{\text{lb}}{\text{hr}}$

Sat Brine Flow = 176 959 + 46,083 − 26,083

= 196,957 lb/SD 8206 lb/hr

Dissolver: Volume = $\frac{176,959\ \text{lb/SD}}{8.33 \times 1.2}\left(\frac{1}{24}\right)(3) = 2200$ gal

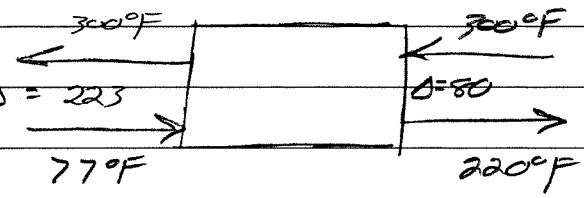
Cryst. Feed Pump: $\frac{196,957\ \text{lb/SD}}{8.33 \times 1.2}\left(\frac{1}{24}\right)\left(\frac{1}{60}\right) = 13.7$ GPM

Assume - Head = 50 Ft

Crystallizer: Feed = $\frac{196,957\ \text{lb/SD}}{2000} = 98.5\ \frac{\text{Ton}}{\text{SD}}$

Cold Brine Pump: Flow = $\frac{176,959\ \frac{\text{lb}}{\text{SD}}}{8.33 \times 1.2}\left(\frac{1}{24}\right)\left(\frac{1}{60}\right) = 12.3$ GPM @ 50 Ft Head

Heater:



$q = 176,959\ \frac{\text{lb}}{\text{D}}\left(\frac{1\text{ D}}{24\text{ hr}}\right)\left(0.8\ \frac{\text{BTU}}{\text{lb °F}}\right)(220-77)$

$q = 843,500\ \frac{\text{BTU}}{\text{HR}}$

$\Delta T_{LM} = \frac{223-80}{\ln\left(\frac{223}{80}\right)} = 139$ F Assume U=100

$A = \frac{843,500\ \text{BTU/Hr}}{100\ \frac{\text{BTU}}{\text{hr. Ft}^2\text{°F}}(139\text{F})} = 60.7\ \text{Ft}^2$

Costs — Jan 1990 ↓

1)	Dissolver	2200 gal	Fig 16.35 pg 731	$ 35,000
2)	Crystallizer	98.4 TPD	Fig 14.76 pg 561	$ 305,000
3)	Heater	Area = 60 ft^2	Fig 15.16 pg 617	$ 2700
4)	C-B Pump	12 GPM 50 ft	Fig 14.40 pg 526	$ 1000
	Motor	1/2 Hp		$ 200
5)	Cryst Feed Pump	14 GPM 50 ft	Fig 14.40 pg 526	$ 1200
	Motor	1/2 Hp		$ 200

Jan 1990 Total $ 345,100

$$FCI = \$345,100 \left(\frac{420}{357}\right)(4.73)(1.15) = \$2,208,437$$

↑ Index ↑ Lang ↑ Contingency

Problem No. 2

Work as a Δ Case

Depreciation = #10,000,000 / yr

Year 1

$$\Delta \text{ Revenue} = \left[9000 \frac{B}{D}\left(42 \frac{gal}{B}\right)\left(\$1.00/_{gal}\right) - 8000 \frac{B}{D}\left(42 \frac{gal}{B}\right)(\$0.75)\right]\left(330 \frac{D}{yr}\right) = \$\ 41,580,000$$

Δ Cost = #10,000,000

Year 2

$$\Delta \text{ Revenue} = \left[10{,}000(42)(1.05) - 8000(42)(0.75)\right]330 = \$\ 62,370,000$$

Δ Cost = #12,000,000

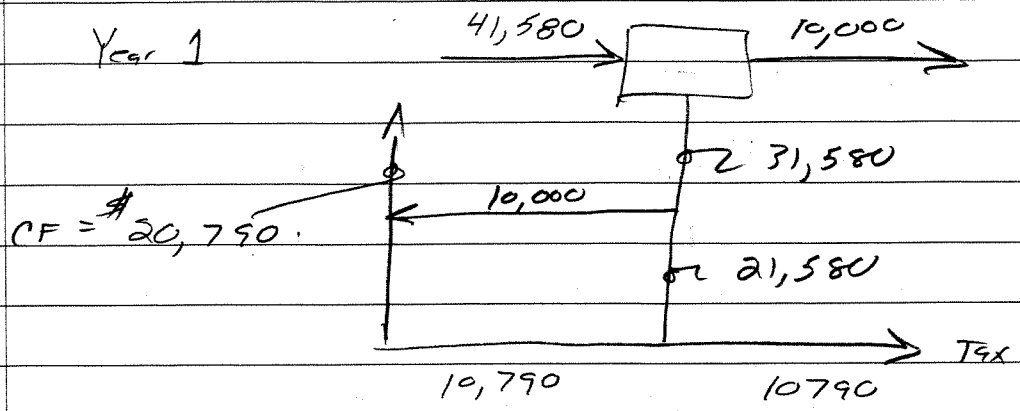
Year 3

$$\Delta \text{ Revenue} = \left[11{,}000(42)(1.10) - 8000(42)(0.80)\right](330) = \$\ 79,002,000$$

Δ Cost = #14,000,000

Cash Flow (Divide by 1000)

Year 1



Year 2 $ 30,185

Year 3 $ 37,500

IRR Calculation

Time	Item	Amount	50% Factor	PW @ 50%
-1 to 0	FCI	-30,000	1.297	-38910
1	CF	20,790	0.787	+16360
2	CF	30185	0.477	+14400
3	CF	37500	0.29	+10875
				2725 OK

IRR ≥ 50% Go For It.