CHAPTER III
PROCEDURE

3.1 Collecting the Data for Design Case from Reformer Area of ATC Plant

The important step in HEN retrofit is data extraction. In this work, the design and the actual data of reformer area of aromatics plant is used for the analysis. For the first phase of study, the design data will be used. The flowsheet of the ATC plant that was used in this research ,the data of hot and cold streams for the existing plant are shown in Figure3.1 and Table 3.1 respectively. The data collected from design case is satisfied with material balance for the streams that involve in the heat exchangers (i.e. temperatures, heat-capacity flowrates, composition).

3.2 Modeling the Heat Exchanger and Streams Data by Using Pro II.

Since the data from the step 1 is enough for doing HEN synthesis, the modeling of all the plant can be neglected. However, in constructing the problem table analysis, the composite curves and grand composite curve for doing targeting, knowing whether there is a phase change or not is important in order to know the temperature interval for sensible heat and latent heat of the stream. Therefore, Pro II is used to simulate the heat exchangers and streams to check the phase change temperature (dew point and bubble point) and the enthalpy change from sensible heat and latent heat.

Pro II Manual

1) Setup the unit of measurement.
2) Specify the components for the system.
3) Specify the thermodynamic property package for the system.
4) Insert stream into process flowsheet.
5) Insert unit operations into process flowsheet.
6) Make connectivity between unit operations and streams.

7) Input the feed stream information, unit operation parameters.

8) Click run button to simulate the program.

9) Check the results.

3.3 Data Extraction

The data required except the streams and heat exchanger networks data are

1) Heat transfer coefficient for each streams
2) Utility and economic data

3.3.1 Stream Heat Transfer Coefficient

Heat transfer coefficient is another important data. The values are calculated based on the correlation and heat exchanger geometry (Seider, *et al.*, 1999). The correlation for the heat transfer coefficient calculation is shown below:

For shell side without phase change, heat transfer coefficient can be calculated by Donohue equation as shown in equation 3.1.

$$\mathrm{Nu} = \left(\frac{hD_o}{k}\right) = 0.33\left(\frac{D_o u\rho}{\mu}\right)^{0.6}\left(\frac{C_p\mu}{k}\right)^{\frac{1}{3}} \tag{3.1}$$

For tube side, Colburn equation as shown in equation 3.2 is used to calculate this value.

$$\mathrm{Nu} = \left(\frac{hD_o}{k}\right) = 0.023\left(\frac{D_o u\rho}{\mu}\right)^{0.6}\left(\frac{C_p\mu}{k}\right)^{\frac{1}{3}} \tag{3.2}$$

where, Nu = Nusselt number

h= heat transfer coefficient

D_o = outside diameter of tube

D_i = inside diameter of tube

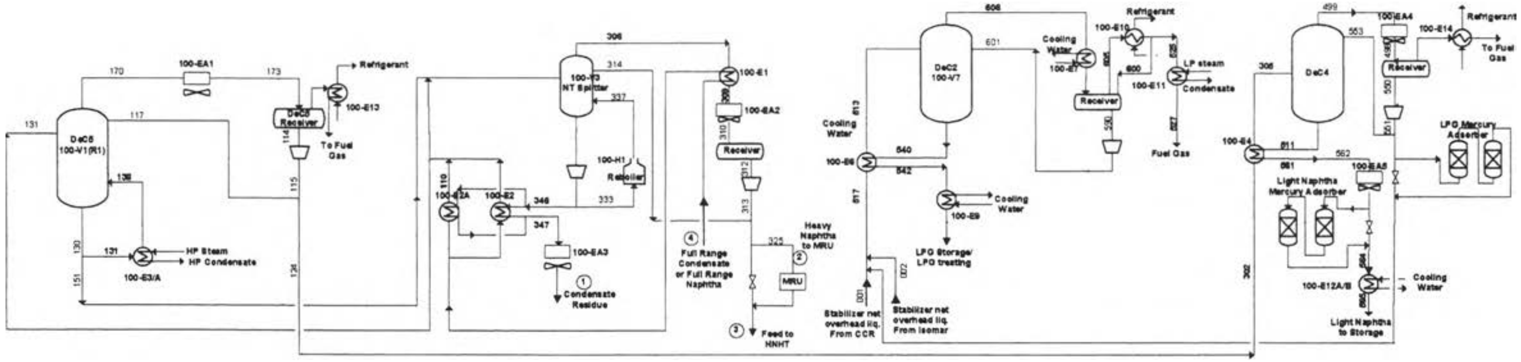
k = thermal conductivity of tube

ρ = fluid density

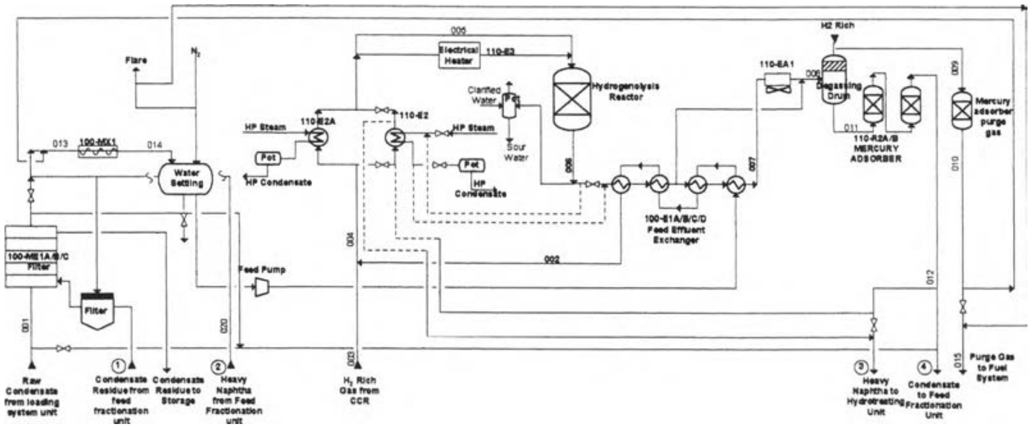
μ = fluid viscosity

C_p = heat capacity of fluid

Unit 100: Feed fractionation unit



Unit 110:MRU



Unit 150: HNHT (Heavy Naphtha Hydrotreater unit)

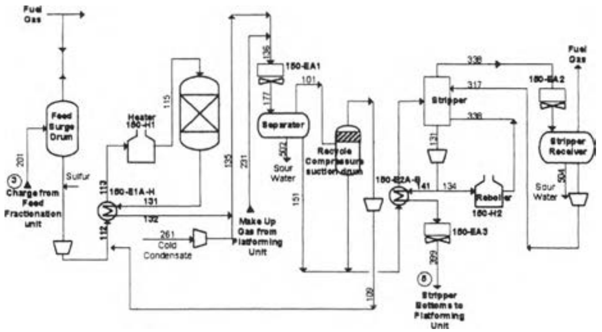
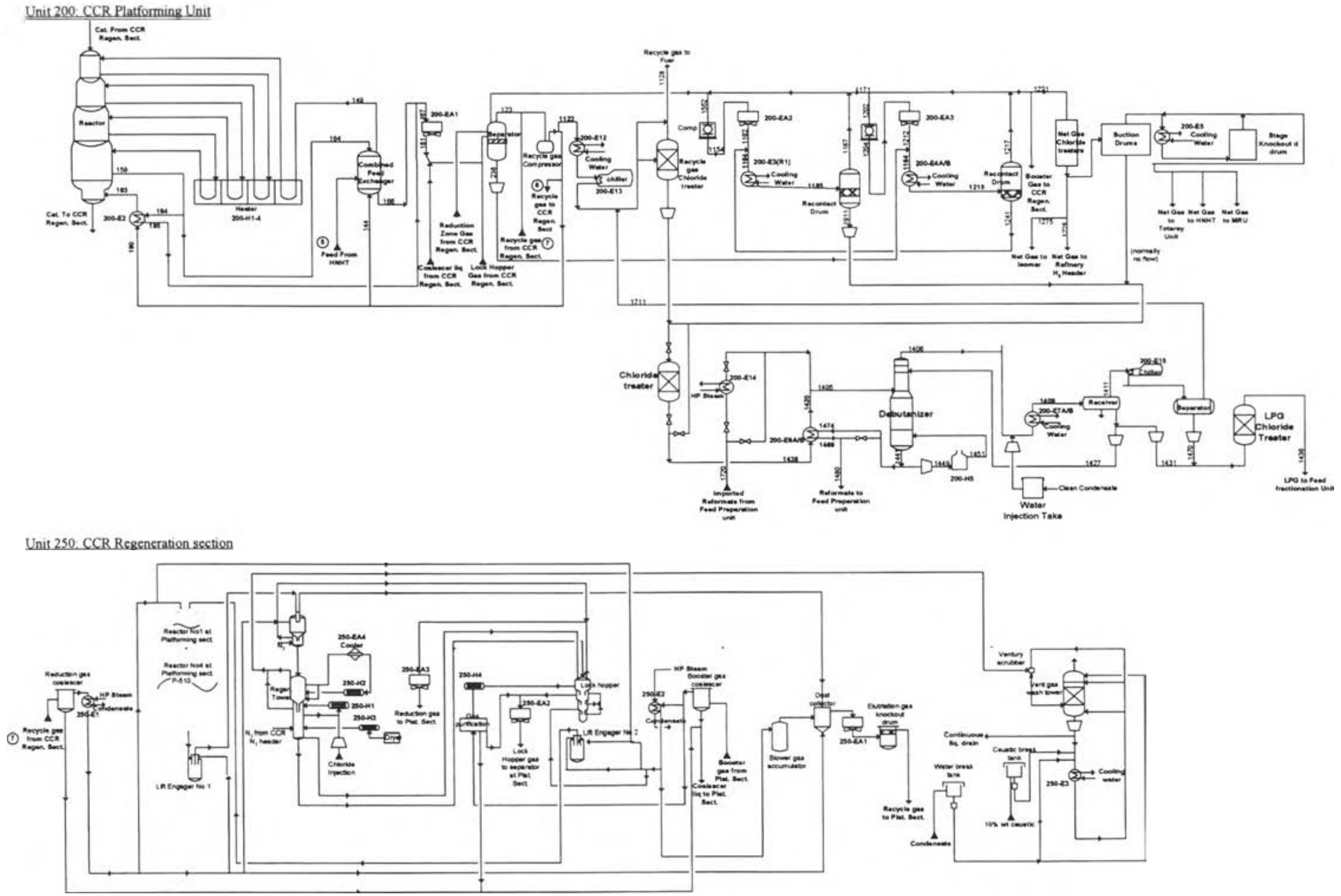


Figure 3.1 Flowsheet of ATC plant.



Unit 200: CCR Platforming Unit

Unit 250: CCR Regeneration section

Figure 3.1 (Continued) Flowsheet of ATC plant.

Table 3.1 Data for hot and cold stream for the existing plant

STREAM	HX	stream in name	stream out name	flowrate kg/hr	Tin C	Tout C	total duty MW
H1	100-E2/2A,100-EA3	346	351	71144	239	49	8.95
H2	100-E1,100-EA2	306	310	220951	149	107	23.76
H3	100-E6,100-E9	540	544	19333	109.00	38.00	1.19
H4	100-E7	606	604	3566	64	40	0.23
H5	100-E10	605	525	792	38	23	0.04
H6	100-E4,100-EA5,100-E12AB	511	565	35173	116	38	1.98
H7	100-EA4	499	498	45847	56	47	4.31
H8	110-E1A-D,110-EA1	006	008	242137	220	60	27.072
H9	150-E1AG	131	132	148267	343	131	32.22
H10	150-EA1	136	137	153252	121	49	8.04
H11	150-EA2	307	309	21174	162	50	3.21
H12	150-E2AB,150-EA3	341	399	146465	222	109	14.45
H13	200-E2	194	195	208.9	524	179.9	0.0615
H14	200-EA1	167	181	176380	103.2	48.53	15.07
H15	200-EA3	1204	1212	22648	132.9	55	2.32
H16	200-E12,200-E13	1122	1123	4080	111.8	8	0.6
H17	200-E3	1164	1165	153530	46.86	37.91	1.087
H18	200-E4AB	1214	1215	137680	56.19	37.78	1.873
H19	200-E5	1254	1265	2519	59.54	37.78	0.0923
H20	200-E6AB	1474	1469	126970	211.7	103.4	9.77
H21	200-E7AB	1406	1409	27055	66.75	38.3	2.67
H22	200-E15	1411	-	985.8	37.78	8	0.08
H23	250-E3			60062.4	40	38	0.152
H24	250-EA1			2750.4	135	55	0.25
H25	250-EA2			525.6	295	66	0.14
H26	250-EA3			309.6	477	66	0.18
H27	250-EA4			34156.8	517	482	0.38
H28	200-EA2	1154	1162	29600	131	56.11	2.65
H29	100-EA1	170	173	113987	97	52	13.11
C1	100-E3/3A	131	138	160237	188	201	16.4
C2	100-E2/2A,100-E1	103	110	265176	38	143	18.18
C3	100-E6	517	513	19690	43	78	0.54
C4	100-E11	525	527	357	24	42	0.004
C5	100-E4	302	305	49679	52	76	0.86
C6	100-E5	507	508	207949	116	118	5.49
C7	110-E2/2A			242137.08	184.5	220	8.238
C9	110-E1A-D		002	241836	36.8	188.7	24.174
C10	150-H1,150-E1A-H	112	115	148267	63	339	38.73
C11	150-E2AB	151	306	146965	49	157	10.3
C12	150-H2	334	338	261020	222	230	6.6
C13	200-E2	190	193	263.6	111.8	315.6	0.0615
C14	200-E14	1720	1405-1420	23928	86	162	1.33
C15	200-E6AB	1438	1420	131800	37	154.1	9.77
C16	200-H5	1449	1451	144620	211.7	228	7.37
C17	250-E1				38	149	9.78
C18	250-E2				38	149	0.08
C19	250-H1			679.68	420	539	0.025
C20	250-H2			34155	452	482	0.322
C21	250-H3			1336.68	38	577	0.211
C22	250-H4			244.8	38	570	0.214

3.3.2 Utility and Economic Data

In this work, the utility data and their associated cost are summarized in Table 3.2.

Table 3.2 Utility data for ATC plant

Utility	Type	Inlet Temp (°C)	Outlet Temp (°C)	Price (US$/unit)	Unit
Refrigerant	Cold	2	2	-	-
Cooling water	Cold	32	42	0.031	m^3
Air	Cold	36	60	-	-
Power	Hot	-	-	51.910	MW-hr
HPS*	Hot	395	395	15.531	Ton
MPS†	Hot	194	194	14.295	Ton
LPS‡	Hot	138	138	13.050	Ton

* High Pressure Steam
† Medium Pressure Steam
‡ Low Pressure Steam

The economic data is used for conducting an economic analysis for the retrofit project. The economic data used in this work is summarized in Table 3.3.

Table 3.3 Annualised utility costs

Refrigerant	0 US$/kW
Cooling water	12.75 US$/kW
Air	0 US$/kW
Power	415.278 US$/kW
HPS	214.510
MPS	207.625
LPS	200 US$/kW

The economic data is used for conducting an economic analysis for the retrofit project. The economic data using in this work is summarized in Table 3.4.

Table 3.4 Economic data For Aromatics plant

Economic parameter	Value
Hours on streams (hours/year)	8000
Plant lifetime (years)	10
Interest rate (%)	15
Required rate of return (%)	15
Payback time (years)	2

The heat exchanger cost is also an important parameter in calculating the capital cost of the project. When capital cost targets for a network was established, the area distribution among the individual exchangers comprising the network is not known. Consequently, the simplest way is to assume each individual exchanger to have the same area. With this assumption the capital cost of heat exchangers can be calculated from this equation (Hall 1995);

$$\text{HE cost} = A + B(\text{area})^{C} \tag{3.3}$$

Where A represents a fixed cost of installation independent of the area, B is the exchanger cost per unit area which also accounts for different materials of construction. In this case, two materials of construction were assumed for the HEN, carbon steel (cs) for lower temperature (≤ 200°C) and stainless steel (ss) for higher temperature (> 200°C) heat exchangers. The two costing law used are as follows:

$$CS = 33422 + 814\,(A)^{0.81} \tag{3.4}$$

$$SS = 33422 + 1784\,(A)^{0.81} \tag{3.5}$$

3.4 Energy Targets

Maximum energy recovery (MER) implies using the minimum amount of utilities. If Q_{Hu} is the heat supplied by hot utility and Q_{Cu} is the heat removed by cold utility, then computation of energy targets involves determining the minimum values of Q_{Hu} and Q_{Cu}. Calculation of energy target for any ΔT_{min} can be done by two ways; constructing the grand composite curve (Hohmann, 1971) and Problem Table Algorithm (PTA) (Linnhoff and Flower, 1978). But PTA can be done easily without plotting the graph. Steps for making problem table algorithm are

Step 1. Determination of Temperature Interval (T_{int})

$\Delta T_{min}/2$ is subtracted from the hot stream temperatures and $\Delta T_{min}/2$ is added to the cold stream temperatures. These temperatures are then sorted in descending order, omitting temperatures common to both hot and cold streams. These form the limits of the various temperature intervals.

This step ensures that there is an adequate driving force of ΔT_{min} between the hot and cold streams for possible heat transfer within each interval.

Step 2. Calculation of Net MC_p in Each Interval ($MC_{p,int}$)

The sum of the MC_p values of the hot streams is subtracted from the sum of the MC_p values of the cold streams present in each temperature interval.

Step 3. Calculation of Net Enthalpy in Each Interval

The $MC_{p,int}$ (calculated in Step 2) is multiplied by the temperature difference of that interval to obtain the heat requirement in the interval (Q_{int}). These are the net surplus ($Q_{int} < 0$) or deficit ($Q_{int} > 0$) in each interval.

Step 4. Calculation of Cascaded Heat (Q_{cas})

The net enthalpy in an interval (obtained in Step 3) is subtracted from the cascaded heat in the previous interval to obtain the cascaded heat in that interval.

Step 5. Revision of Cascaded Heat (R_{cas})

The most negative Q_{cas} in column is subtracted from each value in that column to obtain the revised cascaded heat (R_{cas}) in column. The cascaded heat needs to be revised since a negative heat transfer is thermodynamically infeasible. The negative heat transfer is a consequence of the heat from a higher interval being inadequate to satisfy the requirements of lower intervals. This may be rectified by supplying just enough heat at the highest temperature interval (through a hot utility) to temperature interval. This heat cannot be rejected to any cold stream and thus constitutes the minimum cold utility requirement.

Step 6. Determination of Energy Targets

The minimum hot utility requirement ($Q_{hu,min}$) and the minimum cold utility requirement ($Q_{cu,min}$) are the first and last values in column of R_{cas}. The temperature T_{int} that corresponds to zero revised cascaded heat is called the pinch temperature.

3.5 Area Targets

The calculation of $Q_{hu,min}$ and $Q_{cu,min}$ by the PTA is useful in estimating utility cost; similarly, the calculation of areas is useful in estimating capital costs prior to actual network invention.

The area is calculated assuming overall countercurrent heat exchange which manifests itself as vertical heat transfer on the composite curves. Strictly speaking, this is the minimum area only when the heat transfer coefficients (h) of all the streams and utilities are equal.

Although use of the available temperature differences based on the relative heat transfer coefficients of the streams predicts lower area targets, according to Linnhoff and Ahmad (1990), the deviation of the target area calculated below (Equation 3.4) is not more than 10% of the entire area even when the heat transfer coefficients differ by one order magnitude. This accuracy suffices for targeting purposes in most cases.

The area target is basically given by the following equation (Townsend and Linnhoff, 1984; Linnhoff and Ahmad, 1990);

$$A = \sum_i \left(\frac{1}{F\,LMTD}\right)_i \sum_j \left(\frac{Q_j}{h_j}\right)_i \tag{3.6}$$

where F is the correction factor accounting for noncountercurrent flow, LMTD is the logarithmic mean temperature difference for the interval, Q_j is the enthalpy change of the j-th stream, h_j is the heat transfer coefficient of the j-th stream, subscript i denotes the i-th enthalpy interval, and subscript j denotes j-th stream.

Within an enthalpy interval, all the hot streams undergo the same temperature change (dT_h) as do all the cold streams (dT_c). This gives

$$\sum_j \left(\frac{Q_j}{h_j}\right)_i = \sum_j \frac{Q_j}{h_j} = (dT_h)_i \sum_{jh} \left(\frac{MC_p}{h}\right)_{jh} + (dT_c)_i \sum_{jc} \left(\frac{MC_p}{h}\right)_{jc} \tag{3.7}$$

The first step in area estimation is the generation of a composite plot.

3.5.1 Plotting of Composite Curves

Step 1. Sorting of Hot Stream Temperatures (T_h)

The hot stream temperatures are sorted in ascending order, omitting repeated entries.

Step 2. Calculation of MC_p of Hot streams in Each Interval (Sum MC_p)

The sum of the MC_pvalues of the hot streams present in each temperature interval is calculated.

Step 3. Calculation of Enthalpy in Each Interval ($Q_{int,h}$)

The sum$MC_{p,h}$ in each interval (calculated in step 2) is multiplied by the temperature difference of that interval.

Step 4. Calculation of Cumulative Enthalpy ($CumQ_h$)

This column is calculated using the formula

$$CumQ_{h,i} = CumQ_{h,i-1} + Q_{int,hi} \tag{3.8}$$

With $CumQ_{h,i} = 0$ for i = 0.

Step 5. Plotting of HCC

T_h are plotted against $CumQ_h$ to obtain the HCC

Step 6. Generation of CCC Data

The procedure to be followed for the CCC is virtually identical to that adopted for the HCC. The cold stream temperatures are sorted in ascending order, omitting repeated entries, to obtain T_c. The sum of the MC_p values of the cold streams present in each temperature interval is calculated and entered as Sum$MC_{p,c}$ against the higher temperature limit of the interval. A zero is placed for the first entry. The Sum$MC_{p,c}$ in each interval is multiplied by the temperature difference of that interval to obtain the enthalpy in each interval ($Q_{int,c}$). For the cumulative enthalpy $CumQ_c$ is calculated by using the formula:

$$CumQ_{c,i} = CumQ_{c,i-1} + Q_{int,ci} \tag{3.9}$$

With $CumQ_{c,i} = Q_{cu,min}$ for i = 0. This is the only difference between the plotting procedureds for the HCC and the CCC. While the HCC starts from zero enthalpy, the CCC is displaced by the cold utility target. The CCC is obtain by plotting T_c vs. $CumQ_c$.

Step 7. Determination of Enthalpies for intervals ($CumQ_i$)

The value of $CumQ_h$ and $CumQ_c$ are merged, omitting cumulative enthalpies common to both tables, and the entries are the sorted in ascending order.

This identifies all points where either composite curve has a vertex (change in slope) and thus determines the various enthalpy intervals over which the area is to be summed.

Step 8. Calculation of Interval Temperatures on HCC (T_{hi})

For each $CumQ_i$ from Step 7, a least value of $CumQ_h$ that satisfies $CumQ_h \geq CumQ_i$ is identified. Let this valued be in row r. Then,

$T_{hi} = T_{h,row\ r}$ if $CumQ_{h,row\ r} = CumQ_i$ or

$T_{hi} = T_{h,row\ r} - (CumQ_{h,row\ r} - CumQ_i)/SumMC_{p,h\ row\ r}$

in all other cases. (3.10a)

Step 9. Calculation of Interval Temperatures on CCC (T_{ci})

These temperatures are calculated in a manner similar to that in step 8. For each $CumQ_i$, the least value of $CumQ_c$ is identified such that $CumQ_c \geq CumQ_i$. Let this value in row r. Then,

$T_{ci} = T_{c,row\ r}$ if $CumQ_{c,row\ r} = CumQ_i$ or

$T_{ci} = T_{c,row\ r} - (CumQ_{c,row\ r} - CumQ_i)/SumMC_{p,c\ row\ r}$

in all other cases. (3.10b)

Step 10. Calculation of $\sum(MC_p/h)$ in Each Interval ($\sum(MC_p/h)_h$ and $\sum(MC_p/h)_c$)

These values are calculated in a manner similar to $SumMC_{p,h}$ and $SumMC_{p,c}$. Using the heat transfer coefficients, the sum of the (MC_p/h) values of all the hot process streams present in each temperature interval is calculated and enter against the higher temperature limit of the interval. Similarly, the sum of the (MC_p/h) values of all the cold process streams present in each temperature interval is calculated and entered against the higher temperature limit of the interval.

Step 11. Calculation of Sum(Q/h) in Each Interval as per equation 3.5 (Sum(Q/h))

The $(\sum(MC_p/h)_h$ for the HCC is multiplied by the hot composite stream temperature difference and then added to the corresponding value for the cold composite curve. As per Equation 3.5 the value in interval i is given by

$$\mathrm{Sum}(Q/h) = (T_{h,i} - T_{h,i-1})\,(\sum(MC_p/h)_{h,i} + (T_{c,i} - T_{c,i-1})\,(\sum(MC_p/h)_{c,i} \qquad \text{for } i \geq 1$$

$$\mathrm{Sum}(Q/h) = 0 \qquad \text{for } i = 0 \quad (3.11)$$

Step 12. Calculation of Log Mean Temperature Difference in Each Interval (LMTD$_i$)

This is easily done by the following formula:

$$LMTD_i = \frac{(T_{h,i} - T_{c,i}) - (T_{h,i-1} - T_{c,i-1})}{\ln\left[\dfrac{T_{h,i} - T_{c,i}}{T_{h,i-1} - T_{c,i-1}}\right]} \qquad \text{for } i \geq 1$$

$$LMTD_i = 0 \qquad \text{for } i = 0 \quad (3.12)$$

Step 13. Calculation of Countercurrent Exchanger Area in Each Interval (A$_i$)

The overall Area can be calculated by summing over all the A$_I$ values.

3.5 Retrofitting by Pinch Technology

The good retrofits should be conducted by aiming toward the optimum new design with the effective use of existing area. In other words, it should save much energy as possible using the existing area. However, in practice, we usually have to invest some capital to make changes to an existing network, thus increasing area.

The basic methodology looks at the economics of plant operation and of modification of provided targets. The next step involves network modification to achieve the set targets.

3.5.1 Targeting Based on Constant h-values

The target procedure is based on energy and area targets as well as on the concept of area efficiency. An investment vs. saving plot is used to obtain a target for retrofit design.

Step 1. Calculation of Area Efficiency of Existing Network

For retrofit design, the area efficiency, α, of an existing HEN is important. The area efficiency measures the performance of the existing design compared to the ideal target of the process data. The closer the existing HEN is to the ideal curve in an energy area plot the better the performance, as this indicates that the design is utilising the installed area efficiently. If there is poor correspondence between the two then there exists inefficient use of energy recovery, which implies that there is a large scope for improvement of the existing design. The area efficiency is defined as

$$\alpha = A_{ideal} / A_{existing} \tag{3.13}$$

where A_{ideal} is the ideal target area based on the composite curves corresponding to the current utility levels and $A_{existing}$ is the acual area of the existing network. This would involve use of the PTA to obtain ΔT_{min} and a trial and error procedure to ascertain the ΔT_{min} for the existing utility level.

Step 2. Calculation of Area Targets for Various Energy Levels

The area and energy targets can be calculated at any ΔT_{min} as in section 3.4 and 3.5.

Step 3. Calculation of the Retrofit Curve

One of the aims of retrofitting is to improve the use of area; hence, the efficiency should not decrease and may be chosen to be $\alpha_{existing}$ to provide a most conservative estimate for further calculations.

There are two area efficiency concepts, namely constant and incremental. The constant α method states that the network would use the additional area as efficiently as the existing network over the full energy span.

This is a conservative approach, which gives good targets for networks with high α. However, when α is very low (i.e., $\alpha < 0.9$), the usage of an incremental value of $\Delta\alpha=1$ is recommended (Silangwa, 1986: Ahmad and Polley, 1990). Thus the maximum area to be used in designing the new network may be obtained as

$$A_{max,retr} = A_{ideal}/\alpha_{existing} \quad \text{for } \alpha > 0.9 \qquad (3.14a)$$

$$A_{max,retr} = (A_{ideal} - A_{ideal\ 1})/\ \Delta\alpha + A_{existing} \quad \text{for } \alpha < 0.9 \qquad (3.14b)$$

where $A_{ideal\ 1}$ is the value of A_{ideal} of existing network.

Step 4. Calculation of Energy Saving and Extra Area Required

The formulae are

energy savings = current utility usage - target utility required (based on hot or cold) (3.15a)

extra area = required new area - existing area (3.15b)

Before calculation of the energy saving, the utility usage for multiple utility levels is required and Problem Table Analysis will be very useful in this step.

Step 5. Economic Analysis of Investment vs. Savings

This step involves calculation of the energy saving into amount of saving in \$ and the extra area required into investment cost in US\$. Simplifying assumptions used for the calculation of energy and capital costs are:

- The investment cost refers only to the cost of extra area required to achieve the energy recovery target. No piping or other costs are considered.
- The average size of the heat exchanger shell is calculated from the existing HEN area and number of shells.
- The existing average area per shell in the HEN is the same for the added area.

- For the existing network, the area is calculated for a counter-current single shell pass, single tube pass.

The investment cost is estimated using the following equation:

$$\text{Investment cost} = \Delta N(\, A + B\,(\Delta A/\Delta N)^{C}\,) \qquad (3.16)$$

Where $\Delta N = \Delta A$/average size of exchanger shell.

And ΔN is the number of additional shells required. ΔA is the additional area required to achieve the energy recovery. In the existing HEN, the average size of exchanger shell is approximately 240.4 m^2.

Since there are two exchanger laws used for the existing network to account for variations in material of construction. These two laws correspond to cs (carbon steel) and ss (stainless steel) materials for temperatures below and above 200°C. These two laws have similar A and C coefficients but different B coefficients. For targeting capital cost an average value is assumed. Therefore the investment cost is given by

$$\text{Investment cost(US\$)} = \Delta N(\, 33422 + 1299\,(\Delta A/\Delta N)^{0.81}\,) \qquad (3.17)$$

Step 6. Identification of Target ΔT_{min}

Based on the specified payback period(2 years), the required target is the point where the investment is twice the savings.

3.5.2 Design Procedure

The design procedure will be as follows

1) Identify cross-pinch exchangers. Draw the existing network on the grid (using ΔT_{min}identified in the targeting stage) to find the heat exchangers crossing the pinch.
2) Eliminate cross-pinch exchangers.
3) Complete the network--Position new exchangers and, where possible, reuse exchangers removed in Step2.

4) Evolve improvements--Improve compatibility with existing network via heat load loops and paths. Reuse area of existing exchangers as much as possible.

3.6 Collecting the Data for Actual Case from Reformer Area of ATC Plant

The temperature and flow rate can be read by the TI or TIC and FI or FIC respectively. The average value of these data was concluded in table 3.5. Some of Streams in design case was not be used in this case because the modification of these streams can not be done. In total , the number of the hot and cold streams was reduced to 40 streams which are 24 hot streams and 16 cold streams. After that, the retrofit of actual case can be done by repeating the procedure 3.4 to 3.6.

Table 3.5 Actual temperature and flow rate of ATC plant

STREAM	HX	flowrate kg/hr	Tin C	Tout C
H1	100-E2/2A,100-EA3	76160	241.478	57.508
H2	100-E1,100-EA2	215034.58	133.448	95.209
H3	100-E6,100-E9	20374.123	107.837	35.611
H4	100-E7	3476.8477	55.082	36.955
H5	100-E10	772.19956	36.955	19.197
H6	100-E4,100-EA5, 100-E12AB	28480.223	110.168	31.047
H7	100-EA4	47001.31	55.136	45.852
H8	110-E1A-D,110-EA1	123979.87	190.876	60.002
H9	150-E1AG	131970.9	322.971	132.821
H10	150-EA1	139105	132.821	51.007
H11	150-EA2	27959.735	153.505	49.639
H12	150-E2AB,150-EA3	129864.41	206.704	63.137
H13	200-E2	187.31881	510.925	62.133
H14	200-EA1	139684.41	95.028	46.018
H15	200-EA3	20308.264	130.280	54.492
H16	200-E12,200-E13	3219.1878	112.826	9.710
H17	200-E3	137669.01	43.712	36.712
H18	200-E4AB	123456.46	54.718	36.718
H19	200-E5	2258.7654	67.305	32.527
H20	200-E6AB	152420	207.288	118.902
H21	200-E7AB	24948.368	63.378	39.780
H22	200-E15	1270	38.545	19.475
H28	200-EA2	26543.856	138.810	57.698
H29	100-EA1	115108	80.534	51.693
C1	100-E3/3A	151146.22	184.949	198.949
C2	100-E2/2A,100-E1	252330	29.343	108.184
		252330	108.184	131.399
C3	100-E6	18040.663	42.974	71.778
C4	100-E11	510	19.197	75.175
C5	100-E4	43760	52.125	71.143
C6	100-E5	183161.4	110.168	113.168
C7	110-E2A	123979.87	157.289	192.001
C8	110-E2	129525.79	60.002	81.757
C9	110-E1A-D	129514.34	97.892	157.289
C10	150-H1,150-E1A-H	139105.8	81.865	324.809
C11	150-E2AB	130147.88	51.284	160.705
C12	150-H2	264063.98	206.704	213.158
C13	200-E2	94.515381	112.826	176.999
C14	200-E14	40519.454	35.000	127.322
C15	200-E6AB	116891.27	36.985	157.542
C16	200-H5	149998.55	207.288	230.547