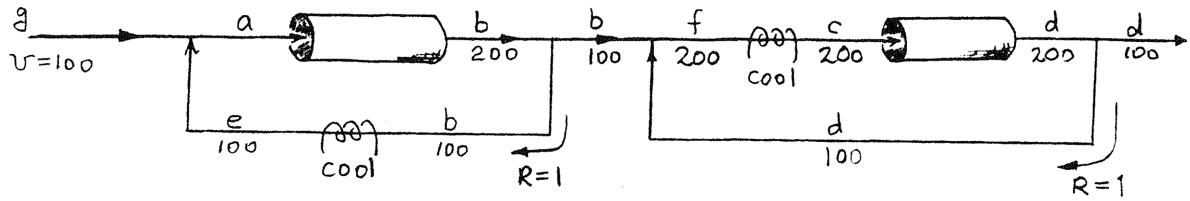
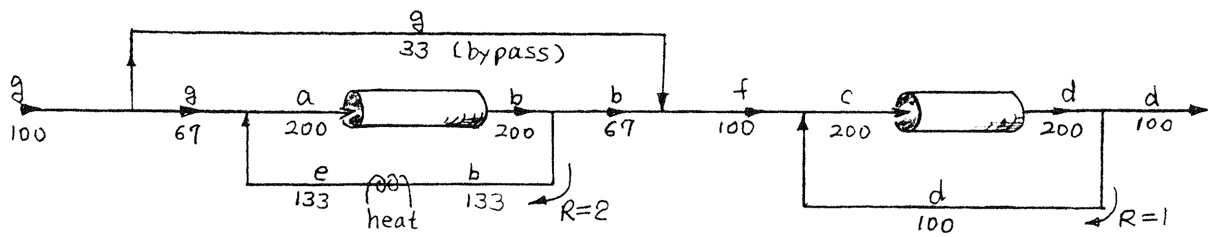
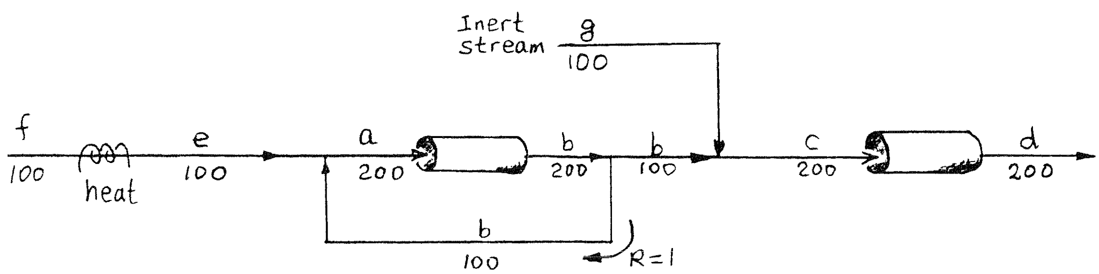
19.1



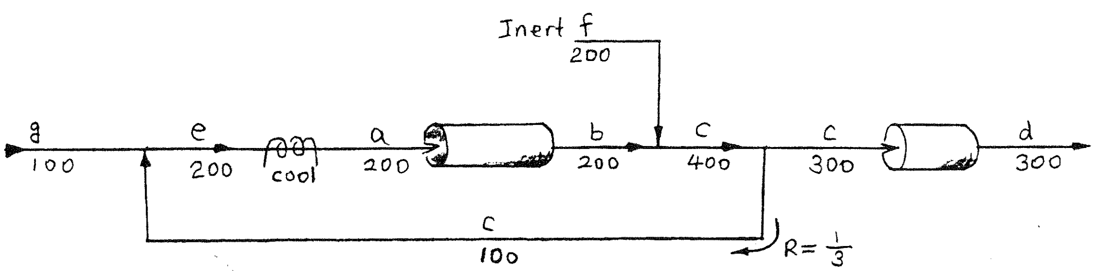
19.3



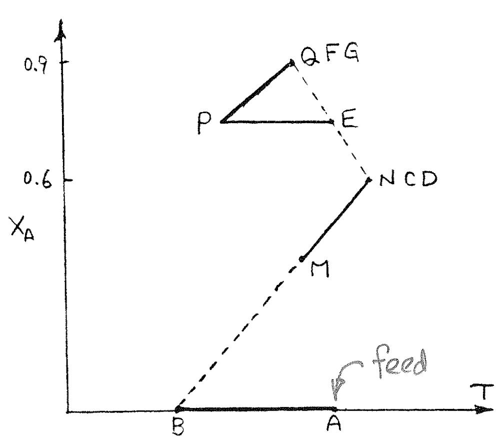
19.5



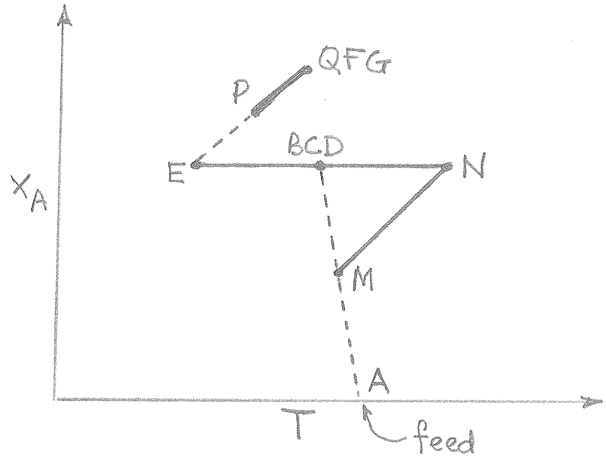
19.7



19.9

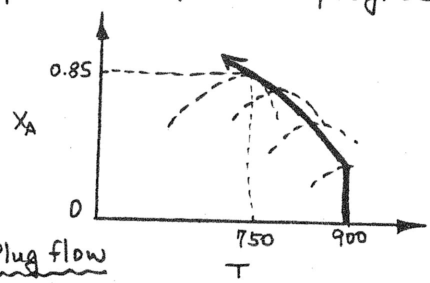


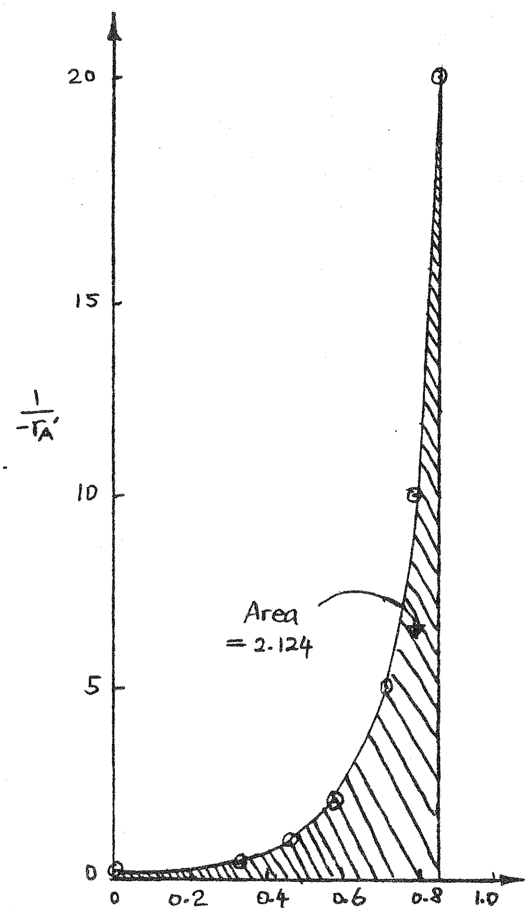
19.11



19.13

Optimal temperature progression





Plug flow

$$W = F_{A0} \int_0^{0.85} \frac{dX_A}{-r_A'} = (100)(2.124) = 212.4 \text{ kg}$$

Heat added ahead of the reactor

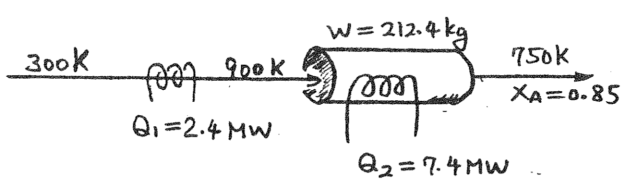
$$Q_1 = F_{A0} C_p \Delta T = (100)(40)(900-300) = 2.4 \times 10^6 \text{ J/s}$$

Heat removed from the reactor

$$Q_2 = F_{A0} X_A (-\Delta H_r) + F_{A0} C_p (\Delta T)$$

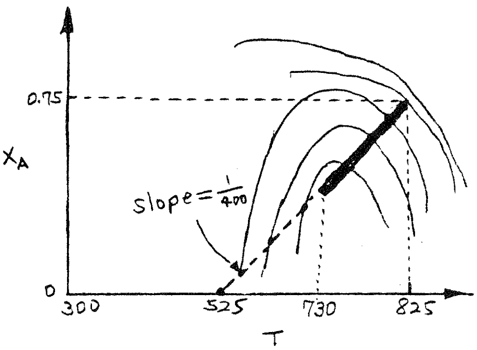
$$= (100)(0.85)(80000) + (100)(40)(900-750)$$

$$= 7.4 \times 10^6 \text{ J/s}$$



19.15 20% A – 80% inert, adiabatic reactor

$$\text{slope} = \frac{C_p}{-\Delta H_r} = \frac{40\times 5}{80000} = \frac{1}{400}$$



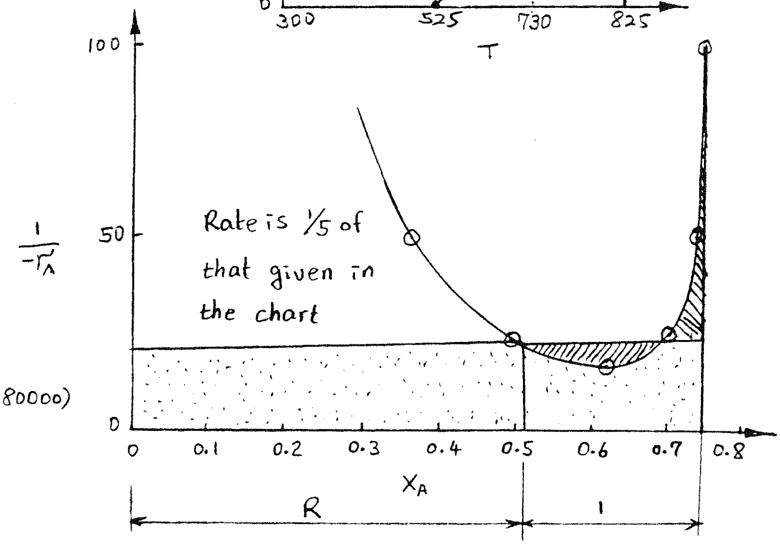
Let us construct $\frac{1}{-r_A}$ vs X_A graph.

From this graph we can see that recycle flow is best and

$$R = \frac{0.51}{0.75-0.51} = 2.125$$

$$W = F_{A_0}\frac{X_A}{-r_A'} = (100\times 0.2)(0.75)(22.8)$$

$$= 342 \text{ kg}$$

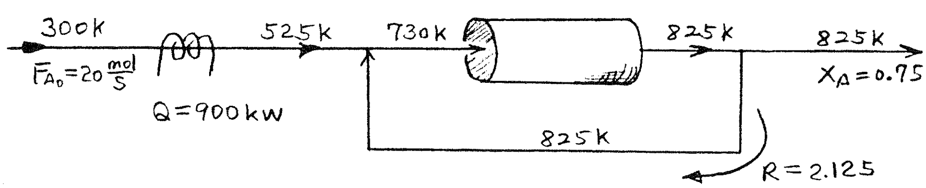


Heat duty

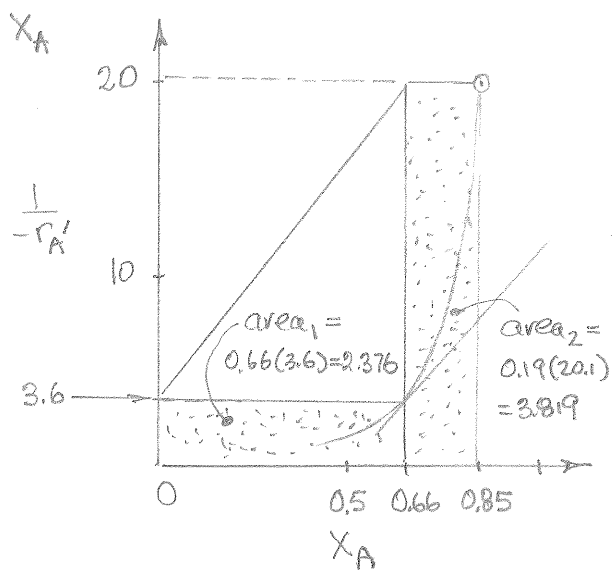
$$Q = F_{TOT}\cdot C_p \Delta T - F_{A_0}X_A(-\Delta H_r)$$

$$= (100)(40)(825-300) - (20)(0.75)(80000)$$

$$= 9\times 10^5 \text{ J/S} \quad \text{(heating)}$$



19.17 From Fig 11 plot the $1/-r'_{A,opt}$ vs X_A curve. By the optimization of rectangles we find the minimum amount of catalyst needed



$$W_1 = F_{A0}(area_1) = 100(2.376)$$
$$= 237.6 \text{ kg}$$

$$W_2 = F_{A0}(area_2) = 100(3.819)$$
$$= 381.9 \text{ kg}$$

19.17 (continued)

Heat duty

$$Q_1 = \left[F_{A0}(C_p \Delta T) - X_A(-\Delta H_r)\right]$$

$$= 100\left[40(815-300) - 0.66(+80000)\right]$$

$$= -3.2\ \text{MW} \quad \text{(remove}$$

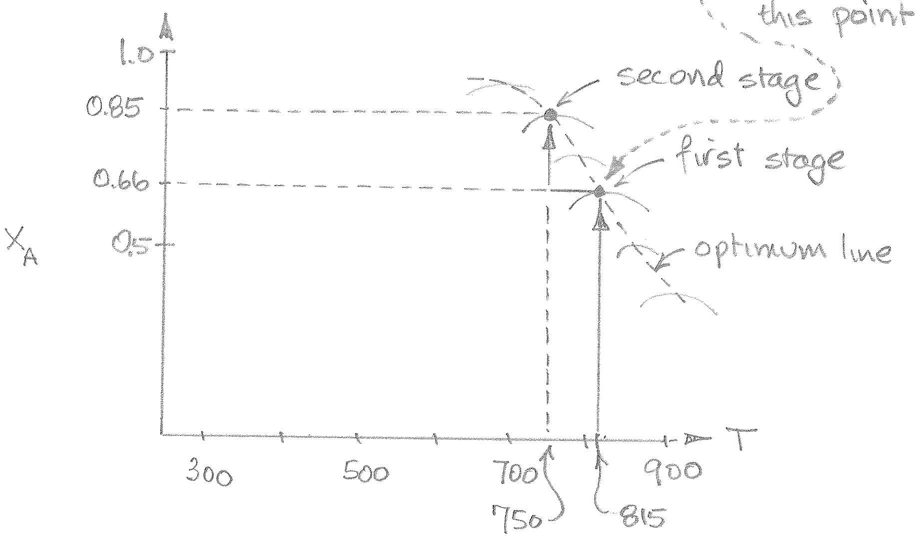
$$Q_2 = \left[F_{A0}(C_p \Delta T) - X_A(-\Delta H_r)\right]$$

$$= 100\left[40(750-815) - 0.19(+80000)\right.$$

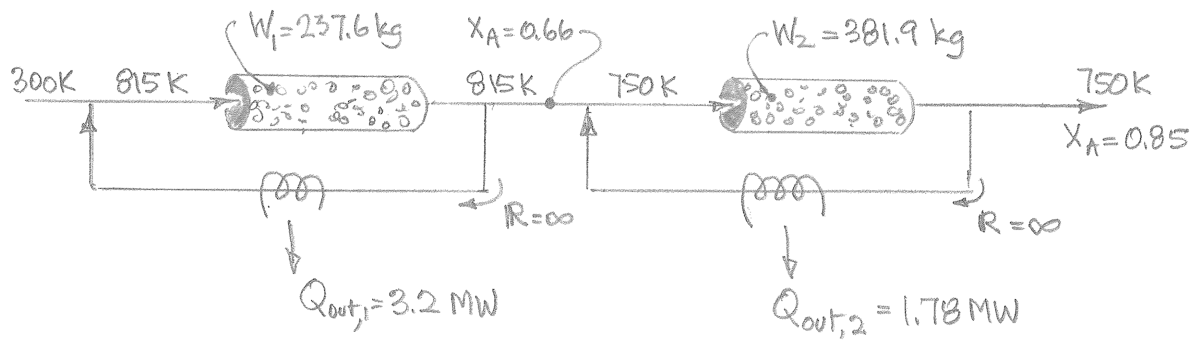
$$= -1.78\ \text{MW}$$

The T vs X_A diagram (Fig 11) is then

from the optimization of rectangles we locate this point



Final design

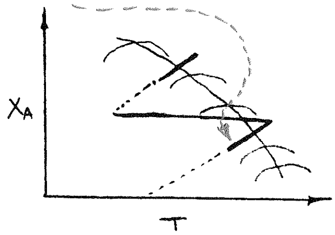


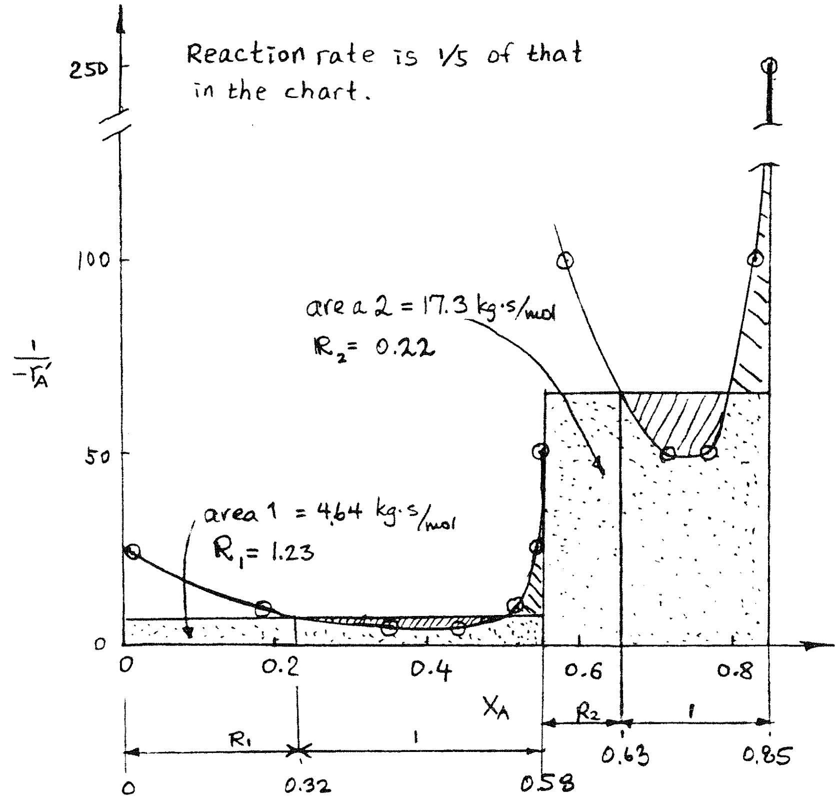
19.19 20% A – 80% B , $X_A = 0.85$

$$\text{slope} = \frac{C_p}{-\Delta H_r} = \frac{40 \times 5}{80000} = \frac{1}{400}$$

Plug flow with recycle is best.

let the opt. of rectangles suggest where to locate this line.





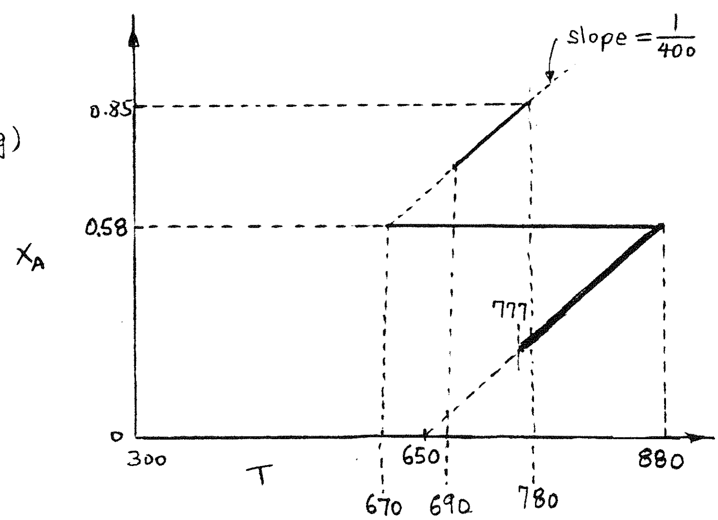
$W_1 = F_{A0} \cdot \text{area 1} = (20)(4.64)$
$= 92.8 \text{ kg}$

$W_2 = F_{A0} \cdot \text{area 2} = (20)(17.3)$
$= 346 \text{ kg}$

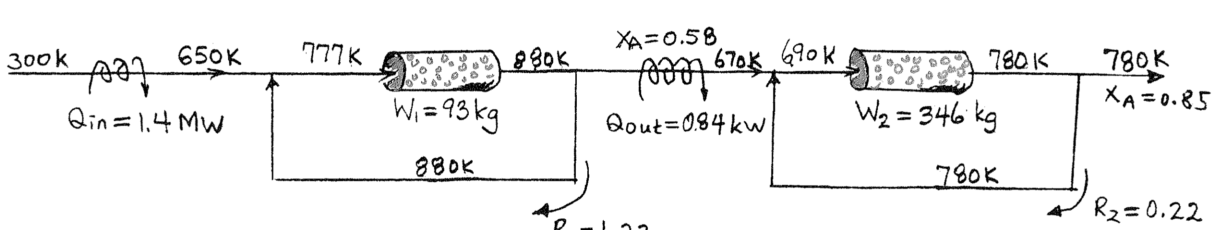
Heat duty

$Q_1 = F_{A0} C_p (\Delta T) = (20)(200)(650-300)$
$= 1.4 \times 10^6 \text{ J/s (heating)}$

$Q_2 = F_{A0} C_p (\Delta T) = (20)(200)(670-880)$
$= -0.84 \times 10^6 \text{ J/s (cooling)}$



Note that this solution was obtained after a few trials.

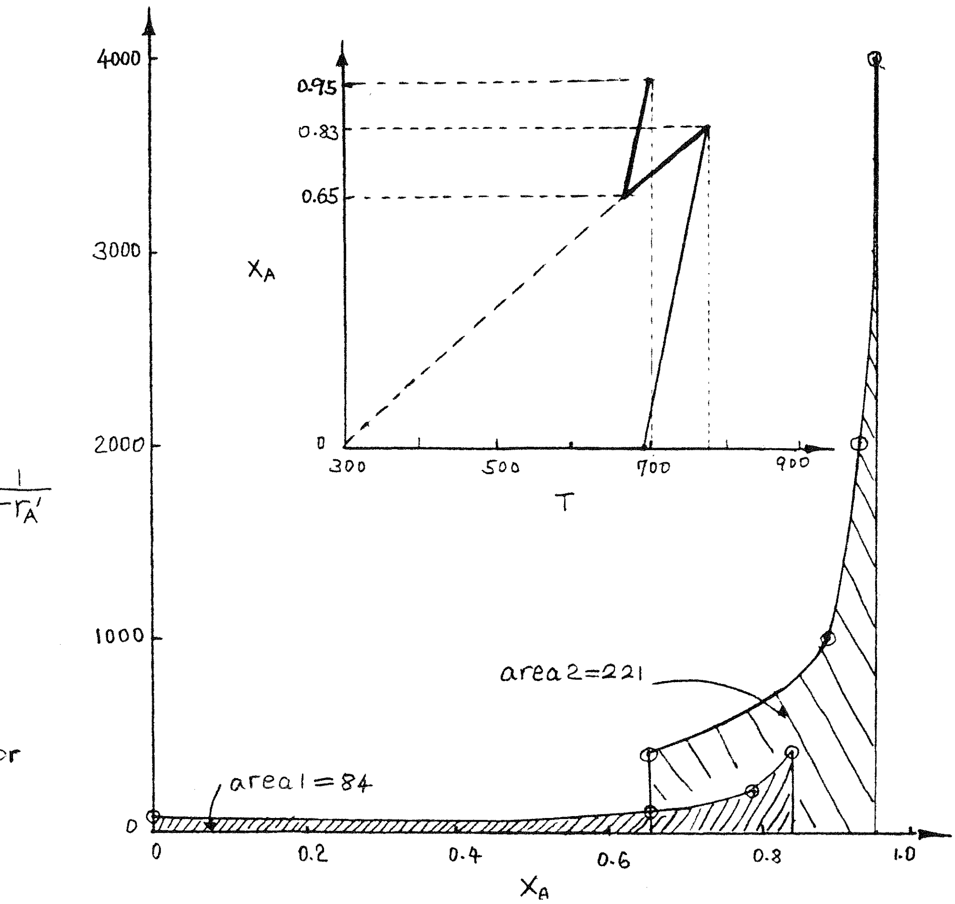


19.21 Injection of cold feed

slope $= \frac{40\times 20}{80000} = \frac{1}{100}$

Fraction of feed A that goes to the first reactor

$\frac{0.65}{0.83} = 0.7831$



$W_1 = F_{A0_1} \cdot \text{area}1 = (5\times 0.7831)(84) = \underline{329\ \text{kg}}$

$W_2 = F_{A0} \cdot \text{area}2 = (5)(221) = \underline{1105\ \text{kg}}$

$\Big\}\ W_{total} = \underline{1434\ \text{kg}}$

$Q = F_{A0_1} \cdot C_p \cdot (\Delta T) = (5\times 0.7831)(800)(690-300) = \underline{1.22\times 10^6\ J/s}$ (heating)

Note: only one heat exchanger is needed in this design.