"APPLICATION OF PINCH TECHNOLOGY IN A COMMISSIONNING UNIT"

A Thesis Submitted in Partial Fulfillment of the Requirement for the degree of

BACHELOR OF TECHNOLOGY
(APPLIED PETROLEUM ENGINEERING)

By

ABHISHEK MEHROTRA (R010207001)
AKANKSHA CHAUDHARY (R240207005)
EPSA SHARMA (R240207020)
VIVEK KUMAR YADAV (r010207067)

Umasankar

Under the Guidance of
MR. UMA SHANKAR
(Assistant Professor, SG)

College of Engineering

University of Petroleum and Energy Studies

Dehradun

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Under the Guidance of
Mr. B. UMA SHANKAR
(Assistant Professor, Chemical Engg. Department)
UPES, DehraDun.

Approved

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Dean

College of Engineering

University of Petroleum and Energy Studies

Dehradun

May, 2011

CERTIFICATE

This is to certify that **Abhishek Mehrotra, Akanksha Chaudhary, Epsa Sharma and Vivek Kumar Yadav** has done their major project at University of Petroleum & Energy Studies during the fourth year of their academics.

The thesis titled "**APPLICATION OF PINCH TECHNOLOGY IN A COMMISSIONNING UNIT**" is original work and has been carried out under supervision and is submitted in partial fulfilment of the requirement for the the degree of Bachelor of Technology, Applied petroleum engineering.

This work is not submitted elsewhere for a degree .

Mr. B. UMA SHANKAR
Assistant Professor,
Chemical Engg. Department
UPES,Dehra Dun.

ACKNOWLEDGEMENT

Major Project in the final year is an indispensable part of any engineering curriculum. It provides the students with an opportunity to gain experience on the practical application of their technical knowledge and to study the various theoretical aspects as well.

We would like to thank our Project Guide **Prof. UMA SHANKAR**, Assistant Professor, Chemical Engg. Department, UPES, Dehra Dun for giving us this opportunity to work under his guidance on this project and for also providing us with all the necessary information. His technical help and goal oriented approach has been unique and a stepping stone towards the successful completion of the project.

We would also like to express our gratitude towards our parents for their kind co-operation and encouragement which helped us in completion of this project.

We would like to express our special gratitude and thanks to industry persons for giving us such attention and time.

Our thanks and appreciations also go to my friends for supporting us in developing the project and people who have willingly helped us out with their abilities.

Abhishek Mehrotra

Akanksha Chaudhary

Date-3 May, 2011

Epsa Sharma

Vivek Kumar Yadav

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ABSTRACT

In the present work our major work analysis was involving energy conservation mode to a newly commissioned refinery unit, where the majority of the simulation has been carried out by using aspen simulation. Pinch analysis is a technique used for energy conservation by managing heat balances throughout the process units by ailing a integration of complete process design and PI diagrams. Improving integration of processes leads to the development of elegant heat recovery networks without using advanced unit operation technology. In the present work, the heat from the out coming streams of the atmospheric unit have been utilized to heat up the incoming streams to the ADU in the preheat train. Thus, making fewer utilities there by conserving energy that would result in improving economic efficiency of the unit.

Chapter-1: INTRODUCTION

While oil prices continue to climb, energy conservation remains the prime concern for many process industries. The term "Pinch Technology" was introduced by Linnhoff and Vredeveld to represent a new set of thermodynamically based methods that guarantee minimum energy levels in design of heat exchanger networks. Pinch Analysis (also known as process integration, heat integration, energy integration, or pinch technology) is method for minimizing the energy costs of a chemical process by reusing the heat energy in the process streams rather than outside utilities. Over the last two decades it has emerged as an unconventional development in process design and energy conservation. The term 'Pinch Analysis' is often used to represent the application of the tools and algorithms of Pinch Technology for studying industrial processes.

Basis of Pinch Analysis

Pinch technology presents a simple methodology for systematically analyzing chemical processes and the surrounding utility systems with the help of the First and Second Laws of Thermodynamics. The First Law of Thermodynamics provides the energy equation for calculating the enthalpy changes (H) in the streams passing through a heat exchanger. The Second Law determines the direction of heat flow. That is, heat energy may only flow in the direction of hot to cold. This prohibits 'temperature crossovers' of the hot and cold stream profiles through the exchanger unit. In a heat exchanger unit neither a hot stream can be cooled below cold stream supply temperature nor can a cold stream be heated to a temperature more than the supply temperature of hot stream. In practice the hot stream can only be cooled to a temperature defined by the 'temperature approach' of the heat exchanger. The temperature approach is the minimum allowable temperature difference (DTmin) in the stream temperature profiles, for the heat exchanger unit. The temperature level at which DTmin is observed in the process is referred to as "pinch point" or "pinch condition". The pinch defines the minimum driving force allowed in the exchanger unit.

Objectives of Pinch Analysis

Pinch Analysis is used to identify energy cost and heat exchanger network (HEN) capital cost targets for a process and recognizing the pinch point. The procedure first predicts, ahead of design, the minimum requirements of external energy, network area, and the number of units for a given process at the pinch point. Next a heat exchanger network design that satisfies these targets is synthesized. Finally the network is optimized by comparing energy cost and the capital cost of the network so that the total annual cost is minimized. Thus, the prime objective of pinch analysis is to achieve financial savings by better process heat integration (maximizing process-to-process heat recovery and reducing the external utility loads.

Development of the Pinch Technology Approach

When the process involves single hot and cold streams (as in above example) it is easy to design an optimum heat recovery exchanger network intuitively by heuristic methods. In any industrial set-up the number of streams is so large that the traditional design approach has been found to be limiting in the design of a good network. With the development of pinch technology in the late 1980's, not only optimal network design was made possible, but also considerable process improvements could be discovered. Both the traditional and pinch approaches are depicted below.

Traditional Design Approach: First, the core of the process is designed with fixed flow rates and temperatures yielding the heat and mass balance for the process. Then the design of a heat recovery system is completed. Next, the remaining duties are satisfied by the use of the utility system. Each of these exercises is performed independently of the others.

Pinch Technology Approach: Process integration using pinch technology offers a novel approach to generate targets for minimum energy consumption before heat recovery network design. Heat recovery and utility system constraints are then considered in the design of the core process. Interactions between the heat recovery and utility systems are also considered. The pinch design can reveal opportunities to modify the core process to improve heat integration. The pinch approach is unique because it treats all processes with multiple streams as a single, integrated system. This method helps to optimize the heat transfer equipment during the design of the equipment.

Areas of Applications of Pinch Technology

Pinch originated in the petrochemical sector and is now being applied to solve a wide range of problems in mainstream chemical engineering. Wherever heating and cooling of process materials takes places there is a potential opportunity. Thus initial applications of the technology were found in projects relating to energy saving in industries as diverse as iron and steel, food and drink, textiles, paper and cardboard, cement, base chemicals, oil, and petrochemicals.

Early emphasis on energy conservation led to the misconception that conservation is the main area of application for pinch technology. The technology, when applied with imagination, can affect reactor design, separator design, and the overall process optimization in any plant. It has been applied to processing problems that go far beyond energy conservation. It has been employed to solve problems as diverse as improving effluent quality, reducing emissions, increasing product yield, debottlenecking, increasing throughput, and improving the flexibility and safety of the processes.

In this project we are applying Pinch to a newly commissioning refinery's ATMOSPHERIC DISTILLATION UNIT.

Chapter-2: LITERATURE SURVEY

What is Pinch??

Network integration and energy targeting are the two technological aspects looked into by pinch analysis technique. Setting energy targets is the first key concept of pinch analysis. Target obtained by pinch analysis are absolute thermodynamic targets showing what the process is inherently capable of achieving if the heat recovery, heating and cooling system are correctly designed.

Benefits of Pinch Analysis

Before 1979, the concept of "learning curve" was used in the improvement of energy consumption which was achieved by successive designs for a given product. But this concept of "learning curve" was not 100% efficient since the minimum energy target was never achieved while pinch analysis sets targets based on objective analysis.

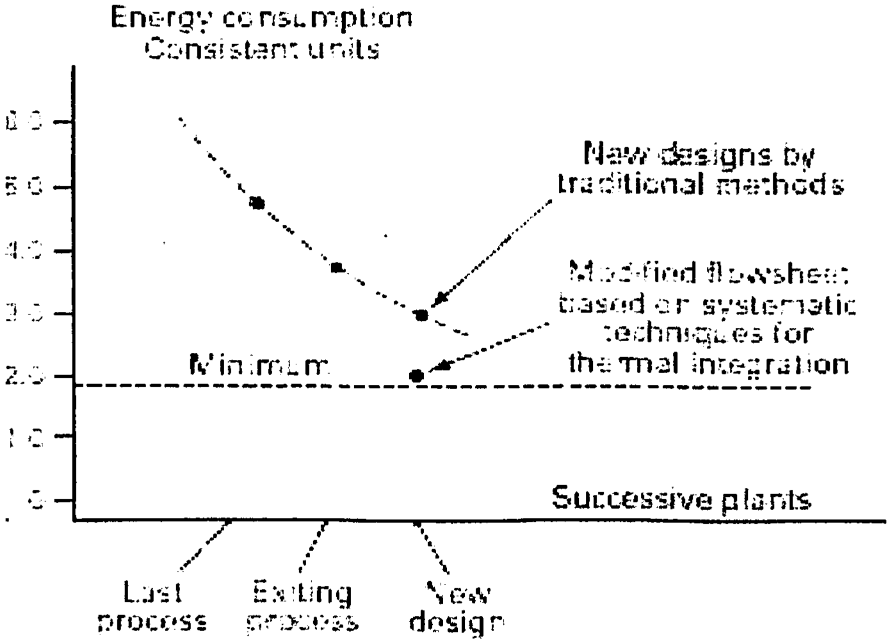


Fig.1 Learning Curves

The Concept of Process Synthesis

Pinch analysis is not just about heat exchanger network improvements come from changing process condition more effective interfacing with utility system and improved operability all under pinned by better process understanding, pinch now is an integral part of overall strategy for process development in design often known as process synthesis it is also used for optimization of the existing plant.

The affectivity of the overall design process can be represented by the onion diagram

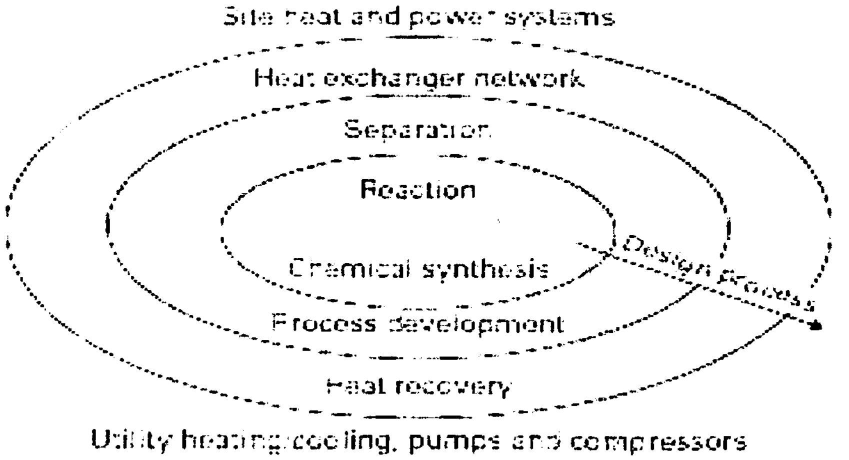


Fig. 2 Onion Diagram

The overall process synthesis is hierarchical in nature. The chemical reaction step is the core of the process. Then come the separation and then heat exchanger network and finally site heat and power system.

Role of Thermodynamics

Pinch analysis applies thermodynamics in a practical way. The approach is not mathematical. The aim of the pinch analysis is to achieve both energy saving and other process benefits using thermodynamics.

Concepts of Pinch Analysis

A stream is any flow which is required to be heated or cooled but its composition does not change. The stream which is heated is known as cold stream and which is cooled is known as hot stream. It is basically the concept of exchanging heat is conservation of heat energy. The heat from the hot stream is taken to heat the cold stream. The temperature enthalpy diagram the heat content of a stream is known as enthalpy. The temperature enthalpy diagram represents the heat exchanger. We are interested in enthalpy changes of stream. Stream can be plotted anywhere on the enthalpy axis provided that it should have same slope and run between the same supply and target temperature. The hot stream at all point is hotter than the cold stream. The slope of the line is represented by dt/dq=1/Cp.

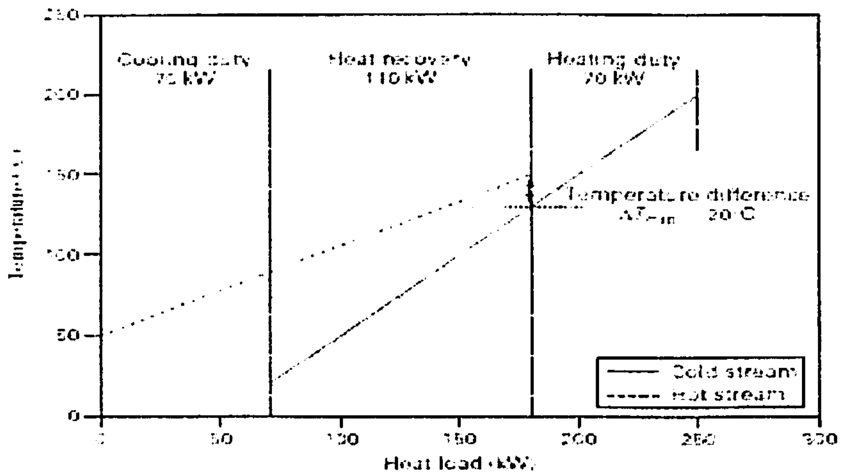


Fig. 3 Graph showing T Minimum

Here the cold stream is shown shifted on x axis (enthalpy) relative to the above hotter stream so the minimum temperature difference is no longer zero. This shifting effects in increasing the utilities by equal amount but reduces the load on heat exchangers by same amount. This arrangement is practical because delta t minimum is not zero; further shifting implies larger t minimum value in larger utility consumption. The optimized delta t minimum will give us the optimized results. This is known as super targeting. This helps us in energy targeting. If cold utility load is increased or decreased by any value, the hot utility load is increased or decreased by same value.

Composite Curves

In case of multiple streams, we add the heat load of all streams existing over any temperature range. Thus a simple composite of all cold and hot stream can be produced in a temperature enthalpy diagram, hence can be handled in just the same way as the two stream problem. The single curve on temperature enthalpy diagram which represent hot stream is known as the hot composite curve. The single curve which represents the entire cold stream is known as the cold composite curve. The overlap between the composite curves represents the maximum amount of heat recovery possible within the process. The overshoot at the top of the cold composite curve represents the minimum amount of heating duty. And the overshoot; at the bottom of the hot composite curve represents the minimum amount of cooling duty.

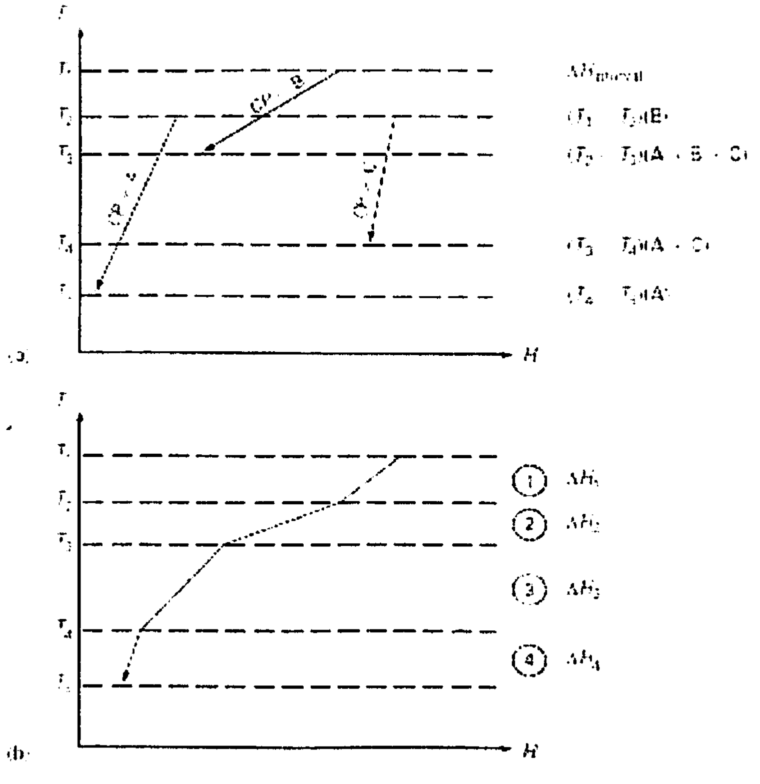


Fig. 4 Composite curves

The temperature at which this delta t minimum occurs is known as pinch temperature and the point of closest approach between the two composite curves is called as pinch.

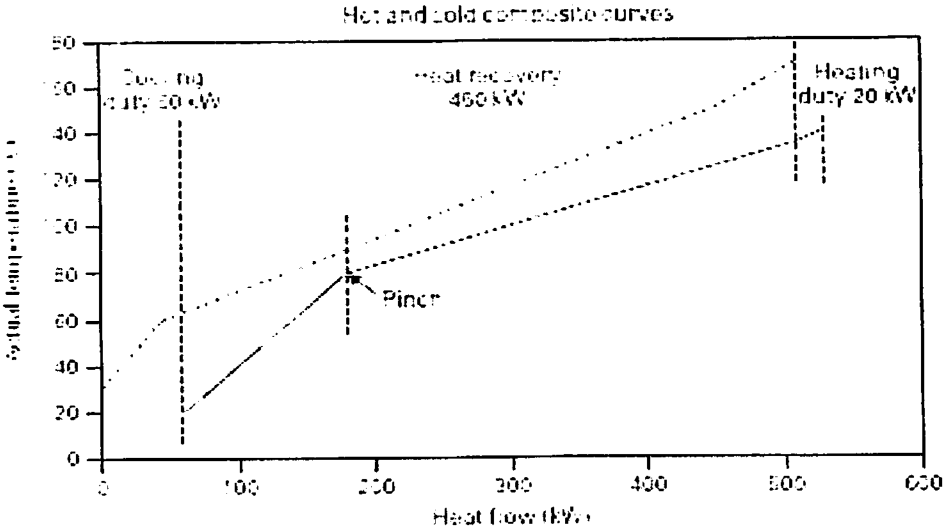


Fig 5 Graph showing pinch temperature

The Grand Composite Curve

The composite curves are replotted by 3 ways

1) Express all temperature in terms of hot stream temperature and increase all cold stream temperature by delta T minimum.
2) Express all temperature in terms of cold stream temperature and reduce all hot stream temperature by delta t minimum
3) Use the shifted temperatures, which are a mean value; delta t min/2 is the reduction in all hot stream temperatures and the increment in all cold stream temperature is by delta t /2.

The minimum amount of heating or cooling duty at a given temperature can be known by using shifted composite curve. A graph between shifted temperature and net heat flow can easily be plotted and is known as grand composite curve. Grand composite curve represents the difference between the heats available from hot stream and the heat required by the cold stream, relative to the pinch at given shifted temperature.

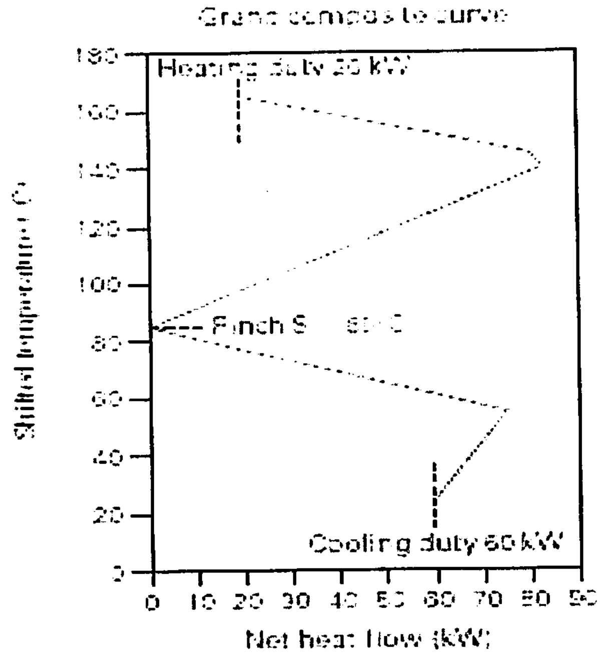


Fig.6 Grand Composite curve

Composite curves help us in obtaining energy targets; energy targeting is a powerful design "process integration".

Golden Rules of Pinch

The 3 golden rules of pinch analysis to achieve minimum utility target are

1) Does not use any hot utility above the pinch
2) Does not use any cold utility below the pinch
3) Don't transfer any heat across the pinch

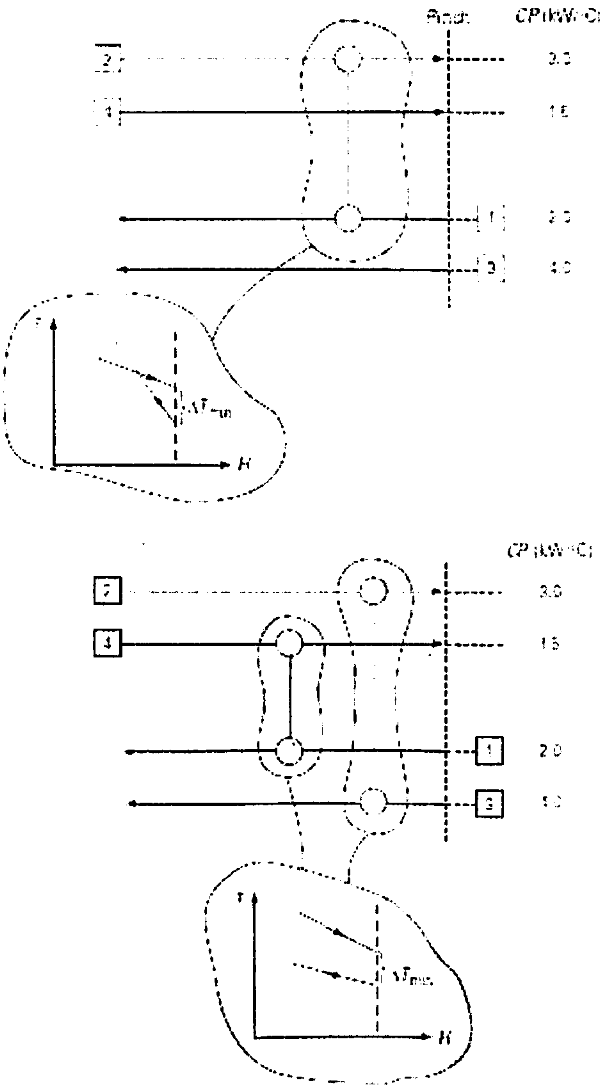


Fig 7. Showing three golden rules of pinch

The other parameters considered in designing are

1) Starting the design at the pinch and moving away

2) Obeying the constraints

   i. Cp of hot stream should be less than equal to Cp of cold stream above the pinch temperature

   ii. Cp of hot stream should be greater than equal to Cp of cold stream below the pinch temperature

3) Divide the problem at pinch point in design each part separator.

4) Exchanger load must be maximized

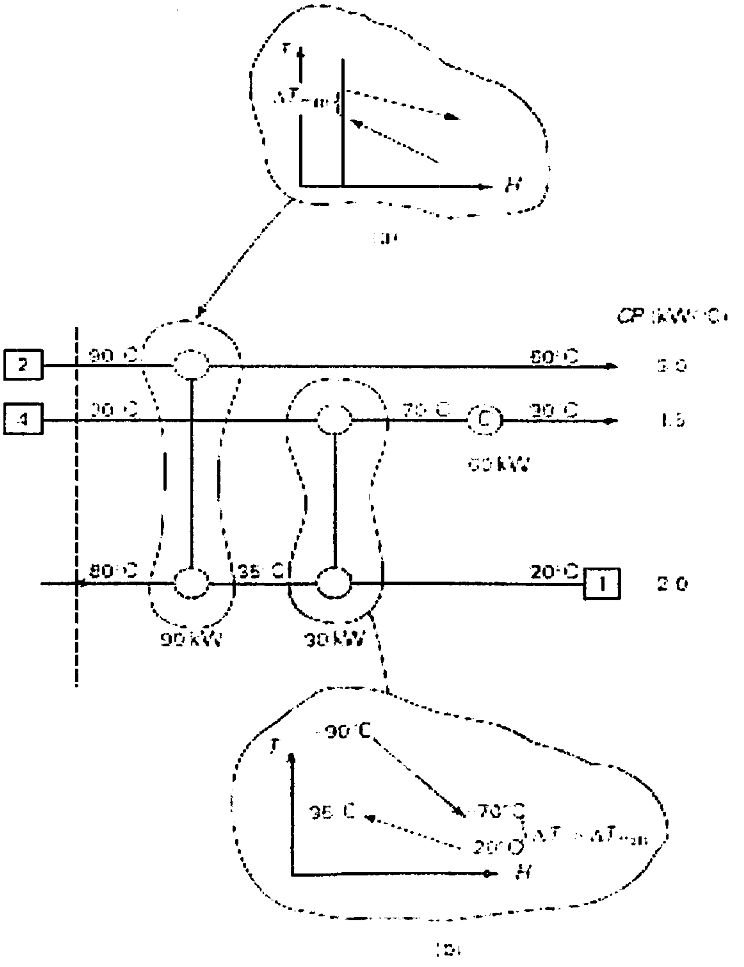


Fig. 8 These are the basic element of (pinch design method)

Methodology of Pinch Analysis

The techniques which should be covered are

1) To take process flow sheet from a consistent mass in heat balance and extract all the stream data required for pinch analysis.-DATA EXTRACTION

2) Find out the best relation between the pinch and utilities, separation system and other process items-the appropriate placement principle

3) Integration of heating and cooling system optimally with the process.-multiple hot and cold utility available

4) Modification of network to eliminate non-profit for other undesirable exchangers-network relaxation and optimization.

5) Modification in the existing exchangers or plant layout-retrofitting.

6) Heat pump and refrigeration system

7) Maximizing heat integration by altering operating conditions of unit operations or streams-process change

8) Handling time dependent situations such as shut down and starts up.

How to Do Pinch Study

The techniques applied are listed above in practice. The stages in pinch analysis of a real process plants or sites are as follows:

1. Produce, or obtain, a copy of the plant flow sheet including flow, temperature and heat capacity data, and produce a consistent heat and mass balance.

2. Extract the stream data from the mass and heat balance.

3. Select ΔT minimum, calculate energy targets and the pinch temperature.

4. Examine opportunities for process change, modify the stream data accordingly And recalculate the targets.

5. Consider possibilities for integrating with other plants on site, or restricting heat Exchange to a subset of the streams; compare new targets with original one.

6. Analyse the site power needs and identify opportunities for combined heat and Power (CHP) or heat pumping.

7. Having decided whether to implement process changes and what utility levels will be used, design a heat exchanger network to recover heat within the process.

8. Design the utility systems to supply the remaining heating and cooling requirements, modifying the heat exchanger network as necessary.

Mixing

Mixing and splitting junctions sometimes cause difficulty in stream data extraction. Taking two process flows having same composition leaving separate units at different temperatures, mixing and then heating to a common final temperature.

This is supposed to be as one stream, and a single heat exchanger can perform the heating duty. But, mixing deteriorates temperature. Considering what can happen if the system is considering as only one stream for energy targeting. If the mixing temperature lies under the pinch temperature, then the "cooling ability" of the cold stream below the pinch deteriorates. Thus heat must therefore be put to utility cooling, and by enthalpy balance, heat should be transferred across the pinch increasing hot utility usage. Ensuring the best energy performance at the targeting stage, mixing can be assumed isothermal. Thus, heat each stream separately to its final temperature, or heat/cool one stream to the temperature of the other, then mix, and then heat/cool the resultant mixture to its final temperature.

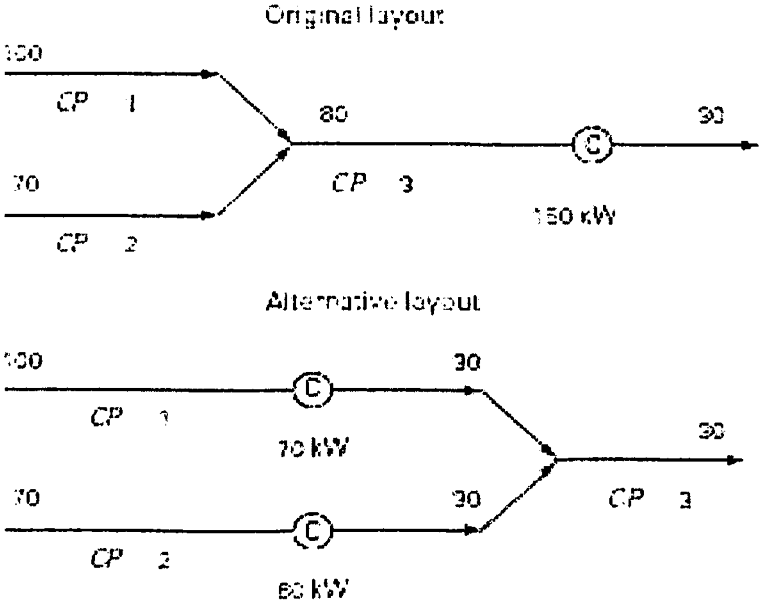


Fig 9. Mixing of two streams

This figure displays a numerical example. this time for two hot streams. The correct method is assumed. that the streams mixes isothermally. here at the target temperature is 30°C. If the original layout was retained and the pinch corresponded to a hot stream temperature between 70°C and 100°C. energy would have been wasted. However, whatever is the pinch temperature , mixing the streams deteriorates temperatures reducing the driving forces in heat exchangers, giving increased capital cost. This is shown by the hot composite curves in figure below

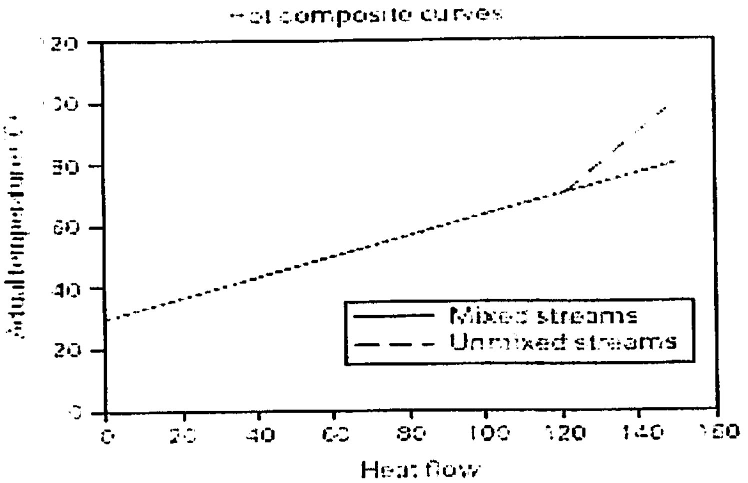


Fig. 10 Hot composite curve

The solid line stands for mixing, broken line for the case when the streams are kept separate and run down to the final temperature.

Energy Targeting

Problem Table calculation searches the hot and cold utility requirements, pinch temperature and relationship between net heat flow and temperature for a chosen ΔT min value. Taking this ahead to look at more detail and a variety of special cases.

Multiple Utilities

Till now, we have assumed that the external heating and cooling requirements are supplied as a single hot utility and single cold utility, at an unknown temperature sufficient to suffice the duty. Practically, greater than one utility may be available. and often price differentials between them exist. Conversely, the requirements of the process can help in choosing utility levels. The GCC is the major tool here.

Different Utility

Hot utilities, that supplies heat to a process:

- furnaces
- flue gas
- steam heaters
- heat rejected from heat engine
- thermal fluid or hot oil systems
- exhaust heat from refrigeration systems and heat pump condensers
- electrical heating

A similarly cold utility system subtracts heat from the process. This comprises:

- cooling water systems
- air coolers
- chilled water systems
- refrigeration systems and heat pump evaporators
- steam raising and boiler feed water heating
- heat engines below the pinch

Balanced Composite Curve and Balanced Grand Composite Curve

Composite curves and Grand Composite Curves may be re-plotted comprising the utility streams (at their target heat loads).Resultant curves have no unbalanced "overshoot" at either end, reason being the utilities must meticulously balance the process net heat loads.

The aftermath is that they are called as **balanced composite curves** (BCC) and the **balanced grand composite curve** (BGCC). Typically required for displaying the effect of multiple utilities, multiple pinches and variable-temperature utilities on temperature driving forces in the network, hence revealing constraints on network design with lucidity.

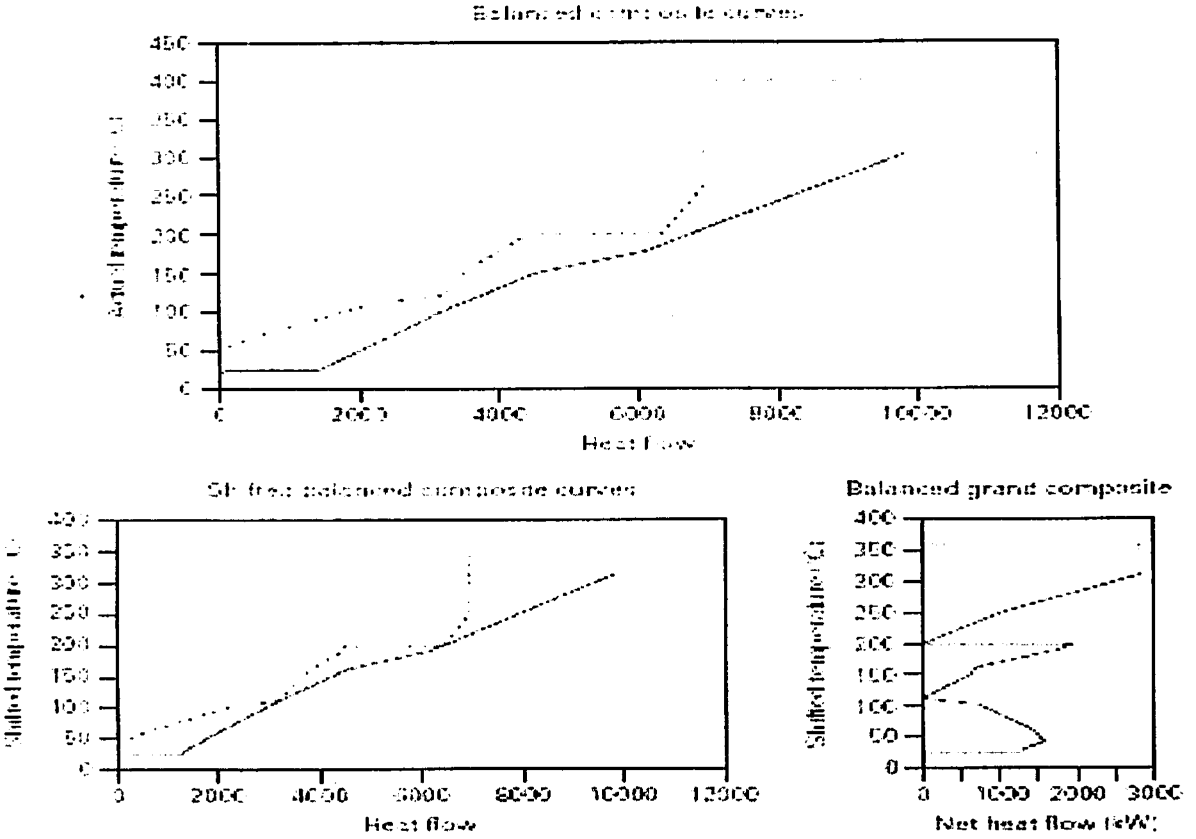


Fig. 11 Balanced composite curve, Shifted balanced composite curve and Balanced grand composite.

Heat Exchange Equipment

Types of Heat Exchanger

Heat exchange equipment can be categorized into three kinds: shell and-tube, plate and recuperative exchangers. Generally the shell-and-tube kind is used for heat exchange between liquids, but could include gases or condensing/boiling streams. Fluid flows through a set of tubes and exchanges heat with another fluid flowing outside the tubes in counter current, crossflow cocurrent or mixed flow. Double-pipe exchangers are a special case of this kind where there is just one central tube with an annular shell surrounding it. Construction is strong and rigid, suited for high pressures and temperatures as found in many chemicals applications. but, adding additional area needs either major retubing or additional shells. Plate kind is also generally used for liquids, and includes gasketed plate, welded plate and plate-fin units. Basic construction is a big number of pressed or stamped plates held against each other, with the recesses between the plates forming narrow flow channels. These give good heat transfer but prone to fouling. It is simple but tedious to dismantle the gasketed type for cleaning; this is much difficult with welded types. Plates are mounted on a frame and there is usually spare space to add more plates; thus, it's simple to increase the heat transfer area if needed. They are best for use as multi-stream exchangers. Recuperative exchangers cover a variety of kinds mainly used for heat transfer to and from gas streams Reason being the low-heat transfer coefficients. heating surfaces are often extended to provide additional surface area (e.g. with fins). Some kinds are simple variants of shell-and-tube units; others work on completely different concepts, like rotary regenerators (heat wheels). where the equipment is alternately supplied with hot and cold gases and acts as short-term heat storage.

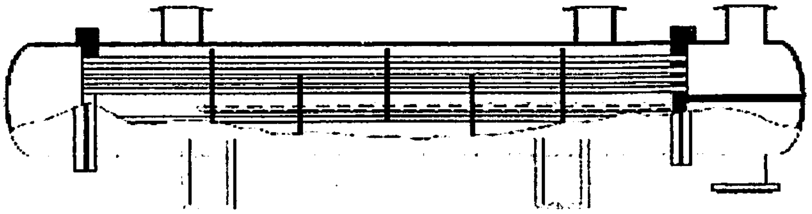
Shell-And-Tube Exchangers

The three main categories of shell-and-tube exchanger:

1) fixed tube
2) floating head
3) U-tube

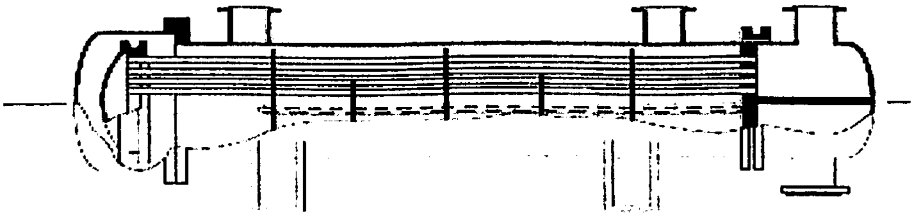
Fixed tubeplate and floating head have straight tubes with the tube side fluid entering at one end and exiting at the other. Fixed tubeplate is cheaper but the shell side is hard to clean and expansion bellows may require dealing with thermal stresses. U-tube type needs a header at one end and the tubes can simply be withdrawn for external cleaning, but internal cleaning is difficult and the flow reversal reduces effective ΔT.

Shell and tube heat exchanger



Fixed tubeplate (type BEM)

U-tube (type BEU)



Floating head (type BES)

Fig. 12 Different type of heat exchangers

Criteria for putting allotting the side (shell or tube) to the fluid:

- Condensing or boiling stream on the shell side (because of easier flows and better temperature differences).
- Fluid with the lower temperature change (or higher CP) on the shell side (yields better temperature differences).
- Corrosive fluids on the tube side; as it is inexpensive to make tubes from exotic alloys than shells, and easier to repair than a shell if it gets corroded.
- Streams whose pressure drop must be minimised is allotted on the shell side (ΔP through the exchanger is much less).
- The boiling or condensing stream is allotted the shell side.
- Fluid having lower temperature change (or higher CP) is assigned the shell side.
- Corrosive fluids are allotted the tube side.
- Streams whose pressure drop must be minimised are allotted the shell side.
- In fixed tube plate units, fouling fluids are allotted on the tube side; in U-tube units, they are placed on the shell side.
- Hot fluid on the tube side minimises structural heat losses.

Plate Exchangers

It's comparatively narrow passages mean that the pressure drop will be high. It is easier to achieve a nearly counter-current flow pattern than in most shell-and-tube exchangers. They are simple to enlarge by adding more plates (there is normally free space between the movable cover and the end mounting) which helps when revamping an existing plant.

Recuperative Exchangers

This includes both gas-to-liquid and gas-to-gas duties. Heat transfer coefficients of gases are lower than that of liquids, and to get a reasonable ΔT without using large area, extended heat exchange surfaces (e.g. finned tubes or elements) are usually needed. Moreover, hot gas streams are usually wet, dusty and heavily fouling. So, glass tube exchangers can be used.

Chapter-3: DESIGN OF ADU/CDU

Atmospheric Unit

The crude oil is pumped through heat exchangers and its temperature raised to around 288 degree C by heat exchanger with product and reflux streams .Then it is heated to around 399 degree C in a furnace and send to the flash zone of the atmospheric column. The discharge temperature of the furnace is very high (around 343 to 399 degree C) which the vaporization of products which are further withdrawn above the flash zone with 10 to 20% of bottoms. Due to in excess internal reflux10 to 20% "over-flash" goes to the trays just above the flash zone.

The tower overheads are then condensed and a portion of the liquid is returned to the top of the tower, and in lower of the tower by pump back and pump around. The amount of reflux is decreased blow the point of draw off by removing products from the side streams. By removing all heat from the top maximum reflux and fractionation can be obtained. The diameter of the top of the tower and liquid loading over the tower length is reduced with help of streams which remove heat to generate reflux below side stream removal points. To perform this, liquid from the tower is removed passes through a heat exchanger, cooled and sent back to the tower again. The vapors coming up are condensed with help of this cold stream hence the reflux below this point is increased.

With the help of pump around reflux the distillation operation efficiency is improved. If sufficient reflux were produced in the overhead condenser to provide for all side stream draw offs as well as the required reflux, all of the heat energy would be exchanged at the bubble-point temperature of the overhead stream. The heat transfer temperatures are increased using pump around reflux at lower points and hence this higher temperature helps in recovering of higher fractions of energy by preheated feed. Though crude towers do not usually use reboilers, many trays are generally incorporated under the flash zone and steam is introduced below the bottom tray to strip any leftover gas oil from the liquid in the flash zone and to produce a high-flash-point bottoms. Steam reduces the partial pressure of the hydrocarbons and therefore lowers the required vaporization temperature. The atmospheric fractionators usually comprise of 30 to 50 fractionation trays. Separation of the complex mixtures in crude oils is relatively simply and generally five to eight trays are required for each side stream product plus the same number above and below the feed plate. Therefore, a crude oil atmospheric fractionation tower with four liquid side stream draw offs will need from 30 to 42 trays. The liquid side stream withdrawn from the tower will contain low-boiling components which decreases the flashpoint, because the lighter products pass through the heavier products and are in equilibrium with them on every tray. These "light ends" are stripped from each side stream in a separate small stripping tower having four to ten trays with steam introduced below the bottom tray. The steam and stripped light ends are vented back to vapor zone of the atmospheric fractionators above the corresponding side-draw tray overhead condenser on the atmospheric tower condenses the pentane and- heavier fraction of the vapors that passes out of the top of the tower. This is the light gasoline portion of the overhead, containing some propane and butanes and essentially all higher-boiling components in the tower overhead vapor.

Some of this condensate is returned to the top of the tower as reflux, and remainder is sent to stabilization section of the refinery gas plant where the butanes and propane are extracted from the C5-180 degree F (C5-82 degree C) LSR gasoline.

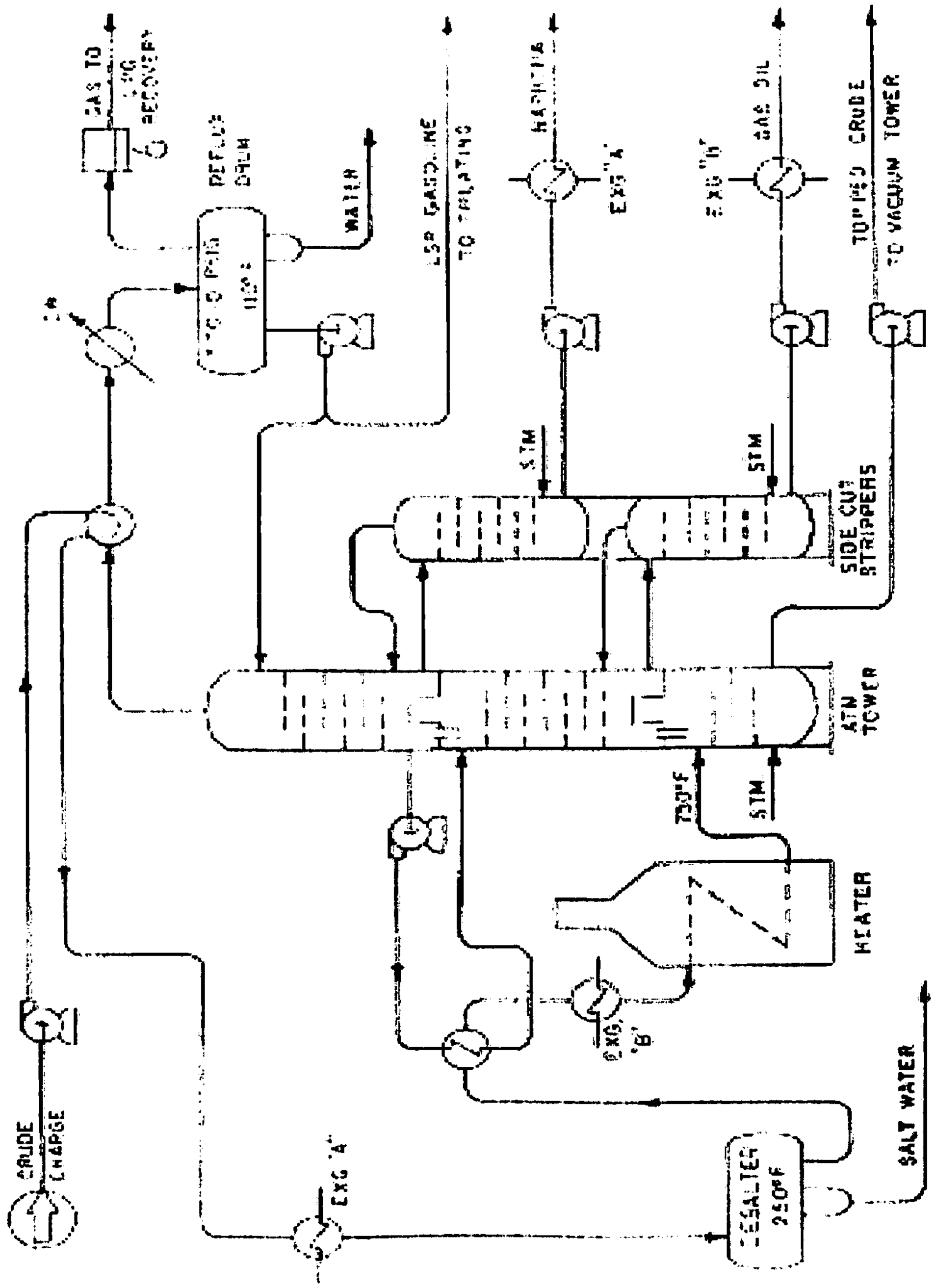

CRUDE CHARGE
EXG 'A'
DESALTER 250°F
SALT WATER
EXG 'B'
HEATER
730°F
STM
ATM TOWER
SIDE CUT STRIPPERS
STM
STM
REFLUX DRUM
WATER
GAS TO LPG RECOVERY
LSR GASOLINE TO TREATING
NAPHTHA
EXG 'A'
EXG "B"
GAS OIL
TOPPED CRUDE TO VACUUM TOWER

Fig. 13 PFD of ADU UNIT

DESIGNING OF CDU

The process of designing consists of the following steps:

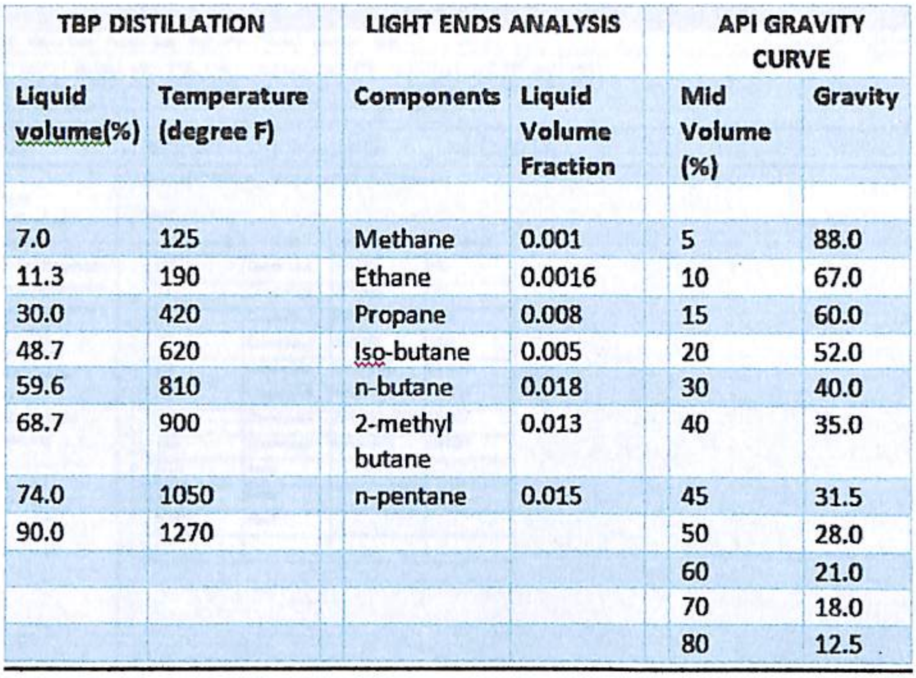
1. The process feed (MIXCRUDE), consisting of a blend of two crude oils,goes to the preflash furnace.
2. The preflash tower (PREFLASH) removes light gases and some naphtha from the partially vaporized feed.
3. Preflash bottoms (CDU-FEED) are further processed in the crude distillation unit (CDU). The CDU consists of a crude unit furnace and an atmospheric tower. First, the crude unit furnace partially vaporizes the bottoms from the preflash. Then the atmospheric tower separates the preflash bottoms into five cuts:

– Heavy naphtha (HNAPHTHA)
– Kerosene (KEROSENE)
– Diesel (DIESEL)
– Atmospheric gas oil (GAS-OIL)
– Reduced crude (RESIDUE)

BLENDING OF CRUDES

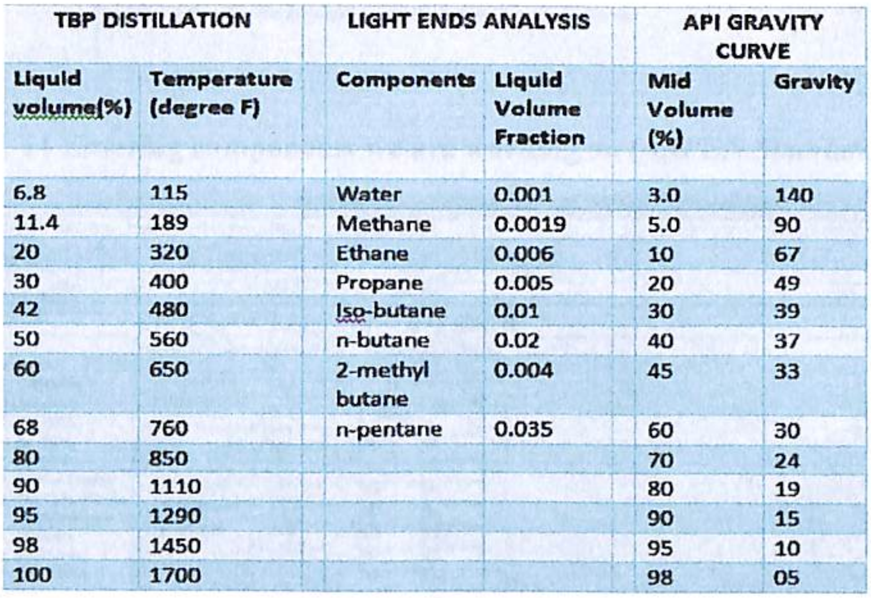
Following two oils are blended together in a ratio of OIL 1: OIL 2 = 1:3

DATA :- OIL 1 (API GRAVITY 30.8)

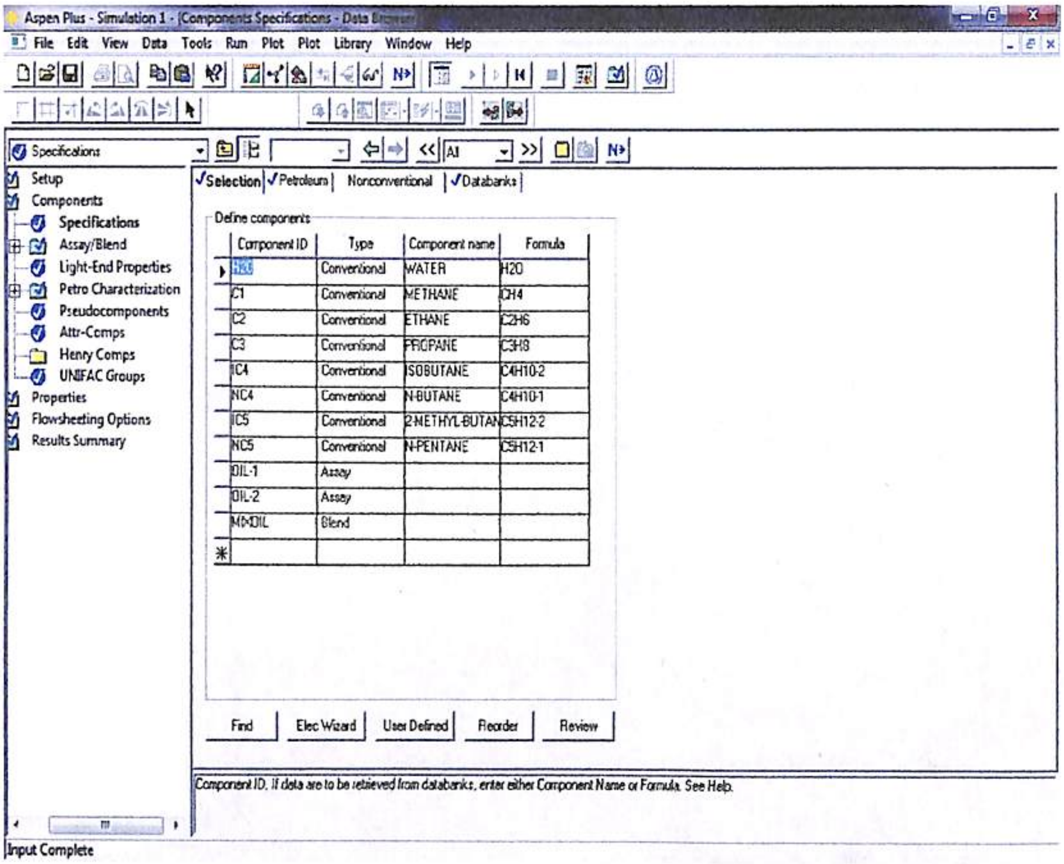


TBP DISTILLATION		LIGHT ENDS ANALYSIS		API GRAVITY CURVE	
Liquid volume(%)	Temperature (degree F)	Components	Liquid Volume Fraction	Mid Volume (%)	Gravity
7.0	125	Methane	0.001	5	88.0
11.3	190	Ethane	0.0016	10	67.0
30.0	420	Propane	0.008	15	60.0
48.7	620	Iso-butane	0.005	20	52.0
59.6	810	n-butane	0.018	30	40.0
68.7	900	2-methyl butane	0.013	40	35.0
74.0	1050	n-pentane	0.015	45	31.5
90.0	1270			50	28.0
				60	21.0
				70	18.0
				80	12.5

DATA :- OIL 2 (API GRAVITY 33.4)



TBP DISTILLATION		LIGHT ENDS ANALYSIS		API GRAVITY CURVE	
Liquid volume(%)	Temperature (degree F)	Components	Liquid Volume Fraction	Mid Volume (%)	Gravity
6.8	115	Water	0.001	3.0	140
11.4	189	Methane	0.0019	5.0	90
20	320	Ethane	0.006	10	67
30	400	Propane	0.005	20	49
42	480	Iso-butane	0.01	30	39
50	560	n-butane	0.02	40	37
60	650	2-methyl butane	0.004	45	33
68	760	n-pentane	0.035	60	30
80	850			70	24
90	1110			80	19
95	1290			90	15
98	1450			95	10
100	1700			98	05

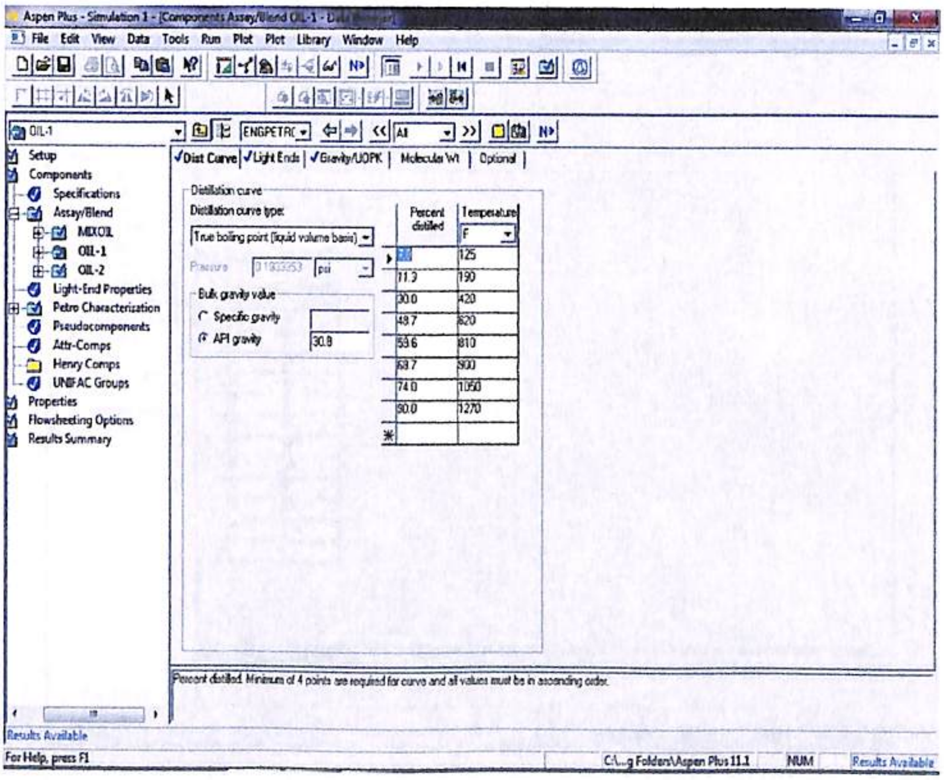


Define components

Component ID	Type	Component name	Formula
H2O	Conventional	WATER	H2O
C1	Conventional	METHANE	CH4
C2	Conventional	ETHANE	C2H6
C3	Conventional	PROPANE	C3H8
IC4	Conventional	ISOBUTANE	C4H10-2
NC4	Conventional	N-BUTANE	C4H10-1
IC5	Conventional	2-METHYL-BUTAN	C5H12-2
NC5	Conventional	N-PENTANE	C5H12-1
OIL-1	Assay		
OIL-2	Assay		
MIXOIL	Blend		

Component ID. If data are to be retrieved from databanks, enter either Component Name or Formula. See Help.

Fig. 14 Entering components we are working on *(ASPEN Simulation)*



Distillation curve

Distillation curve type: True boiling point (liquid volume basis)

Pressure 0.1933353 psi

Bulk gravity value

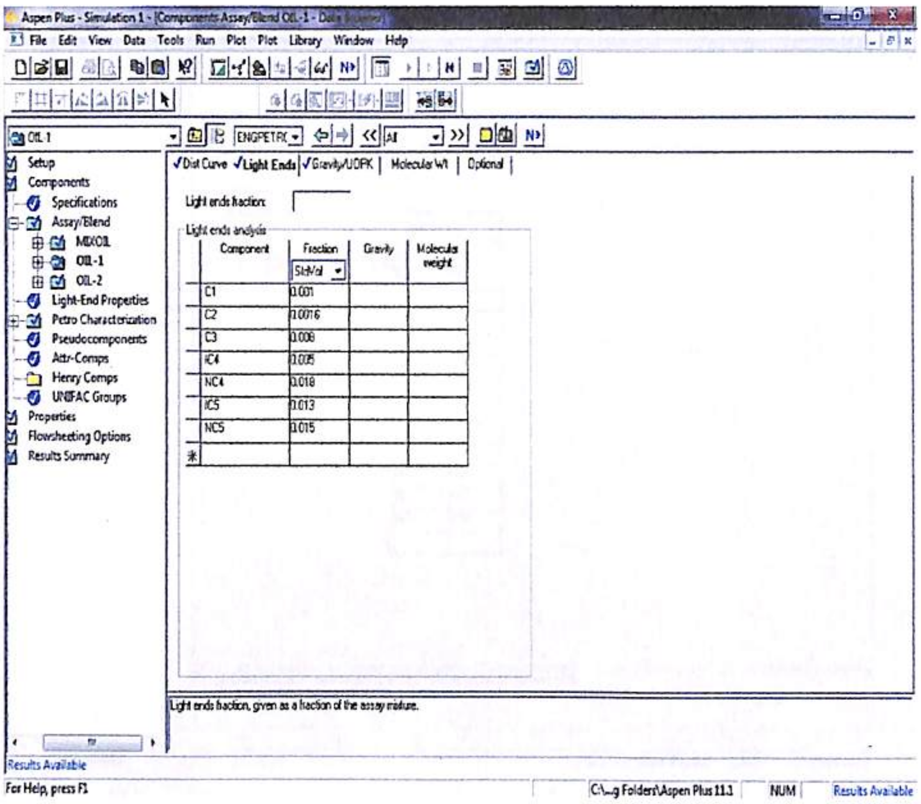
○ Specific gravity

● API gravity 30.8

Percent distilled	Temperature F
[illegible]	125
11.3	190
30.0	420
49.7	620
59.6	810
68.7	900
74.0	1050
90.0	1270

Percent distilled. Minimum of 4 points are required for curve and all values must be in ascending order.

Fig. 15 OIL-1 data entry (*ASPEN Simulation)*



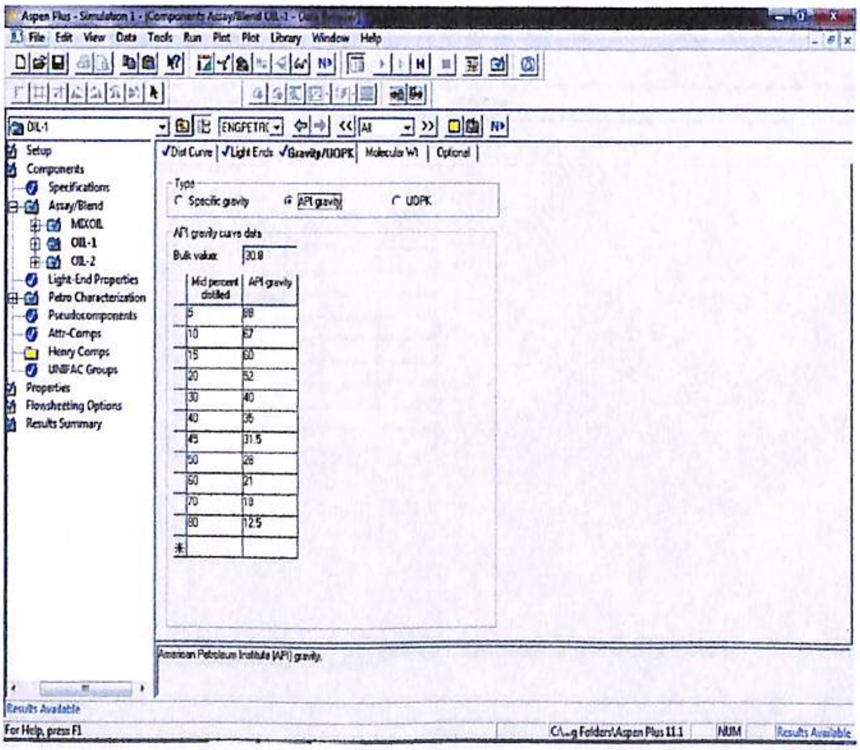
Light ends fraction:

Light ends analysis

Component	Fraction StdVol	Gravity	Molecular weight
C1	0.001		
C2	0.0016		
C3	0.008		
IC4	0.005		
NC4	0.018		
IC5	0.013		
NC5	0.015		

Light ends fraction, given as a fraction of the assay mixture.

Fig.16 OIL-1 LIGHT ENDS entry (*ASPEN Simulation)*



Type
○ Specific gravity ● API gravity ○ UOPK

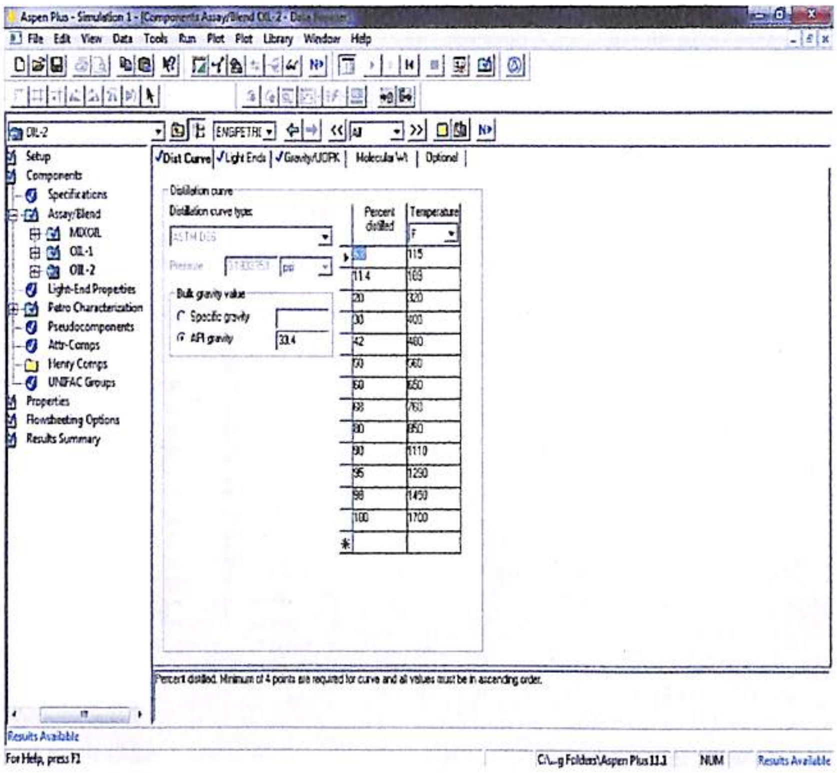
API gravity curve data

Bulk value: 30.8

Mid percent distilled	API gravity
5	88
10	67
15	60
20	52
30	40
40	35
45	31.5
50	28
60	21
70	18
80	12.5

American Petroleum Institute (API) gravity.

Fig. 17 OIL-1 GRAVITY SPECIFICATION entry (*ASPEN Simulation)*



Distillation curve

Distillation curve type: ASTM D86

Bulk gravity value

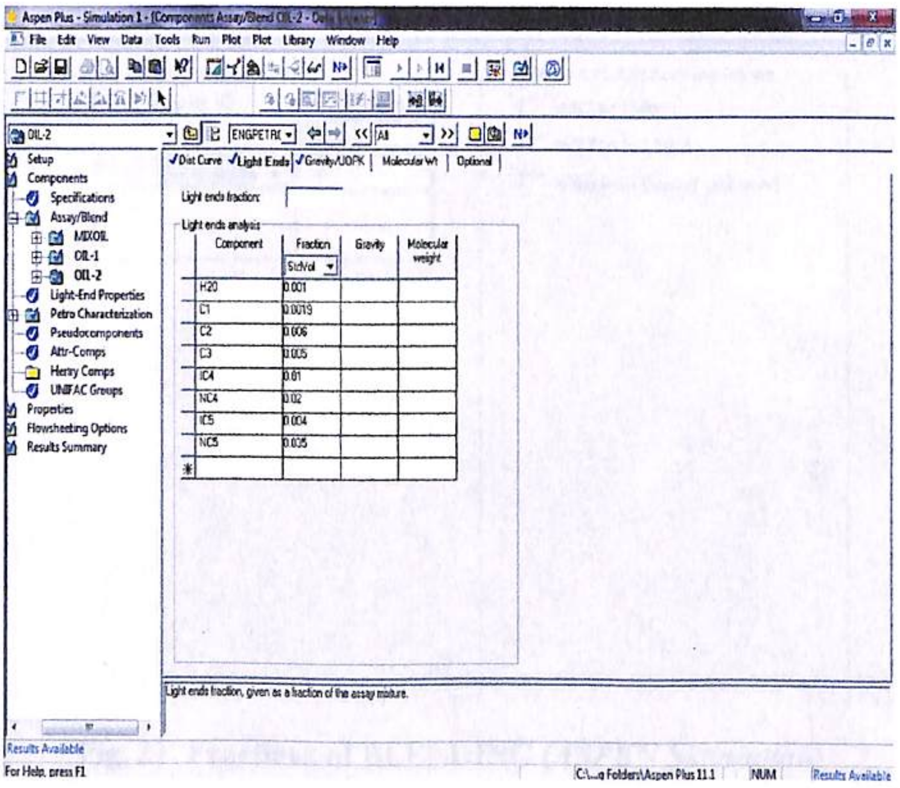
○ Specific gravity

● API gravity 33.4

Percent distilled	Temperature F
[illegible]	115
11.4	169
20	320
30	400
42	480
50	560
60	650
68	760
80	850
90	1110
95	1290
98	1450
100	1700

Percent distilled. Minimum of 4 points are required for curve and all values must be in ascending order.

Fig. 18 OIL-2 DISTILLATION CURVE data (*ASPEN Simulation)*



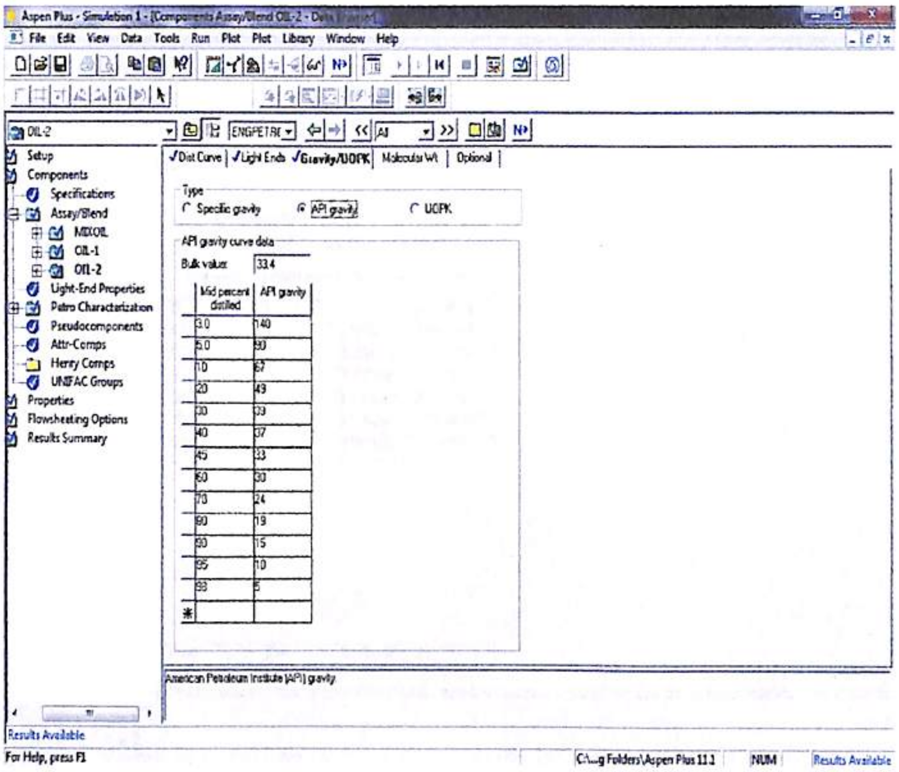
Light ends fraction:

Light ends analysis

Component	Fraction StdVol	Gravity	Molecular weight
H20	0.001		
C1	0.0019		
C2	0.006		
C3	0.005		
IC4	0.01		
NC4	0.02		
IC5	0.004		
NC5	0.005		

Light ends fraction, given as a fraction of the assay mixture.

Fig. 19 OIL-2 LIGHT ENDS entry (*ASPEN Simulation)*



Type

○ Specific gravity ● API gravity ○ UOPK

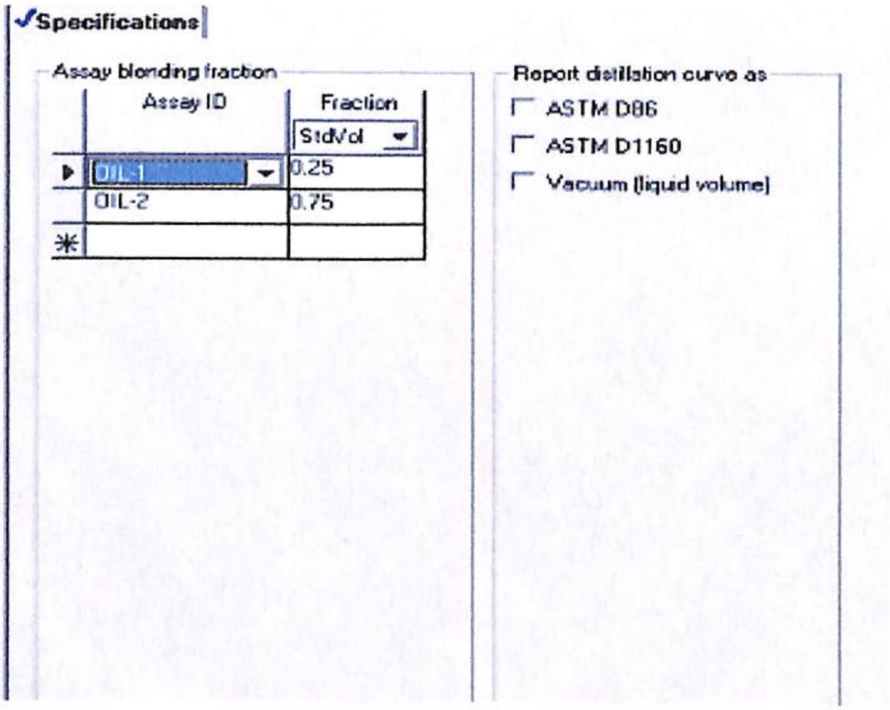
API gravity curve data

Bulk value: 33.4

Mid percent distilled	API gravity
3.0	140
5.0	90
10	67
20	49
30	39
40	37
45	33
60	30
70	24
80	19
90	15
95	10
98	5
*	

American Petroleum Institute (API) gravity

Fig. 20 OIL-2 GRAVITY SPECIFATION entry(*ASPEN Simulation)*



Assay blending fraction

Assay ID	Fraction StdVol
OIL-1	0.25
OIL-2	0.75
*	

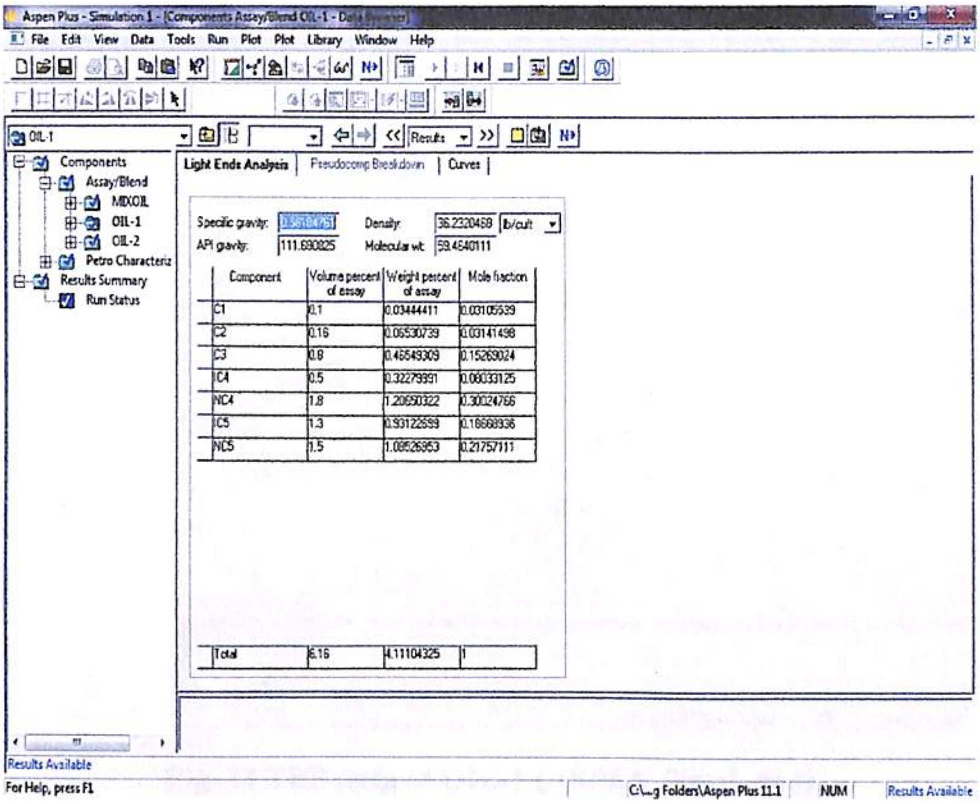
Report distillation curve as

☐ ASTM D86

☐ ASTM D1160

☐ Vacuum (liquid volume)

Fig. 21 Fractions of BLENDING (*ASPEN Simulation)*



Specific gravity: 0.56184761

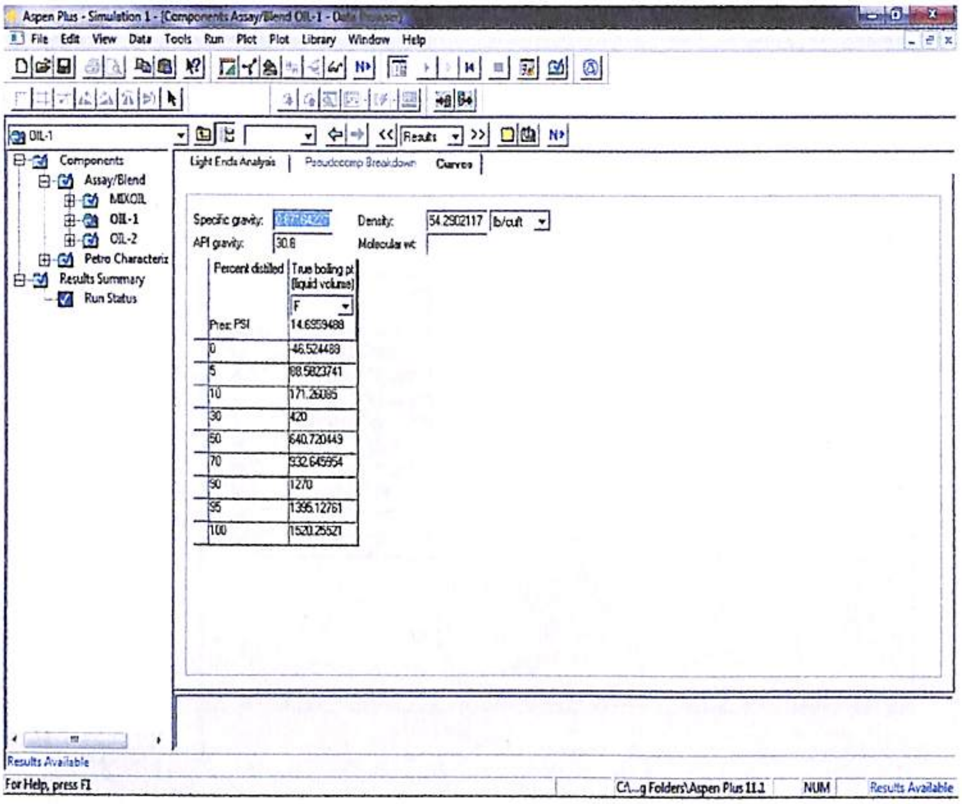
Density: 36.2320468 lb/cuft

API gravity: 111.690825

Molecular wt: 59.4540111

Component	Volume percent of assay	Weight percent of assay	Mole fraction
C1	0.1	0.03444411	0.03105539
C2	0.16	0.06530739	0.03141498
C3	0.8	0.46549309	0.15269024
IC4	0.5	0.32279991	0.08033125
NC4	1.8	1.20650322	0.30024766
IC5	1.3	0.93122699	0.16668936
NC5	1.5	1.08526953	0.21757111
Total	6.16	4.11104325	1

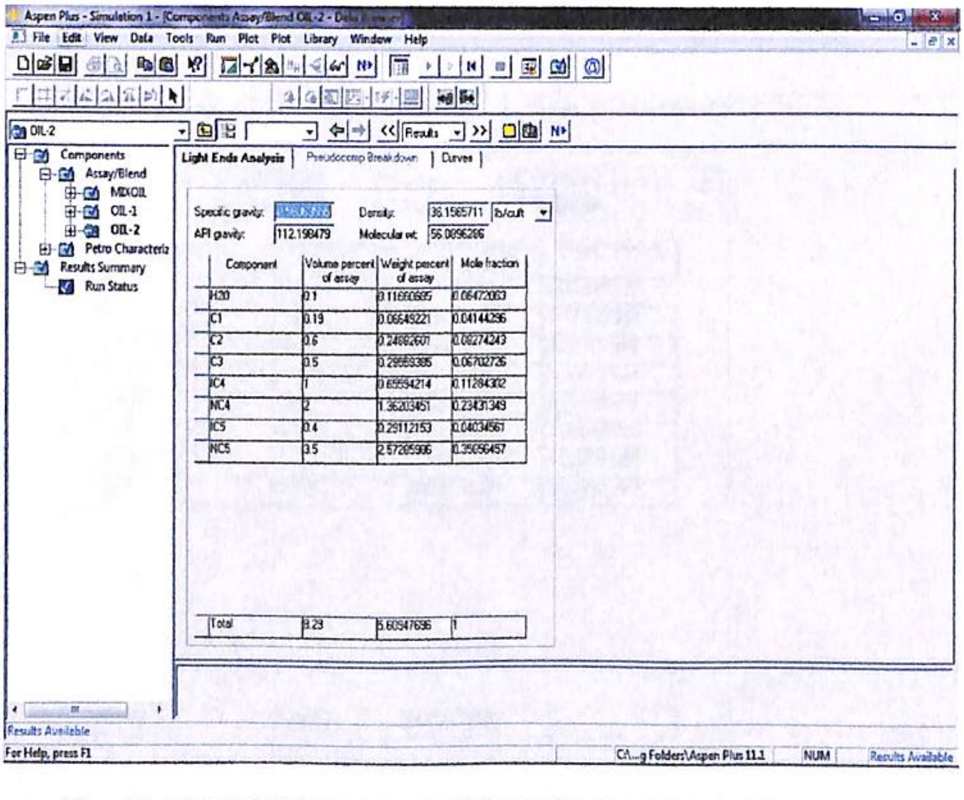
Fig. 22 Results LIGHT ENDS OF OIL-1 (*ASPEN Simulation)*



Specific gravity: [illegible]
Density: 54.2902117 lb/cuft
API gravity: 30.8
Molecular wt:

Percent distilled	True boiling pt (liquid volume) F
Pres: PSI	14.6959488
0	46.524488
5	88.5823741
10	171.26085
30	420
50	640.720443
70	932.645954
90	1270
95	1395.12761
100	1520.25521

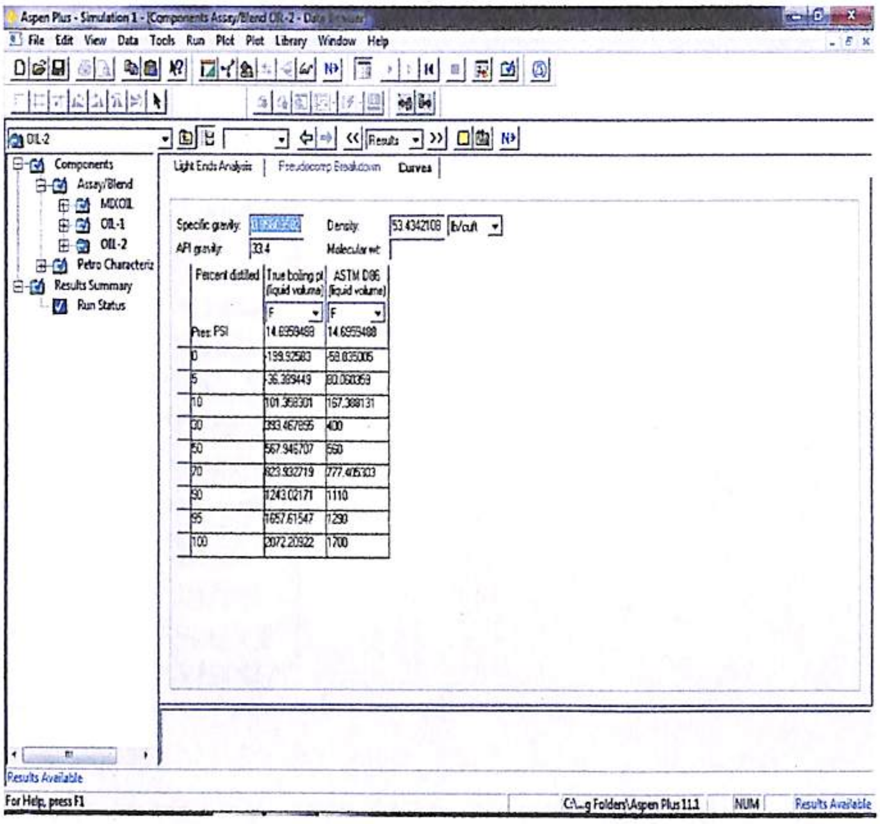
Fig. 23 TBP data of OIL-1 (*ASPEN Simulation)*



Specific gravity: [illegible]
Density: 36.1565711 lb/cuft
API gravity: 112.198479
Molecular wt: 56.0896286

Component	Volume percent of assay	Weight percent of assay	Mole fraction
H2O	0.1	0.11660685	0.06472063
C1	0.19	0.06649221	0.04144296
C2	0.6	0.24692601	0.08274243
C3	0.5	0.29569385	0.06702726
IC4	1	0.65594214	0.11284302
NC4	2	1.36203451	0.23431349
IC5	0.4	0.29112153	0.04034561
NC5	3.5	2.57285986	0.35056457
Total	8.29	5.60947696	1

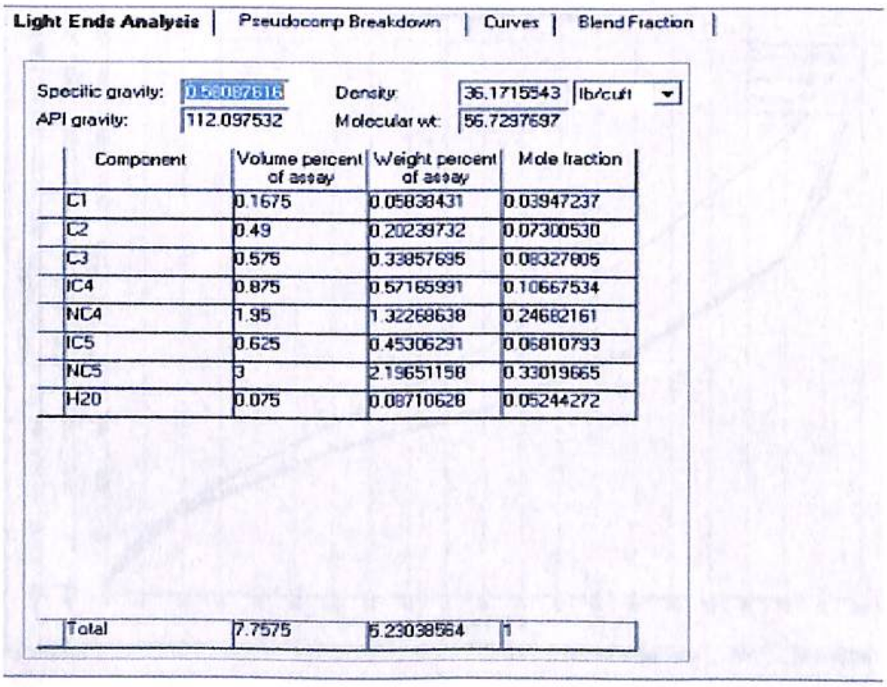
Fig. 24 LIGHT END ANALYSIS OIL-2 (*ASPEN Simulation)*



Specific gravity: [illegible]
Density: 53.4342108 lb/cuft
API gravity: 33.4
Molecular wt:

Percent distilled	True boiling pt (liquid volume)	ASTM D86 (liquid volume)
	F	F
Pres: PSI	14.6959488	14.6959488
0	-199.92583	-58.035005
5	-36.389449	80.060359
10	101.358301	167.388131
30	393.467895	400
50	567.946707	550
70	823.932719	777.405303
90	1243.02171	1110
95	1657.61547	1290
100	2072.20922	1700

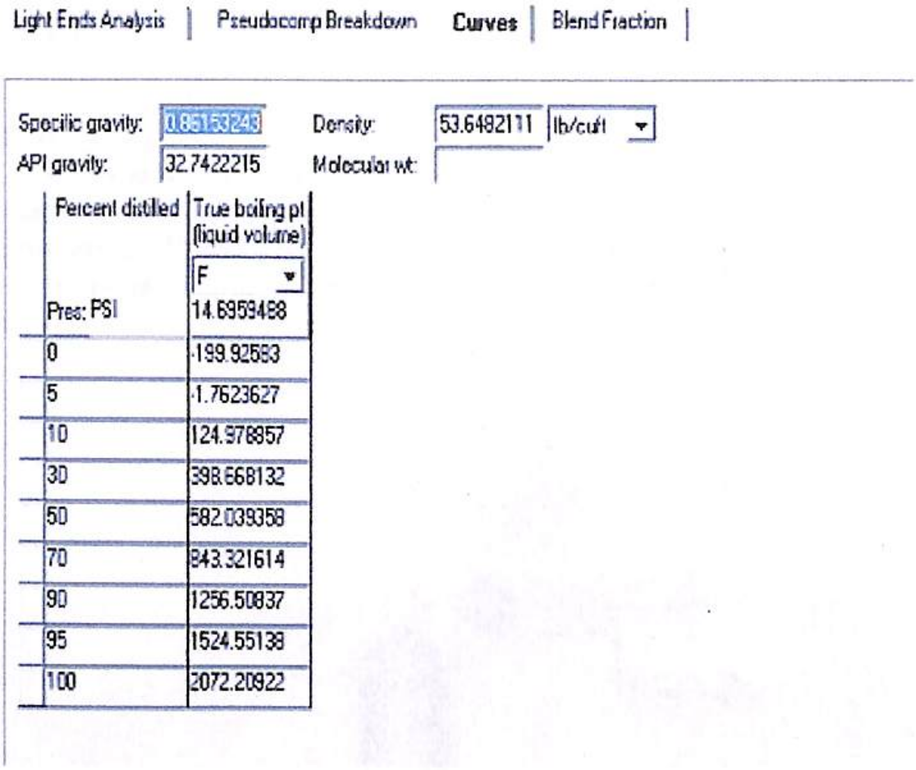
Fig. 25 TBP data OIL-2 (*ASPEN Simulation)*



Specific gravity: 0.58087616
Density: 36.1715543 lb/cuft
API gravity: 112.097532
Molecular wt: 56.7297697

Component	Volume percent of assay	Weight percent of assay	Mole fraction
C1	0.1675	0.05838431	0.03947237
C2	0.49	0.20239732	0.07300530
C3	0.575	0.33857695	0.08327805
IC4	0.875	0.57165991	0.10667534
NC4	1.95	1.32268638	0.24682161
IC5	0.625	0.45306291	0.06810793
NC5	3	2.19651158	0.33019665
H2O	0.075	0.08710628	0.05244272
Total	7.7575	5.23038564	1

Fig. 26 Data Analysis MIXED CRUDE (*ASPEN Simulation)*



Specific gravity: 0.86153243

API gravity: 32.7422215

Density: 53.6482111 lb/cuft

Molecular wt:

Percent distilled	True boiling pt (liquid volume)
	F
Pres: PSI	14.6959488
0	-199.92583
5	-1.7623627
10	124.978857
30	398.668132
50	582.039358
70	843.321614
90	1256.50837
95	1524.55138
100	2072.20922

Fig. 27 TBP Data MIXED CRUDE (*ASPEN Simulation)*

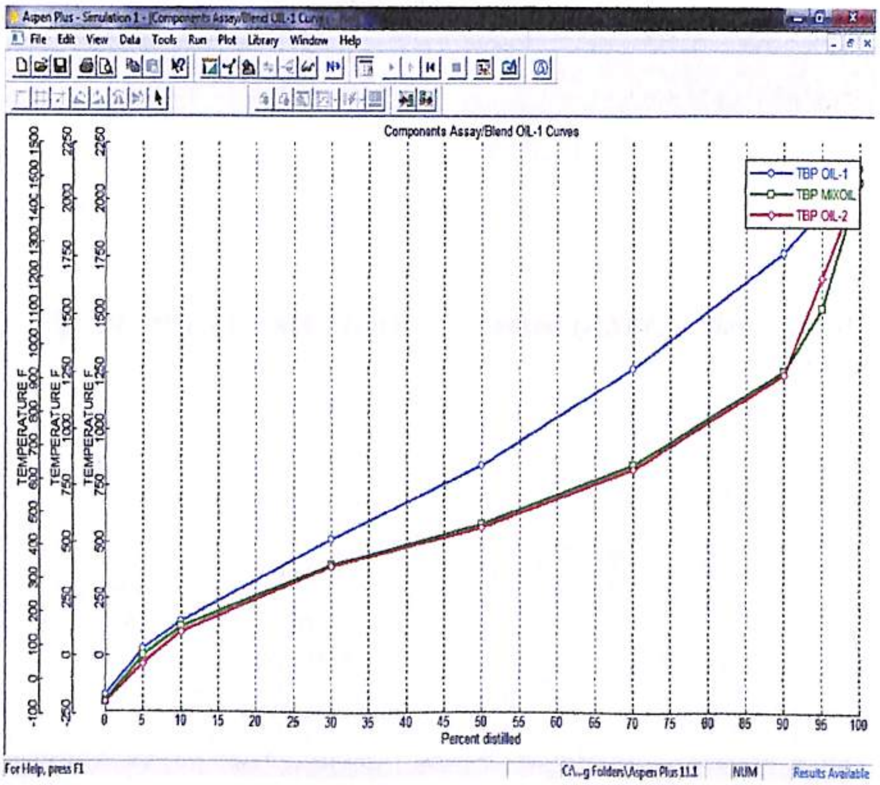


Fig. 28 TBP plot (OIL-1, OIL-2 and MIXCRUDE) (*ASPEN Simulation)*

MODELLING OF TOPPING UNIT

Simulated the tower with 8 theoretical stages, no reboiler, and a partial condenser and inlet temperature of feed being 180 F. The condenser operates at 170 F and 39.7 psia, with a pressure drop of 2 psi. The tower pressure drop is 3 psi. The tower is stripped with open steam in the bottom. The steam stream is at 400 F and 60 psia, and has a flow rate of 5,000 lb/hr. The furnace operates at a pressure of 50 psia and a temperature of 450 F. The distillate rate is estimated at 15,000 bbl/day. Its value is manipulated to produce a wide naphtha cut with an ASTM 95% temperature of 375 F.

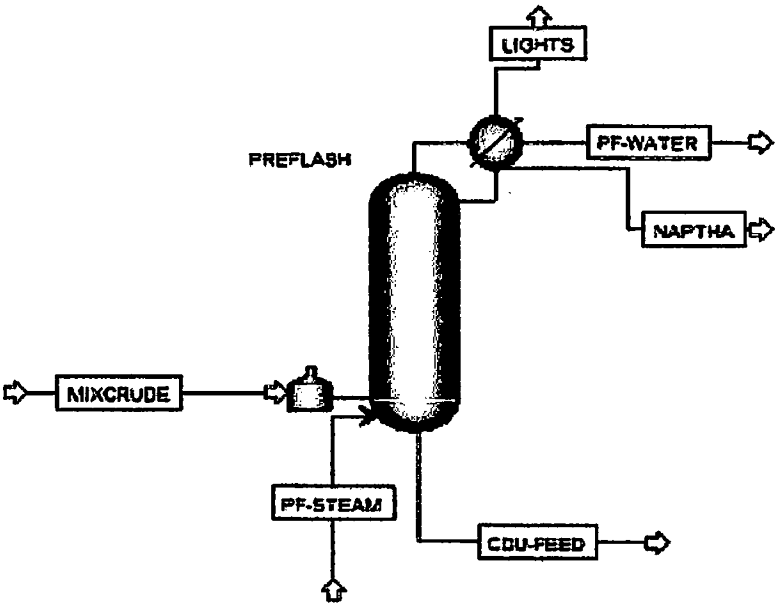
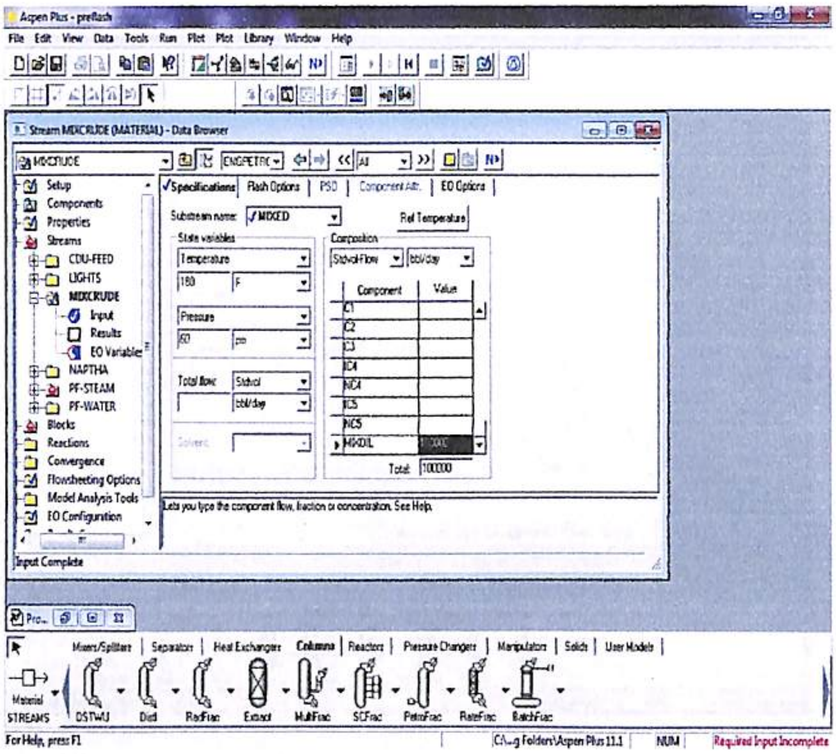


Fig. 29 PREFLASH MODEL Created (*ASPEN Simulation)*



Stream MIXCRUDE (MATERIAL) - Data Browser

MIXCRUDE

Substream name: MIXED

State variables

Temperature: 180 F

Pressure: 60 psi

Total flow: Stdvol bbl/day

Composition: Stdvol-Flow bbl/day

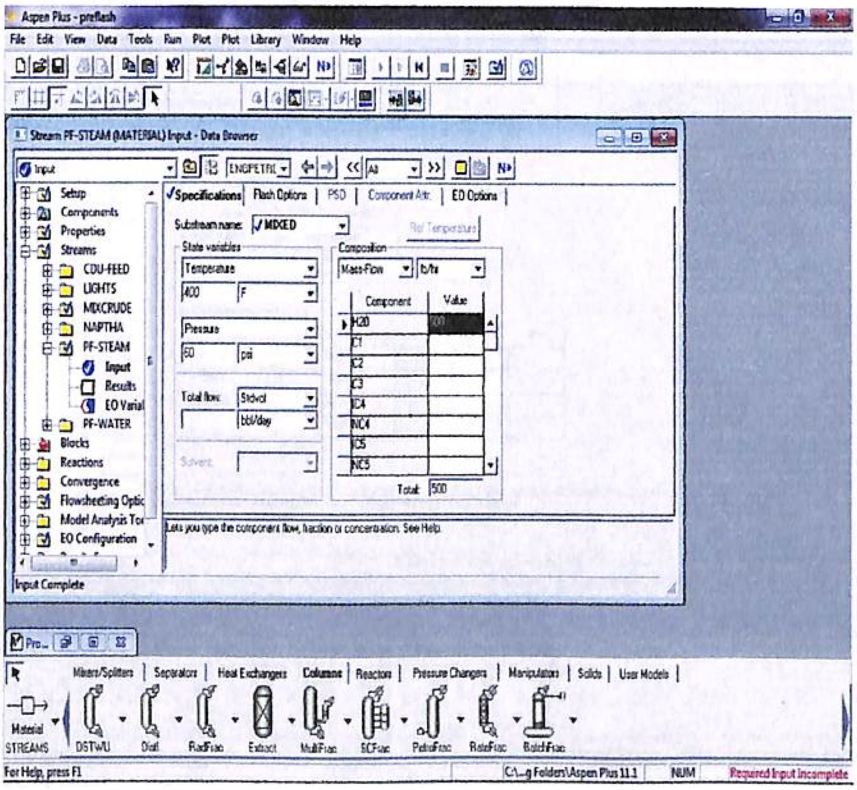
Component	Value
C1	
C2	
C3	
IC4	
NC4	
IC5	
NC5	
MIXOIL	100000

Total: 100000

Lets you type the component flow, fraction or concentration. See Help.

Input Complete

Fig.30 MIXED CRUDE flow rate entry (*ASPEN Simulation)*



Stream PF-STEAM (MATERIAL) Input - Data Browser

Input

Substream name: MIXED

State variables

Temperature: 400 F

Pressure: 60 psi

Total flow: Stdvol bbl/day

Composition: Mass-Flow lb/hr

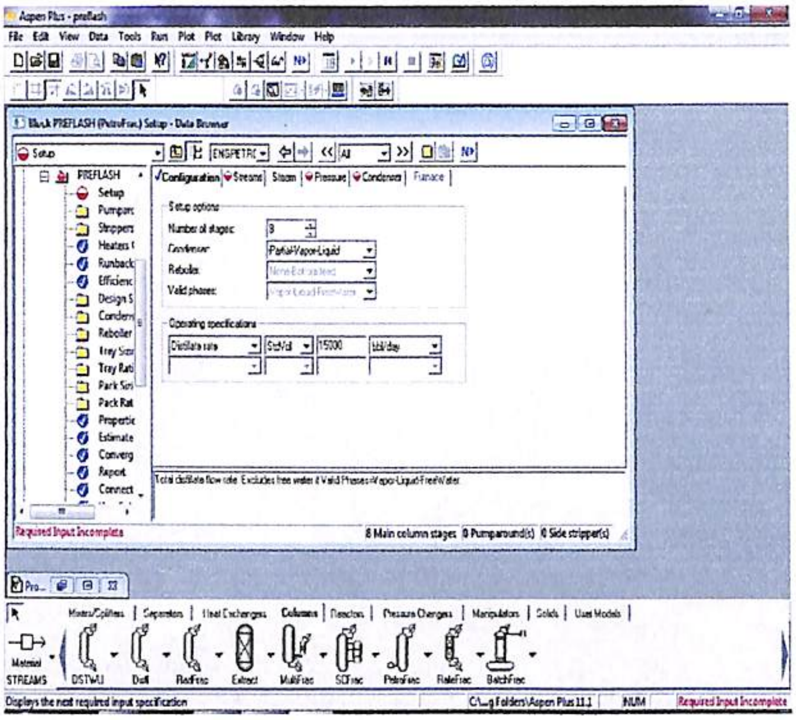
Component	Value
H2O	500
C1	
C2	
C3	
IC4	
NC4	
IC5	
NC5	

Total: 500

Lets you type the component flow, fraction or concentration. See Help.

Input Complete

Fig. 31 STEAM flowrate entry (*ASPEN Simulation)*



Aspen Plus - preflash

Block PREFLASH (PetroFrac) Setup - Data Browser

Setup options

Number of stages: 8

Condenser: Partial-Vapor-Liquid

Reboiler: None-Bottom feed

Valid phases: Vapor-Liquid-FreeWater

Operating specifications

Distillate rate | StdVol | 15000 | bbl/day

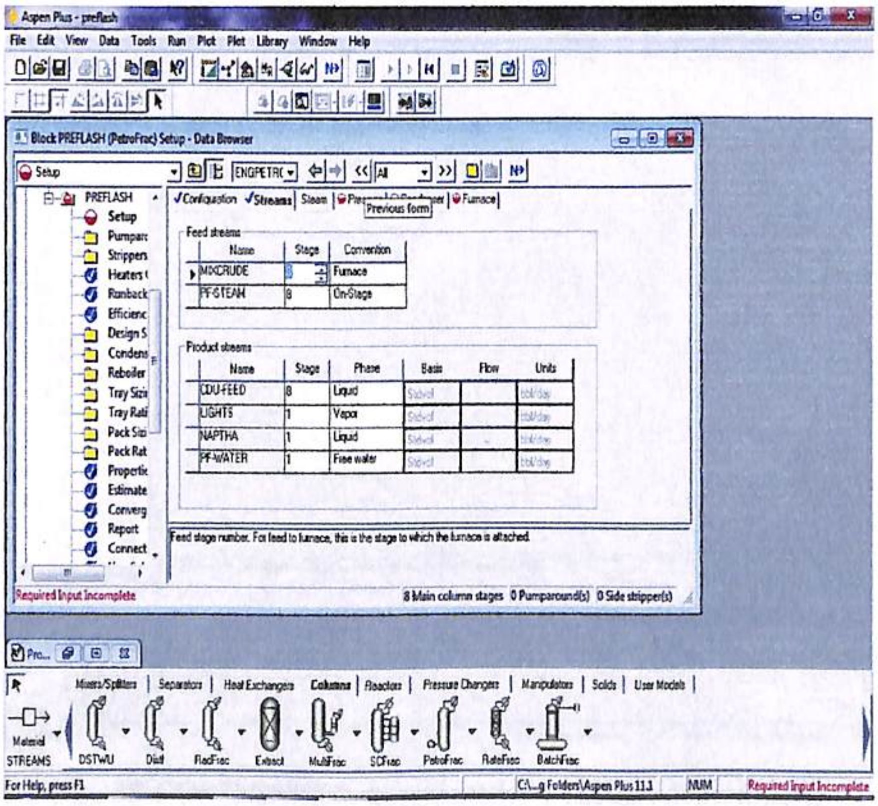
Total distillate flow rate. Excludes free water if Valid Phases=Vapor-Liquid-FreeWater

Required Input Incomplete

8 Main column stages 0 Pumparound(s) 0 Side stripper(s)

Displays the next required input specification

Fig. 32 PREFLASH CHAMBER configuration (*ASPEN Simulation)*



Aspen Plus - preflash

Block PREFLASH (PetroFrac) Setup - Data Browser

Feed streams

Name	Stage	Convention
MIXCRUDE	8	Furnace
PF-STEAM	8	On-Stage

Product streams

Name	Stage	Phase	Basis	Flow	Units
CDU-FEED	8	Liquid	Stdvol		bbl/day
LIGHTS	1	Vapor	Stdvol		bbl/day
NAPTHA	1	Liquid	Stdvol		bbl/day
PF-WATER	1	Free water	Stdvol		bbl/day

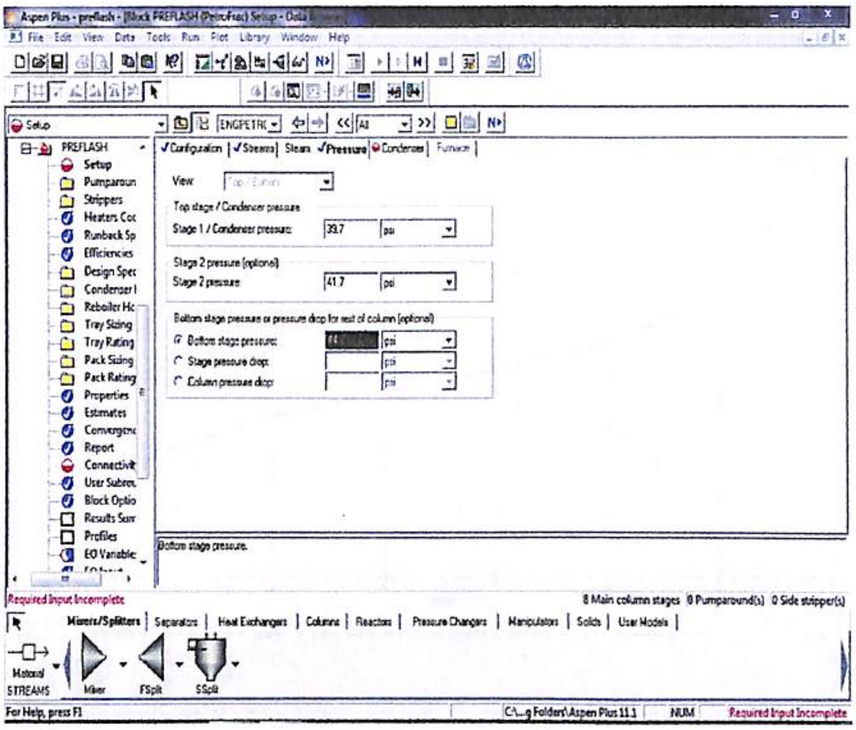
Feed stage number. For feed to furnace, this is the stage to which the furnace is attached.

Required Input Incomplete

8 Main column stages 0 Pumparound(s) 0 Side stripper(s)

For Help, press F1

Fig. 33 STAGES of streams entering and leaving (*ASPEN Simulation)*



Aspen Plus - preflash - [Block PREFLASH (PetroFrac) Setup - Data

View: Top / Bottom

Top stage / Condenser pressure
Stage 1 / Condenser pressure: 39.7 psi

Stage 2 pressure (optional)
Stage 2 pressure: 41.7 psi

Bottom stage pressure or pressure drop for rest of column (optional)
● Bottom stage pressure: 44 psi
○ Stage pressure drop: psi
○ Column pressure drop: psi

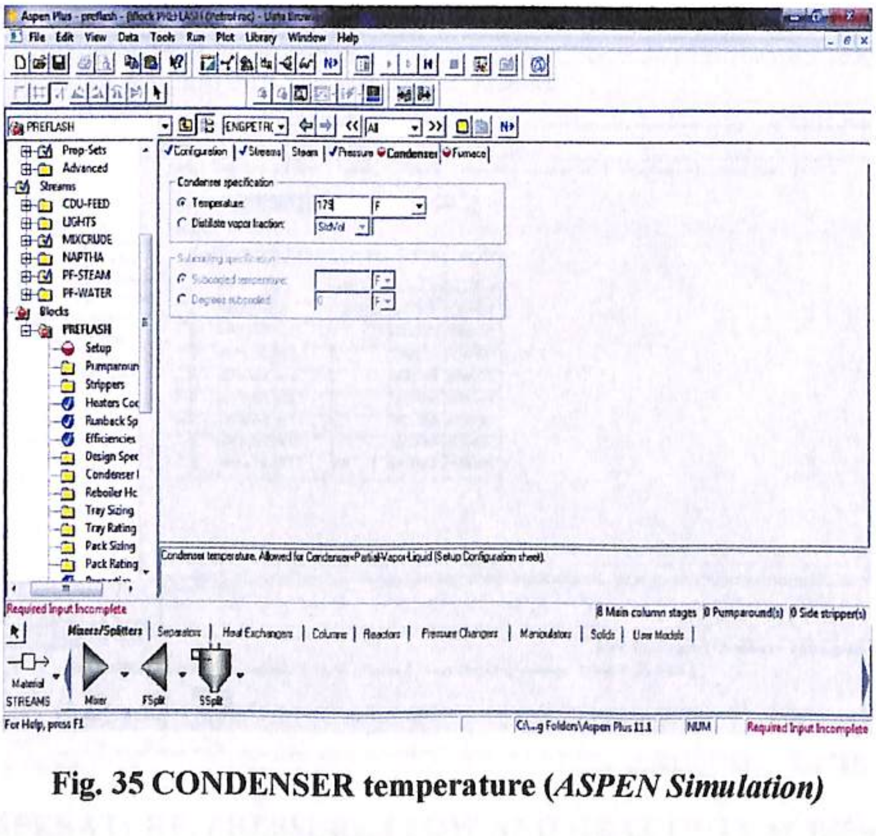
Bottom stage pressure.

Required Input Incomplete

8 Main column stages 0 Pumparound(s) 0 Side stripper(s)

For Help, press F1 C:\...g Folders\Aspen Plus 11.1 NUM Required Input Incomplete

Fig. 34 PRESSURE at different stages of preflash chamber (*ASPEN Simulation)*



Aspen Plus - preflash - [Block PREFLASH (PetroFrac) - Data Browser

Condenser specification
● Temperature: 179 F
○ Distillate vapor fraction: StdVol

Subcooling specification
● Subcooled temperature: F
○ Degrees subcooled: 0 F

Condenser temperature. Allowed for Condenser=Partial-Vapor-Liquid (Setup Configuration sheet).

Required Input Incomplete

8 Main column stages 0 Pumparound(s) 0 Side stripper(s)

For Help, press F1 C:\...g Folders\Aspen Plus 11.1 NUM Required Input Incomplete

Fig. 35 CONDENSER temperature (*ASPEN Simulation)*

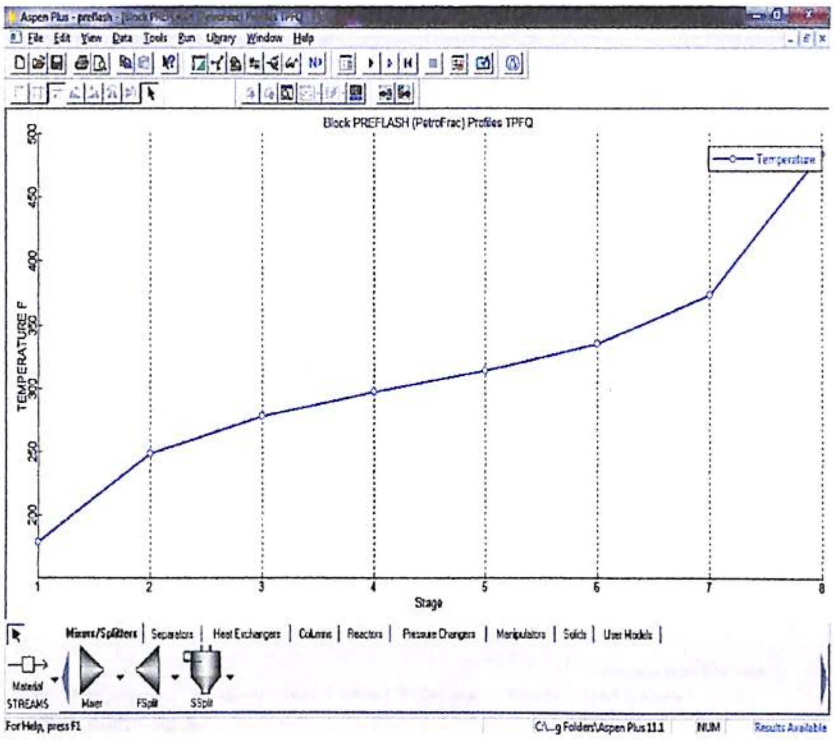
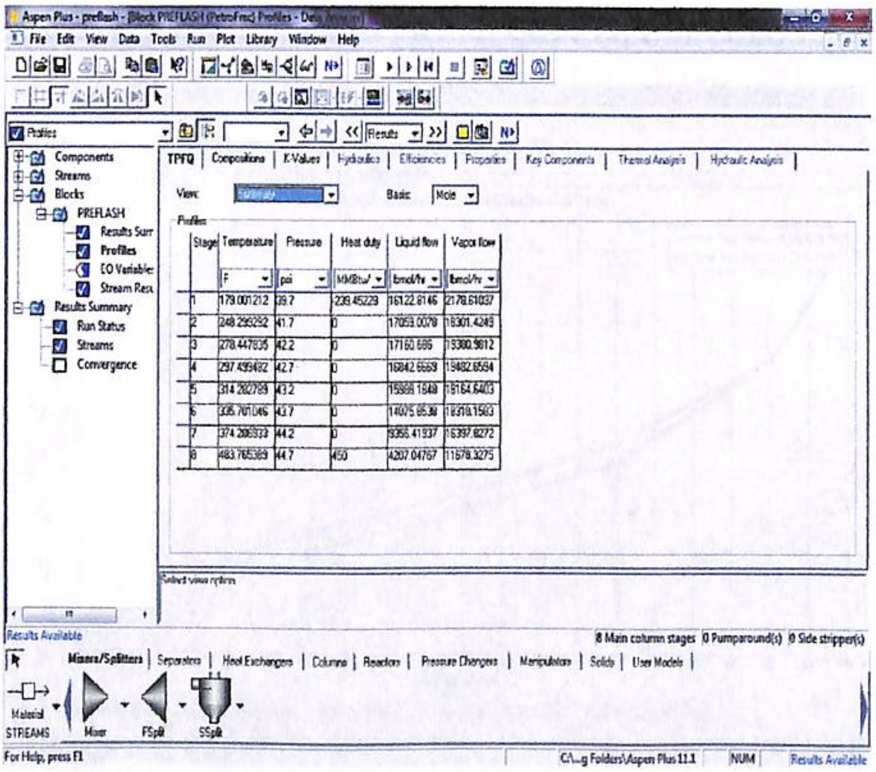


Fig. 36 Curve showing TEMPERATURE AT DIFFERENT STAGES (*ASPEN Simulation*)



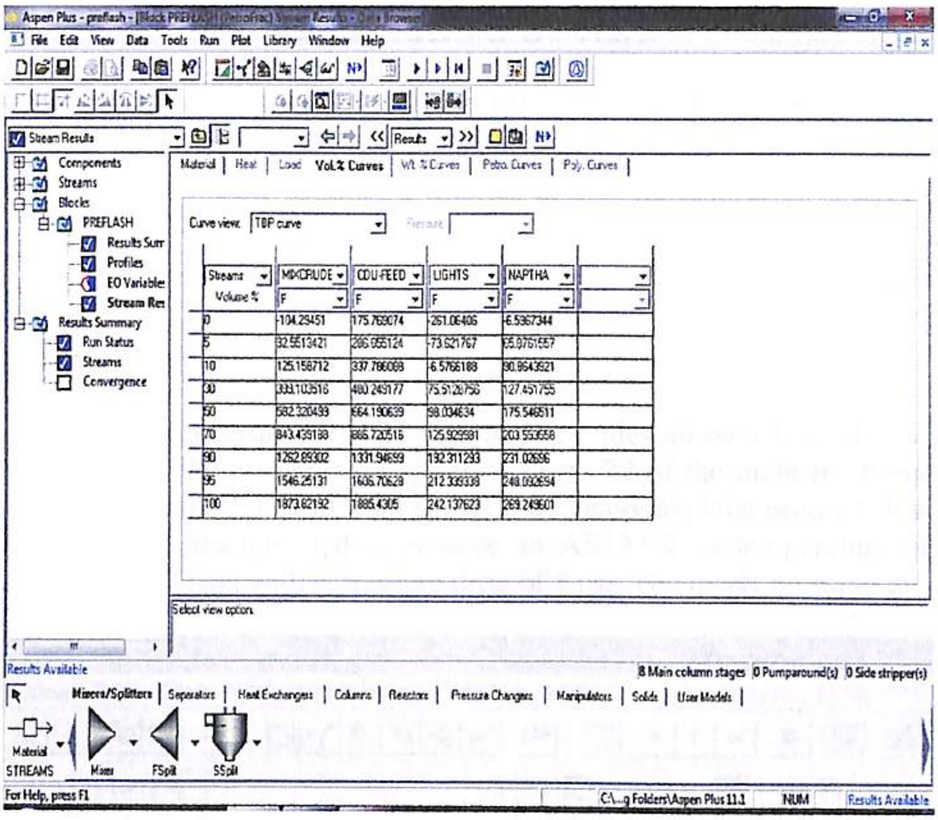
View: Summary Basis: Mole

Profiles

Stage	Temperature F	Pressure psi	Heat duty MMBtu/	Liquid flow lbmol/hr	Vapor flow lbmol/hr
1	179.001212	39.7	-238.45229	16122.8146	2178.61037
2	248.299292	41.7	0	17059.0078	18301.4249
3	278.447835	42.2	0	17160.686	19380.9812
4	297.499482	42.7	0	16842.6569	19482.6594
5	314.282789	43.2	0	15989.1849	19164.6403
6	335.701046	43.7	0	14075.8538	18310.1583
7	374.206933	44.2	0	9356.41937	16397.8272
8	483.765369	44.7	450	4207.04767	11578.3275

8 Main column stages 0 Pumparound(s) 0 Side stripper(s)

Fig. 37 TEMPERATURE, PRESSURE,FLOW AND HEAT DUTY at different stages of preflash column (*ASPEN Simulation*)



Curve view: TBP curve

Streams / Volume %	MIXCRUDE F	CDU-FEED F	LIGHTS F	NAPTHA F
0	-104.29451	175.769074	-261.06406	-6.5367344
5	32.5513421	286.055124	-73.621767	65.9761557
10	125.158712	337.786088	-6.5766188	90.8643921
30	333.103516	480.249177	75.5128756	127.451755
50	582.320499	664.190639	98.034634	175.546511
70	843.439188	866.720516	125.929581	203.553658
90	1262.89302	1331.94699	192.311293	231.02696
95	1546.25131	1606.70628	212.339339	248.092694
100	1873.82192	1885.4305	242.137623	269.249601

Select view option.

Fig. 38 TBP data of different streams PREFLASH COLUMN (*ASPEN Simulation)*

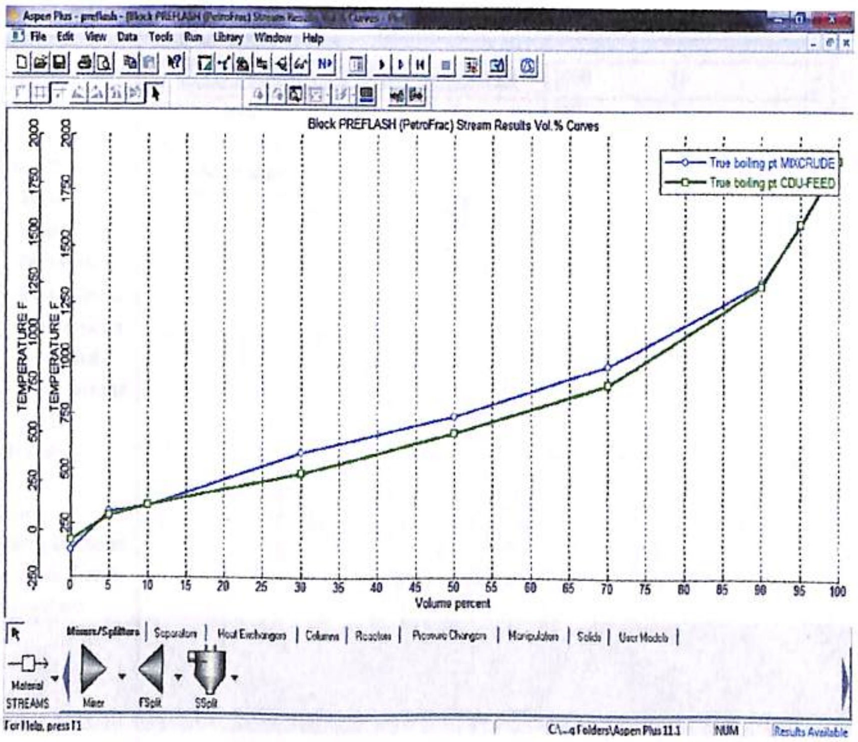


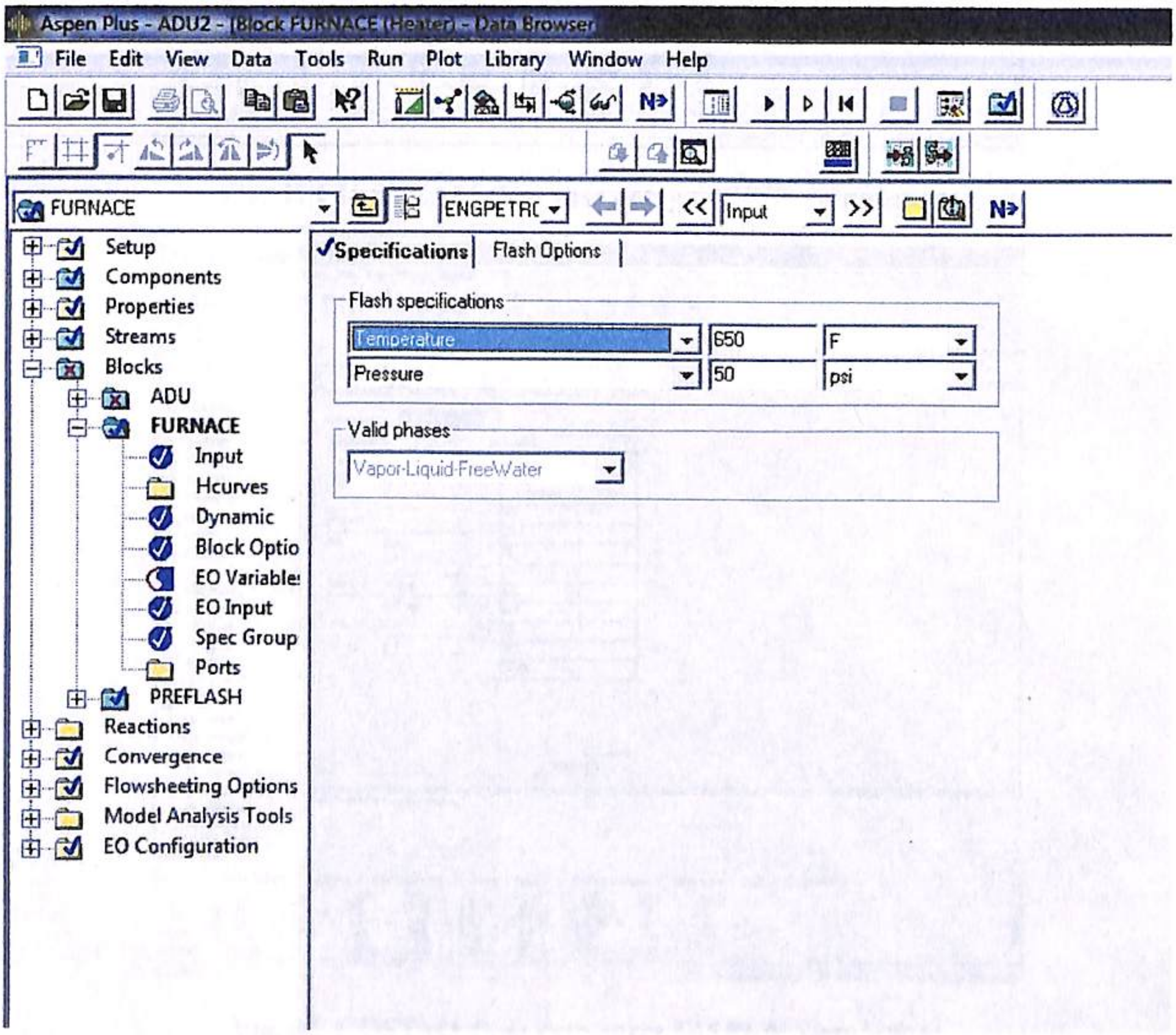
Fig. 39 TBP curve of MIX-CRUDE AND CDU-FEED (*ASPEN Simulation)*

MODELLING OF ADU

Figure below shows the process flowsheet we have developed. The topped crude from the preflash tower goes first to the crude furnace, then to the atmospheric tower.

The tower has:
- A total condenser.
- Three coupled side strippers.
- Two pumparound circuits.

The furnace operates at a pressure of 24.18 psia and provides an overflash of 3% in the tower. The furnace outlet enters the atmospheric tower on stage 22 of the main fractionator.The main fractionator is modeled with 25 equilibrium stages. The heavy naphtha product flow is estimated at 13,000 bbl/day, and is manipulated to achieve an ASTM 95% temperature of 375 F. The condenser operates at 15.7 psia with a pressure drop of 5 psi. The tower pressure drop is 4 psi.



Flash specifications

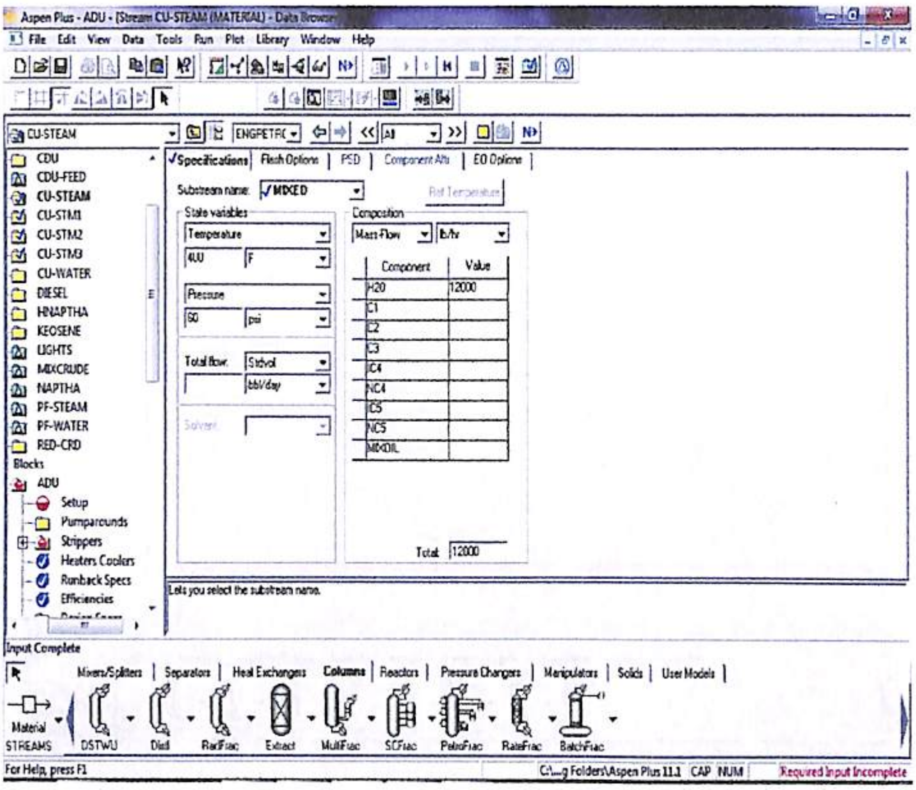
Temperature 650 F

Pressure 50 psi

Valid phases

Vapor-Liquid-FreeWater

Fig. 40 Specifications of FURNACE unit (*ASPEN Simulation)*



Substream name: MIXED

State variables

Temperature: 4UU F

Pressure: 60 psi

Total flow: Stdvol bbl/day

Solvent:

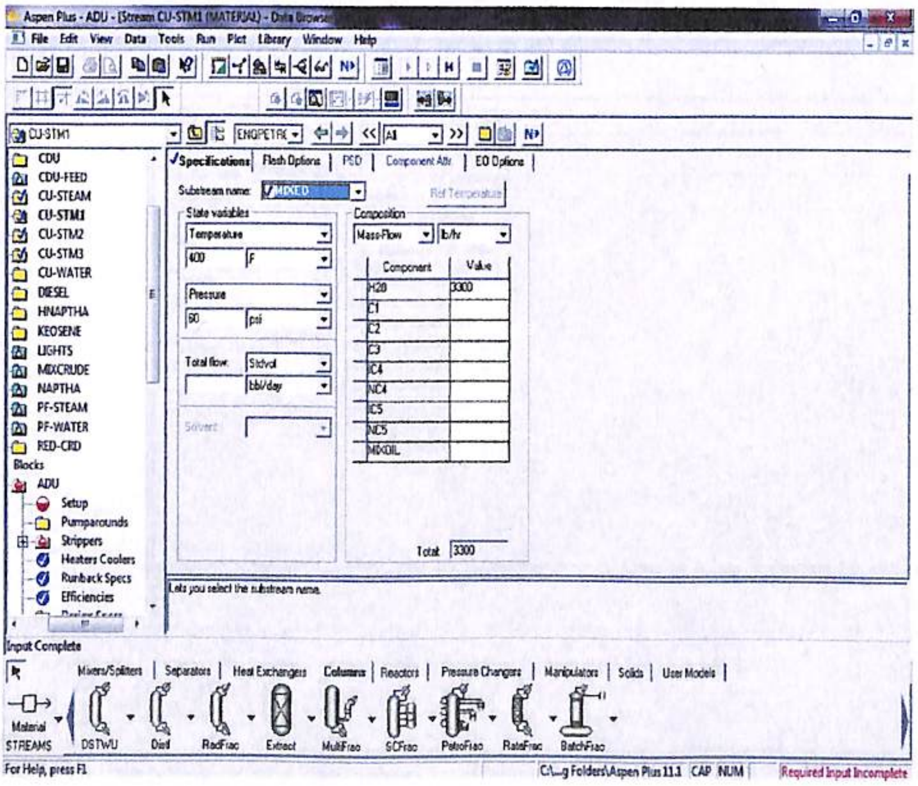
Composition: Mass-Flow lb/hr

Component	Value
H20	12000
C1	
C2	
C3	
IC4	
NC4	
IC5	
NC5	
MIXOIL	

Total: 12000

Lets you select the substream name.

Fig. 41 CU-STEAM flow rate entry (*ASPEN Simulation)*



Substream name: MIXED

State variables

Temperature: 400 F

Pressure: 60 psi

Total flow: Stdvol bbl/day

Solvent:

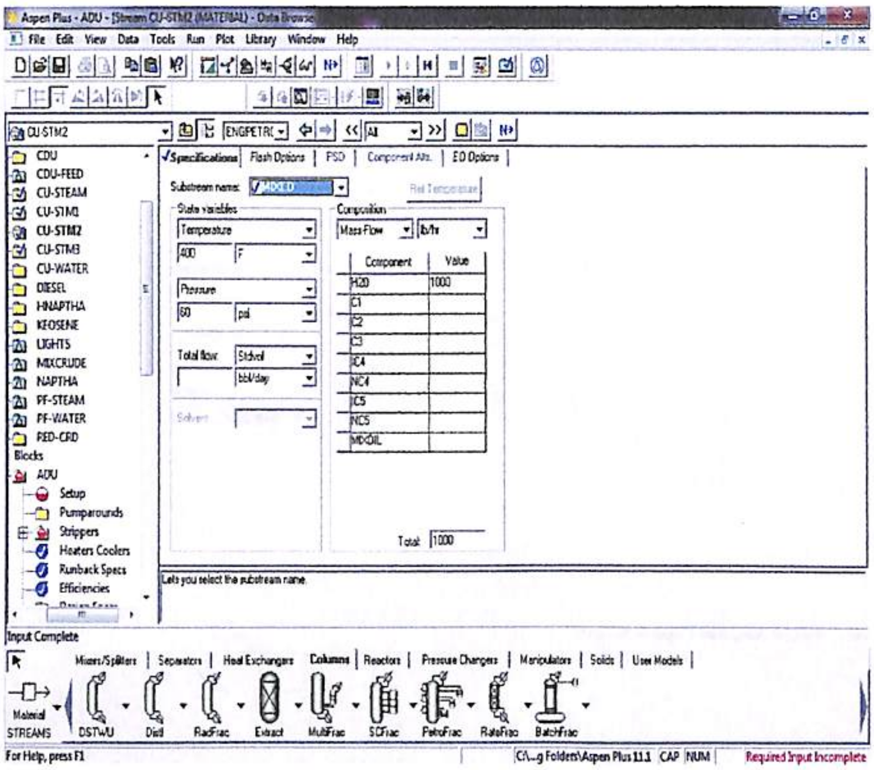
Composition: Mass-Flow lb/hr

Component	Value
H20	3300
C1	
C2	
C3	
IC4	
NC4	
IC5	
NC5	
MIXOIL	

Total: 3300

Lets you select the substream name.

Fig. 42 CUSTM1 flow rate entry (*ASPEN Simulation)*



Substream name: MIXED

State variables

Temperature: 400 F

Pressure: 60 psi

Total flow: StdVol bbl/day

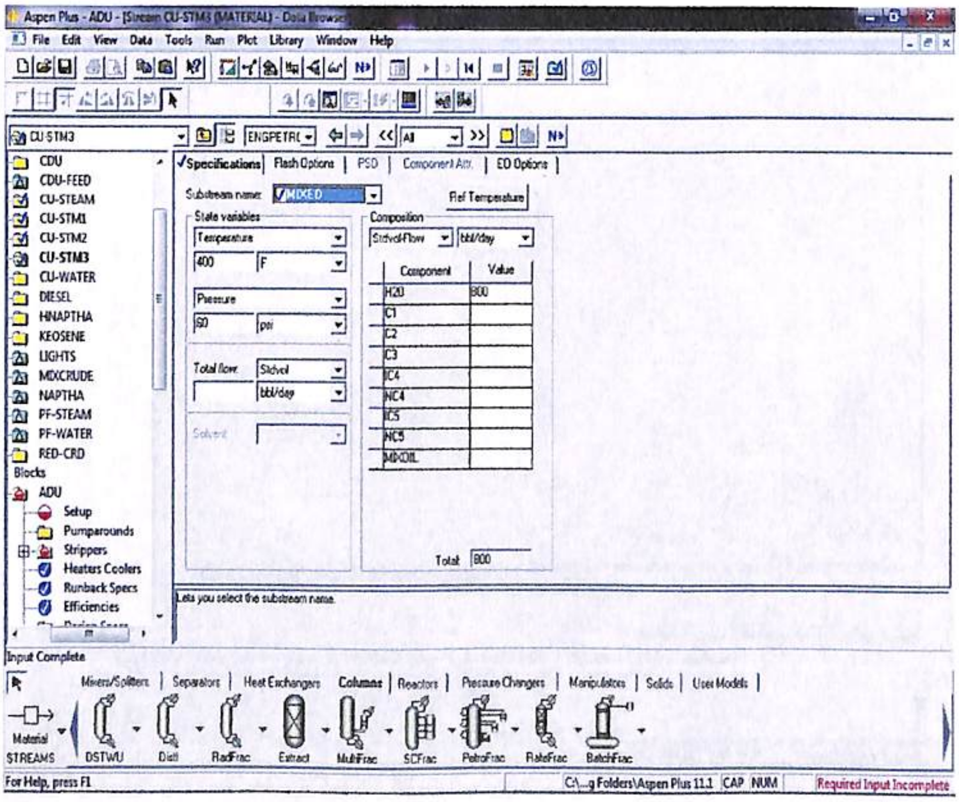
Composition: Mass-Flow lb/hr

Component	Value
H2O	1000
C1	
C2	
C3	
IC4	
NC4	
IC5	
NC5	
MIXOIL	

Total: 1000

Lets you select the substream name.

Fig. 43 CUSTM2 flowrate entry (*ASPEN Simulation)*



Substream name: MIXED

State variables

Temperature: 400 F

Pressure: 60 psi

Total flow: StdVol bbl/day

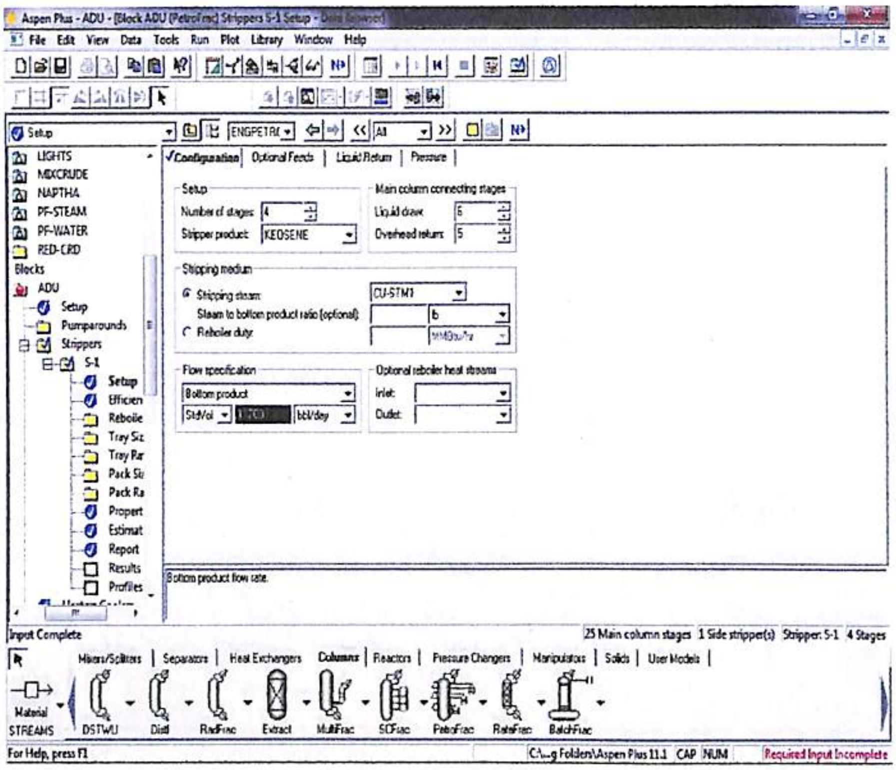
Composition: StdVol-Flow bbl/day

Component	Value
H2O	800
C1	
C2	
C3	
IC4	
NC4	
IC5	
NC5	
MIXOIL	

Total: 800

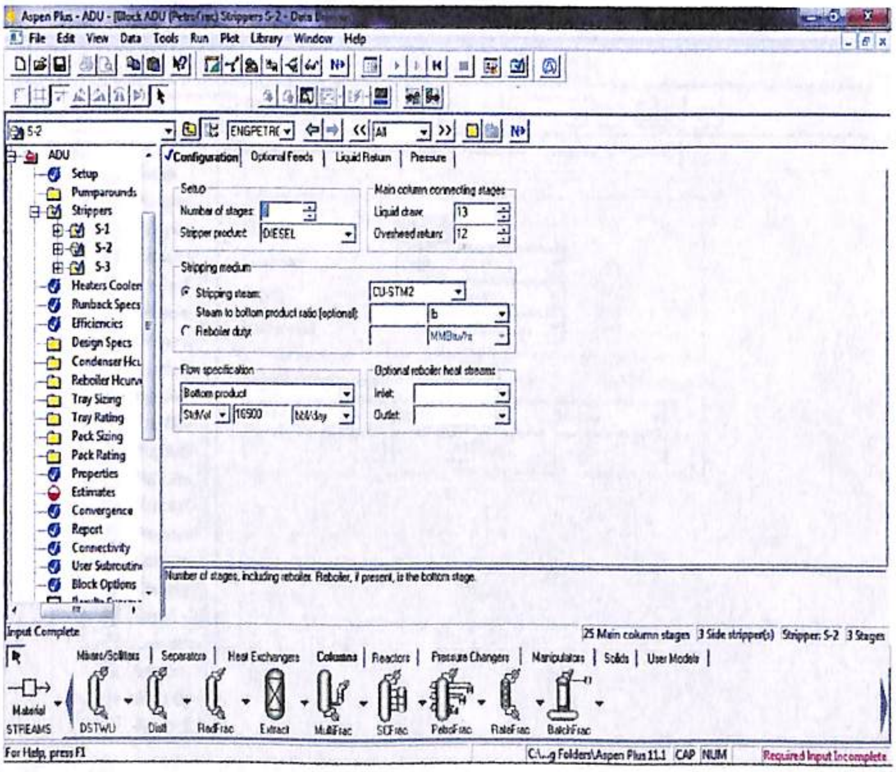
Lets you select the substream name.

Fig. 44 CUSTM3 flow rate entry (*ASPEN Simulation)*



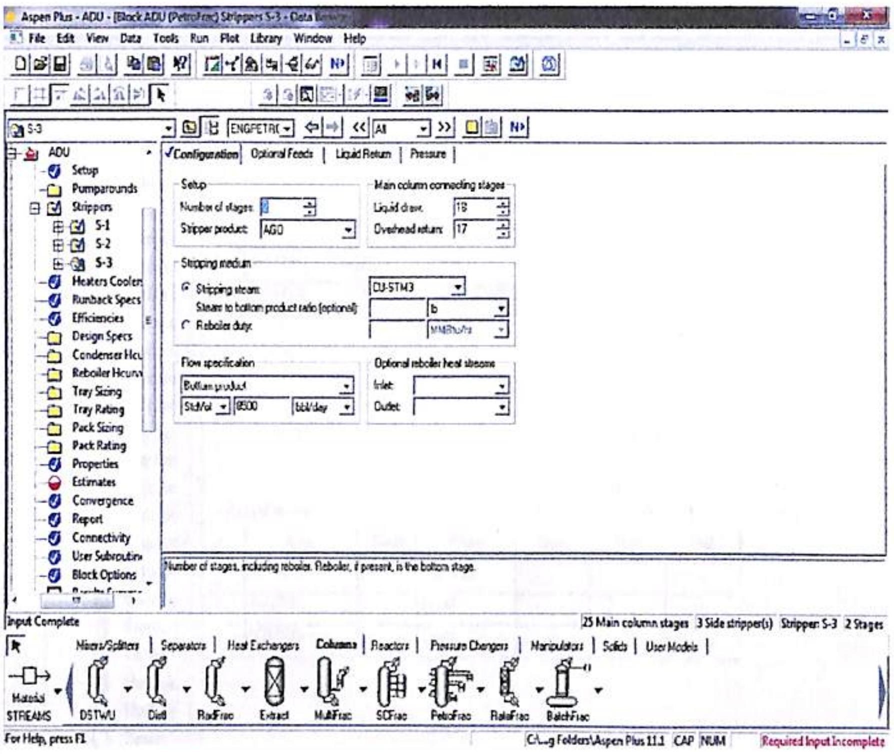
Setup
Number of stages: 4
Stripper product: KEOSENE
Main column connecting stages
Liquid draw: 6
Overhead return: 5
Stripping medium
● Stripping steam: CU-STM1
Steam to bottom product ratio (optional): lb
○ Reboiler duty: MMBtu/hr
Flow specification
Bottom product
StdVol 11700 bbl/day
Optional reboiler heat streams
Inlet:
Outlet:
Bottom product flow rate.
Input Complete
25 Main column stages 1 Side stripper(s) Stripper: S-1 4 Stages
For Help, press F1
C:\...g Folders\Aspen Plus 11.1 CAP NUM Required Input Incomplete

Fig. 45 SIDE STRIPPER 1 configuration entry (*ASPEN Simulation)*



Setup
Number of stages:
Stripper product: DIESEL
Main column connecting stages
Liquid draw: 13
Overhead return: 12
Stripping medium
● Stripping steam: CU-STM2
Steam to bottom product ratio (optional): lb
○ Reboiler duty: MMBtu/hr
Flow specification
Bottom product
StdVol 10500 bbl/day
Optional reboiler heat streams
Inlet:
Outlet:
Number of stages, including reboiler. Reboiler, if present, is the bottom stage.
Input Complete
25 Main column stages 3 Side stripper(s) Stripper: S-2 3 Stages
For Help, press F1
C:\...g Folders\Aspen Plus 11.1 CAP NUM Required Input Incomplete

Fig. 46 SIDE STRIPPER 2 configuration entry (*ASPEN Simulation)*



Setup
Number of stages: 2
Stripper product: AGO

Main column connecting stages
Liquid draw: 18
Overhead return: 17

Stripping medium
● Stripping steam: CU-STM3
Steam to bottom product ratio (optional): lb
○ Reboiler duty: MMBtu/hr

Flow specification
Bottom product
StdVol 8500 bbl/day

Optional reboiler heat streams
Inlet:
Outlet:

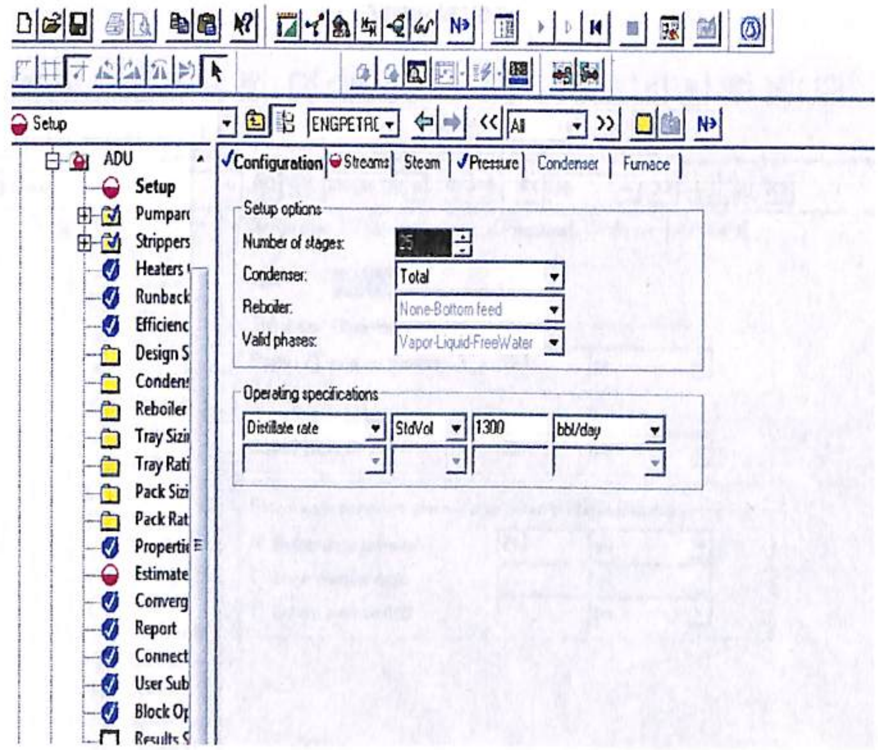
Number of stages, including reboiler. Reboiler, if present, is the bottom stage.

Input Complete

25 Main column stages | 3 Side stripper(s) | Stripper: S-3 | 2 Stages

Required Input Incomplete

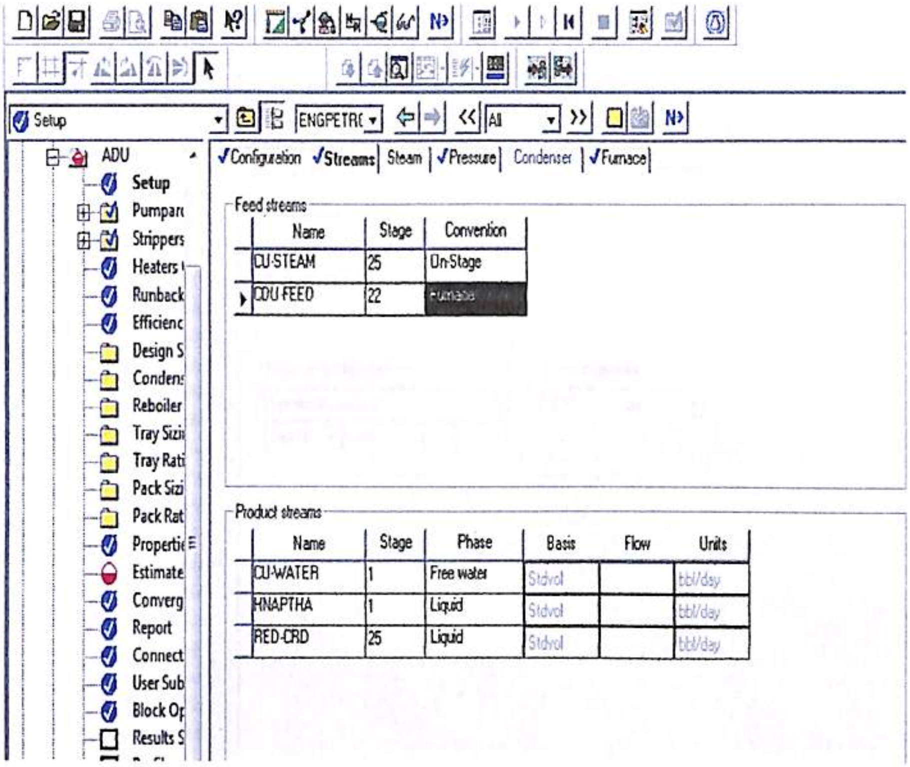
Fig. 47 SIDE STRIPPER 1 configuration entry (*ASPEN Simulation)*



Setup options
Number of stages: 25
Condenser: Total
Reboiler: None-Bottom feed
Valid phases: Vapor-Liquid-FreeWater

Operating specifications
Distillate rate | StdVol | 1300 | bbl/day

Fig. 48 Specifying number of stages in the ADU column (*ASPEN Simulation)*



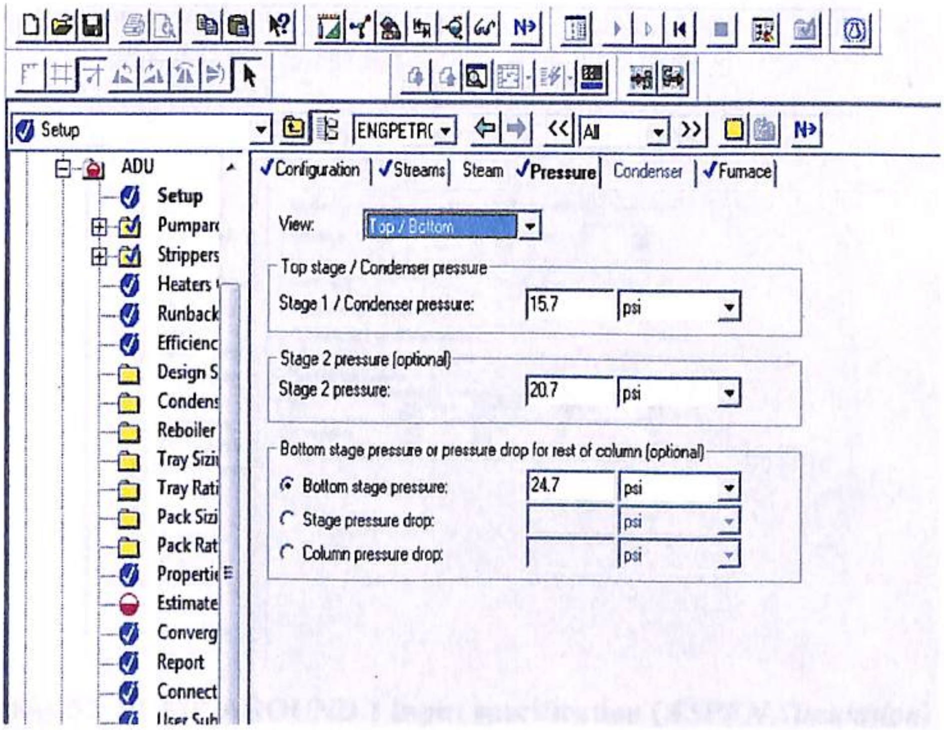
Feed streams

Name	Stage	Convention
CU-STEAM	25	On-Stage
CDU-FEED	22	Furnace

Product streams

Name	Stage	Phase	Basis	Flow	Units
CU-WATER	1	Free water	Stdvol		bbl/day
HNAPTHA	1	Liquid	Stdvol		bbl/day
RED-CRD	25	Liquid	Stdvol		bbl/day

Fig. 49 Specifying the stages of different streams are entering and leaving (*ASPEN Simulation)*



View: Top / Bottom

Top stage / Condenser pressure

Stage 1 / Condenser pressure: 15.7 psi

Stage 2 pressure (optional)

Stage 2 pressure: 20.7 psi

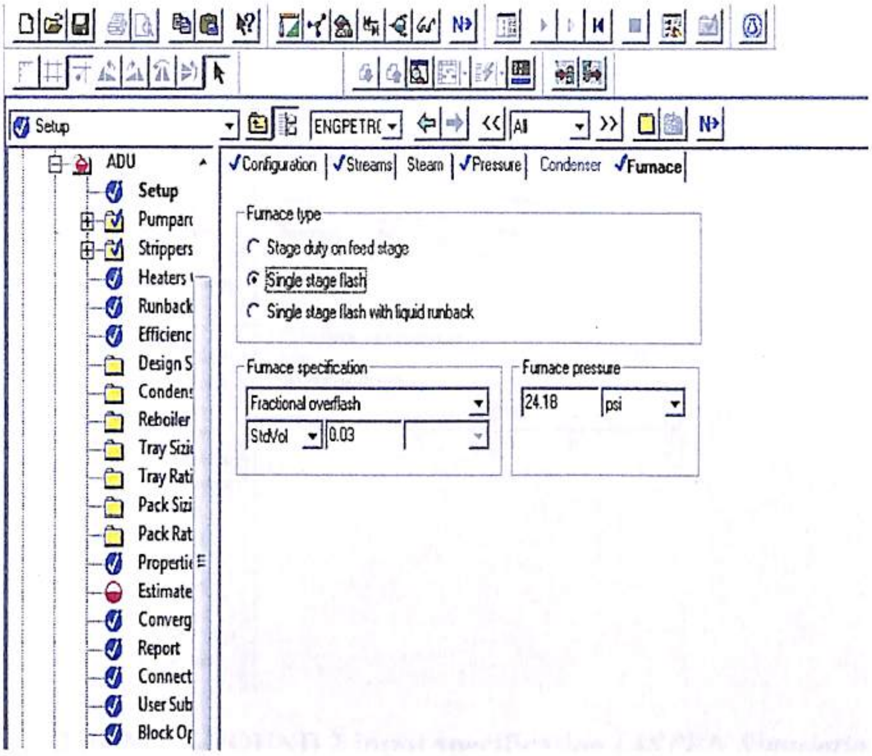
Bottom stage pressure or pressure drop for rest of column (optional)

● Bottom stage pressure: 24.7 psi

○ Stage pressure drop: psi

○ Column pressure drop: psi

Fig. 50 PRESSURE input at different stages (*ASPEN Simulation)*



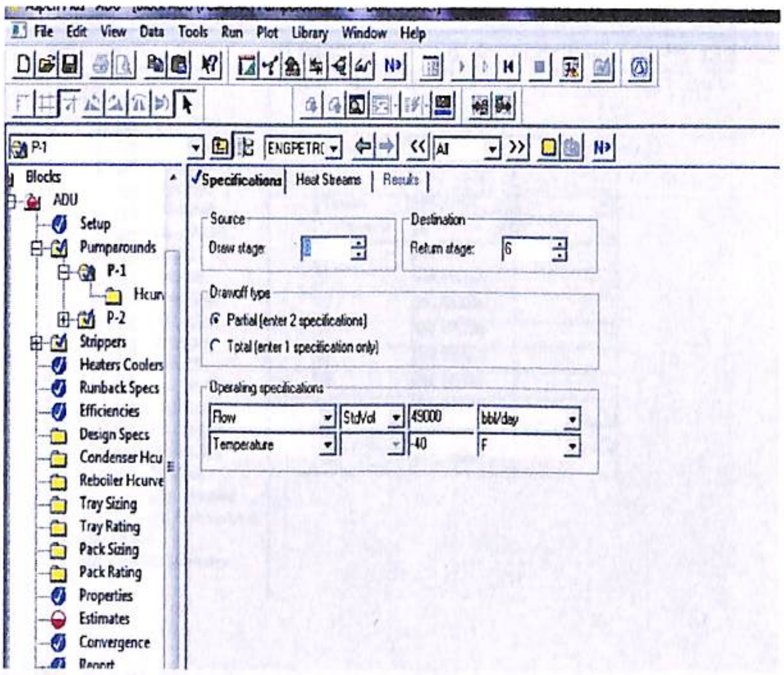
Furnace type

○ Stage duty on feed stage
● Single stage flash
○ Single stage flash with liquid runback

Furnace specification: Fractional overflash
StdVol 0.03

Furnace pressure: 24.18 psi

Fig. 51 Specifying FURNACE TYPE and FRACTIONAL OVERFLASH (*ASPEN Simulation)*



Source
Draw stage: 8

Destination
Return stage: 6

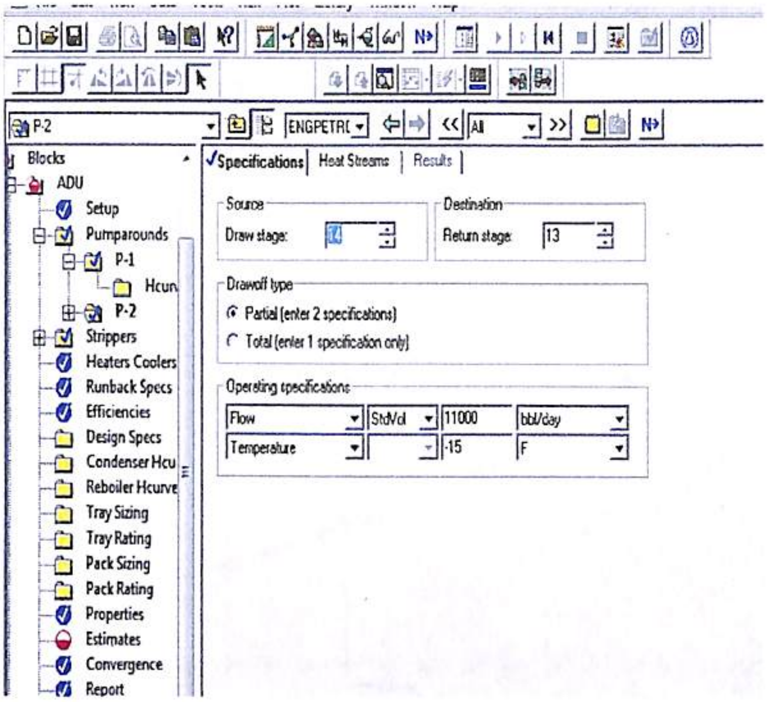
Drawoff type

● Partial (enter 2 specifications)
○ Total (enter 1 specification only)

Operating specifications

Flow StdVol 49000 bbl/day
Temperature -40 F

Fig. 52 PUMP AROUND 1 input specification (*ASPEN Simulation)*



Source

Draw stage: 14

Destination

Return stage: 13

Drawoff type

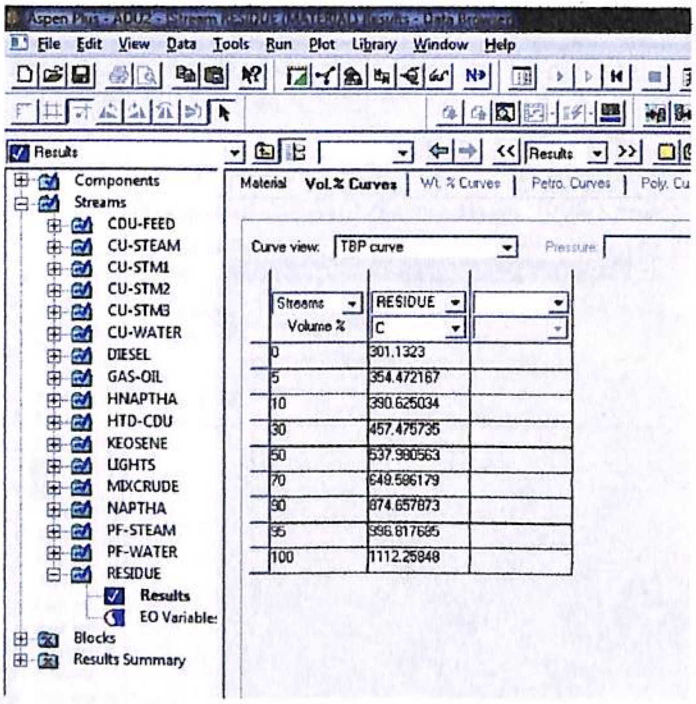
● Partial (enter 2 specifications)

○ Total (enter 1 specification only)

Operating specifications

Flow	StdVol	11000	bbl/day
Temperature		-15	F

Fig. 53 PUMP AROUND 2 input specification (*ASPEN Simulation)*



Curve view: TBP curve

Streams	RESIDUE	
Volume %	C	
0	301.1323	
5	354.472167	
10	390.625034	
30	457.475735	
50	537.980563	
70	649.596179	
90	874.657873	
95	996.817685	
100	1112.25848	

Fig. 54 Results from Residue stream (*ASPEN Simulation)*

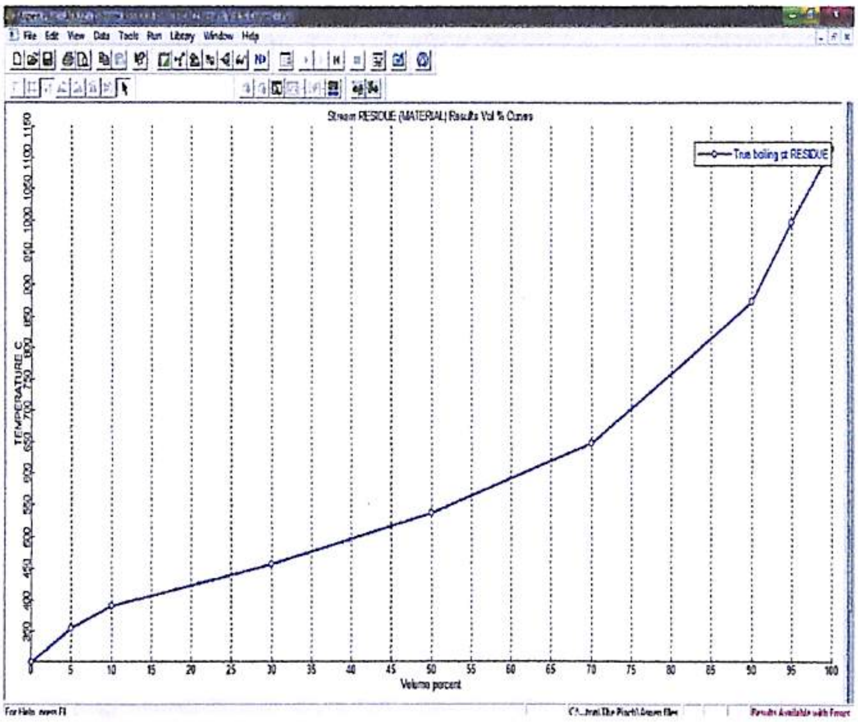
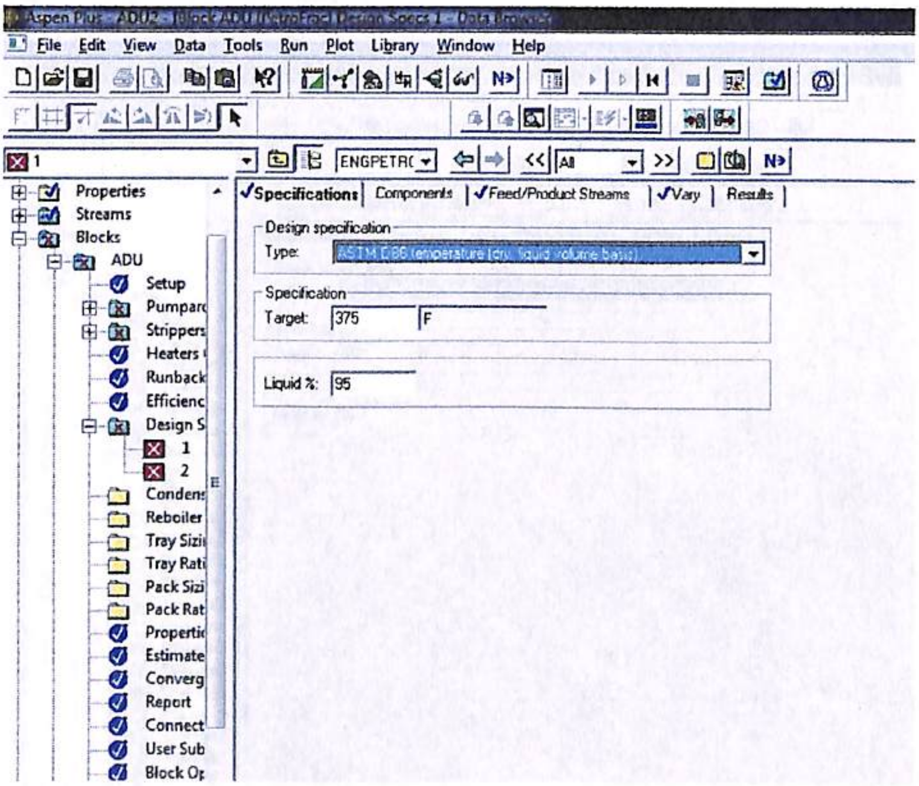


Fig. 55 Plot of results from Residue stream (*ASPEN Simulation)*



Design specification

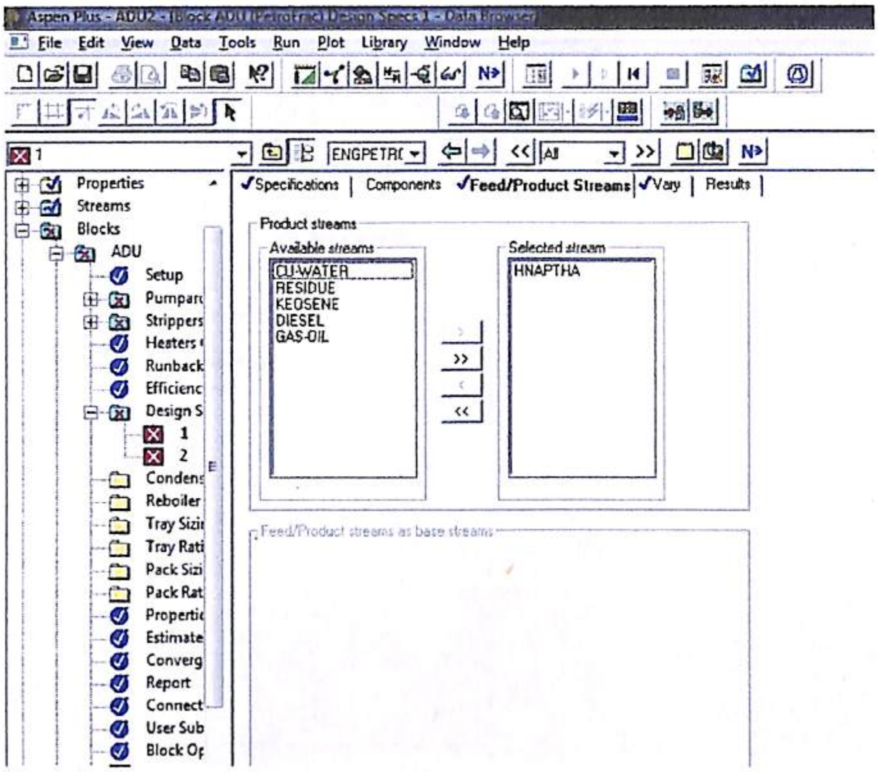
Type: ASTM D86 temperature (dry, liquid volume basis)

Specification

Target: 375 F

Liquid %: 95

Fig.56 ASTDM Specifications HNAPTHA (*ASPEN Simulation)*

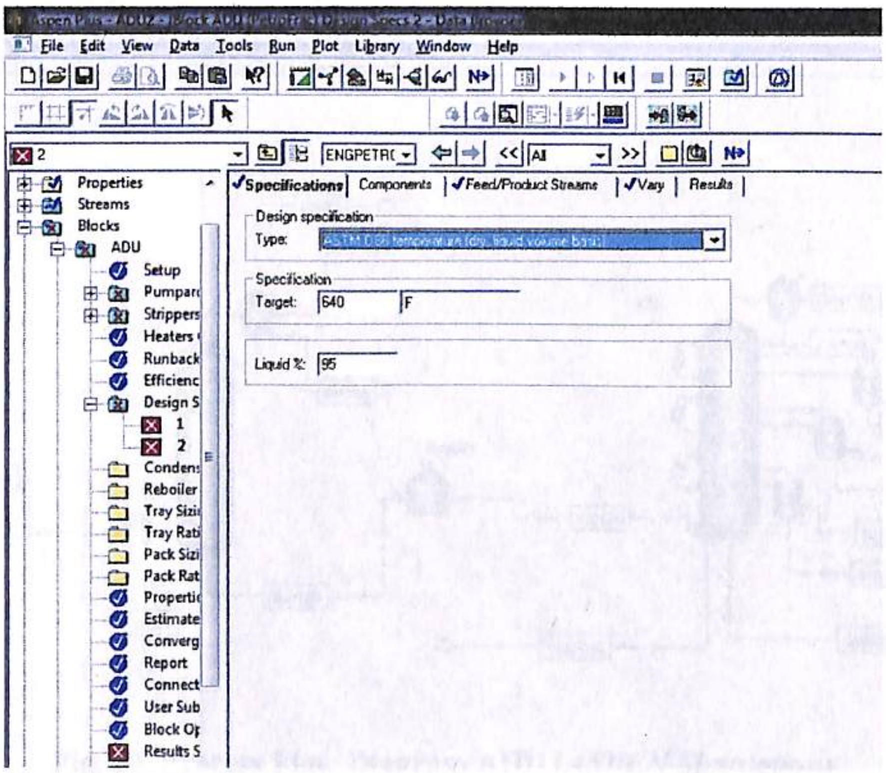


Product streams

Available streams:
CU-WATER
RESIDUE
KEOSENE
DIESEL
GAS-OIL

Selected stream:
HNAPTHA

Fig. 57 Selecting HNAPTHA for design specifications (*ASPEN Simulation)*

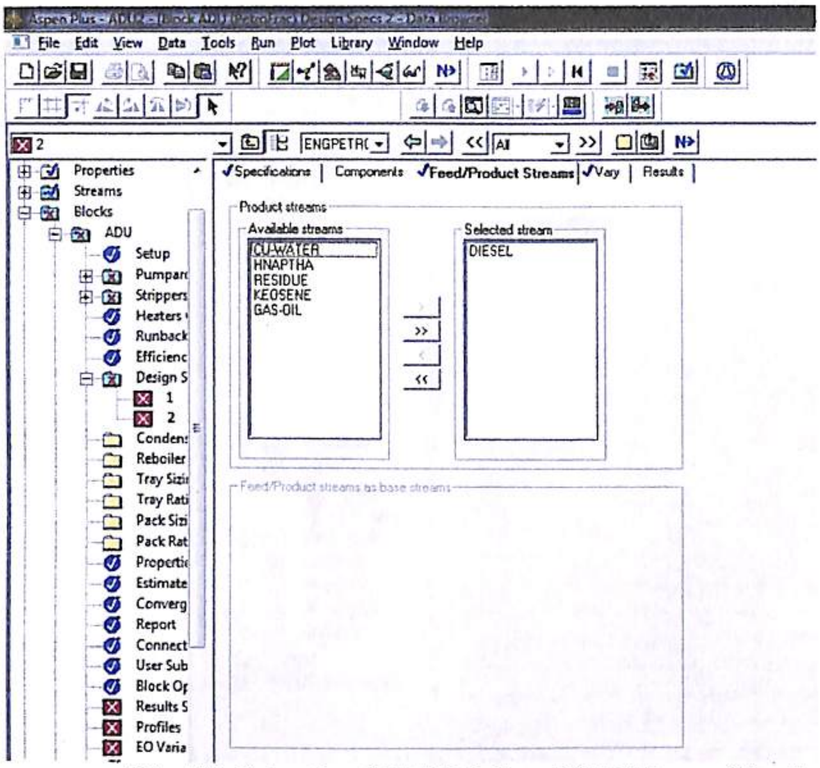


Design specification
Type: ASTM D86 temperature (dry, liquid volume basis)

Specification
Target: 640 F

Liquid %: 95

Fig. 58 ASTDM specifications for DIESEL (*ASPEN Simulation)*



Available streams:
CU-WATER
HNAPTHA
RESIDUE
KEOSENE
GAS-OIL

Selected stream:
DIESEL

Fig. 59 Selecting DIESEL for ASTDM specifications (*ASPEN Simulation*)

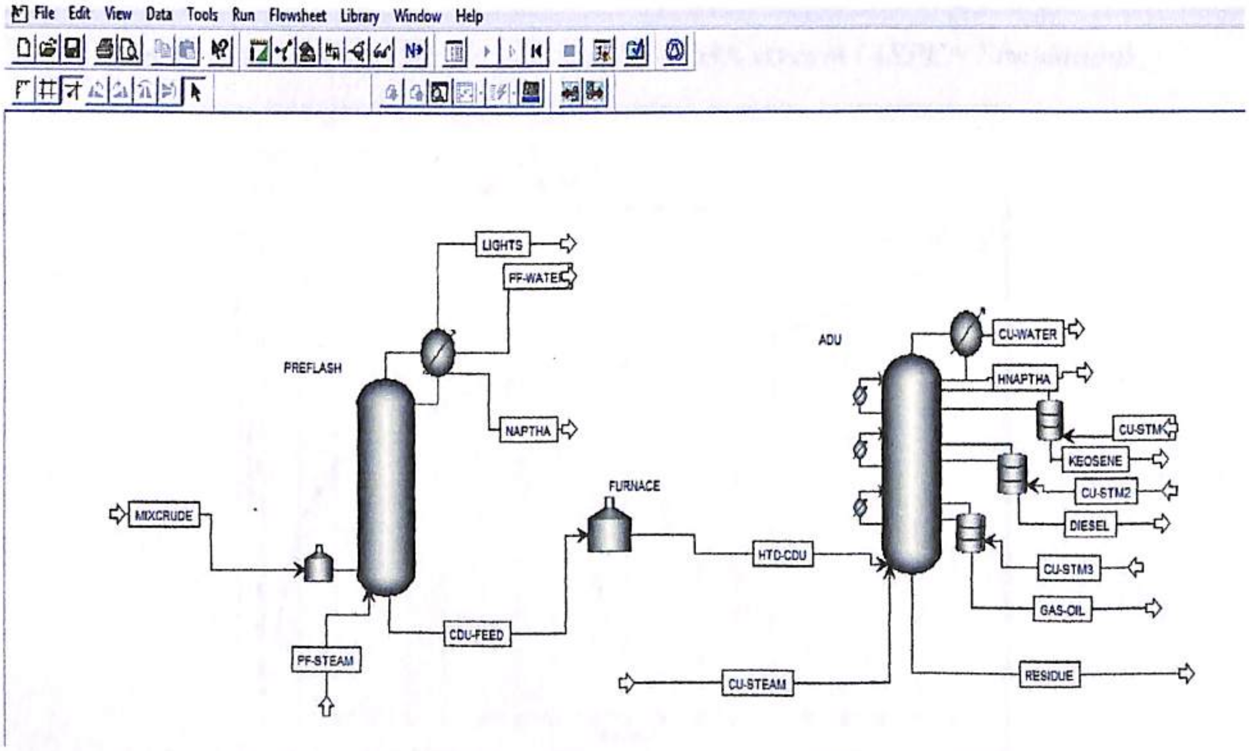
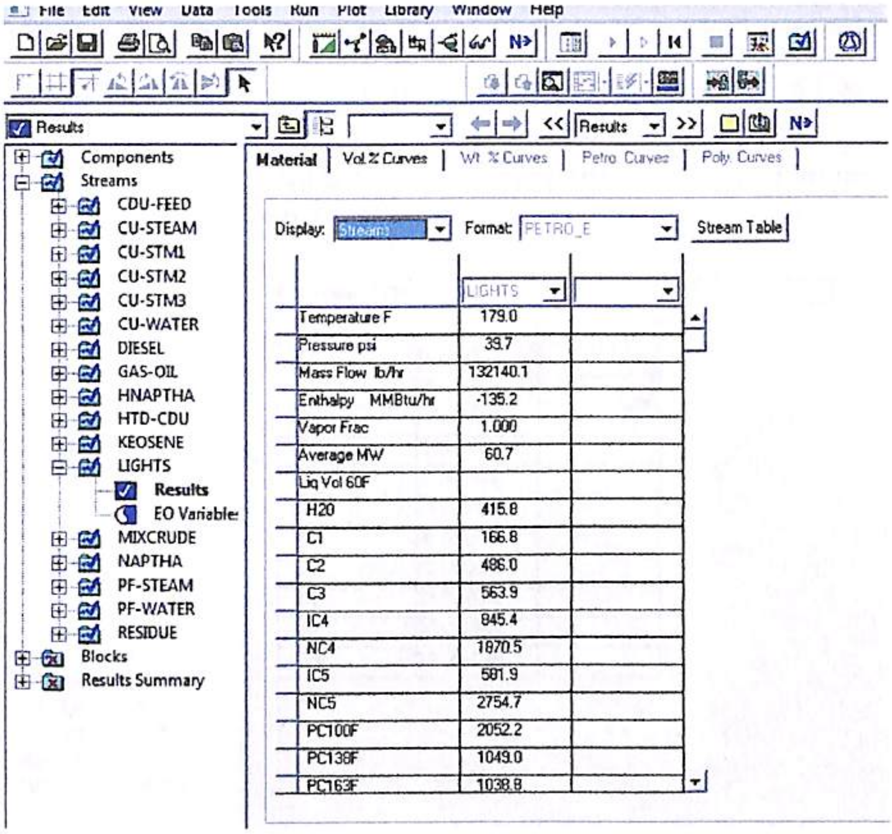


Fig. 60 Process Flow Diagram ADU (*ASPEN Simulation*)



Display: Stream

Format: PETRO_E

	LIGHTS	
Temperature F	179.0	
Pressure psi	39.7	
Mass Flow lb/hr	132140.1	
Enthalpy MMBtu/hr	-135.2	
Vapor Frac	1.000	
Average MW	60.7	
Liq Vol 60F		
H20	415.8	
C1	166.8	
C2	486.0	
C3	563.9	
IC4	845.4	
NC4	1870.5	
IC5	581.9	
NC5	2754.7	
PC100F	2052.2	
PC138F	1049.0	
PC163F	1038.8	

Fig. 61 Plot of TBP data of LIGHT NAPTHA stream (*ASPEN Simulation)*

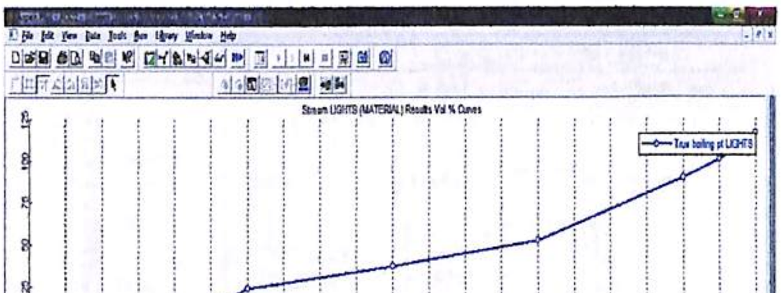
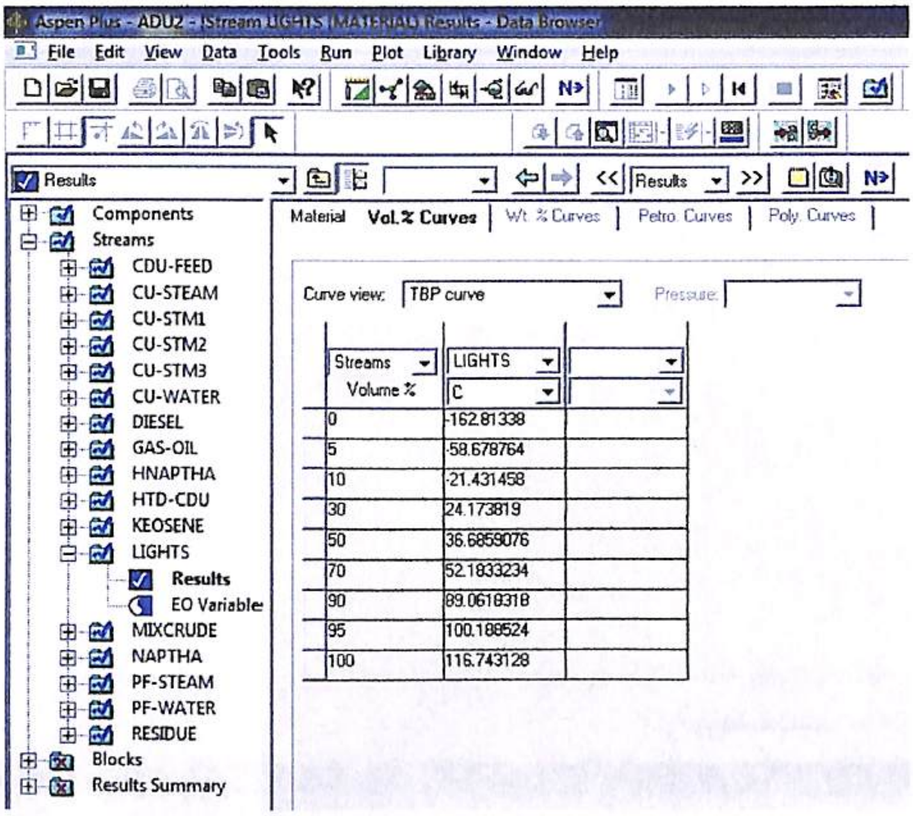


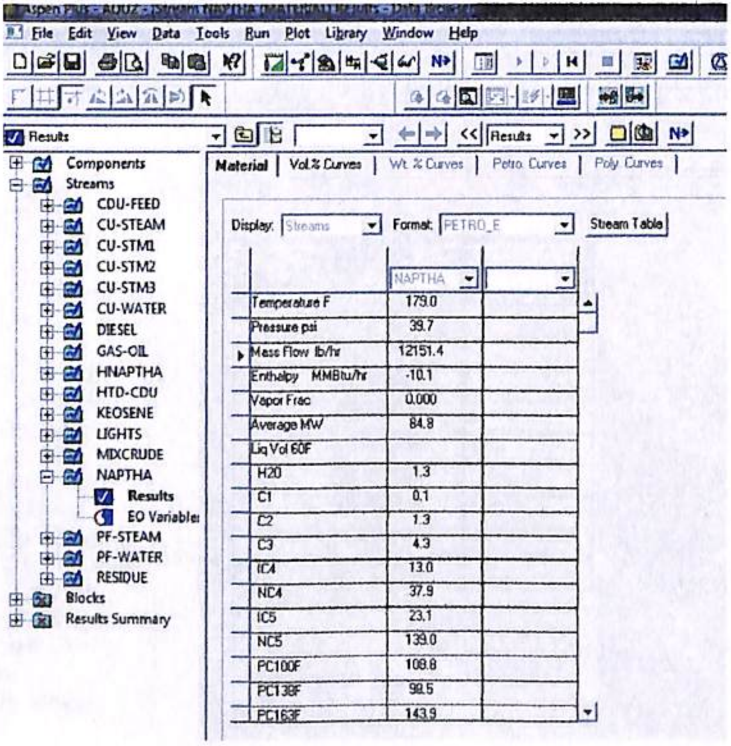
Fig. 62 TBP Data LIGHT NAPTHA Stream (*ASPEN Simulation)*



Curve view: TBP curve

Streams	LIGHTS
Volume %	C
0	-162.81338
5	-58.678764
10	-21.431458
30	24.173819
50	36.6859076
70	52.1833234
90	89.0618318
95	100.188524
100	116.743128

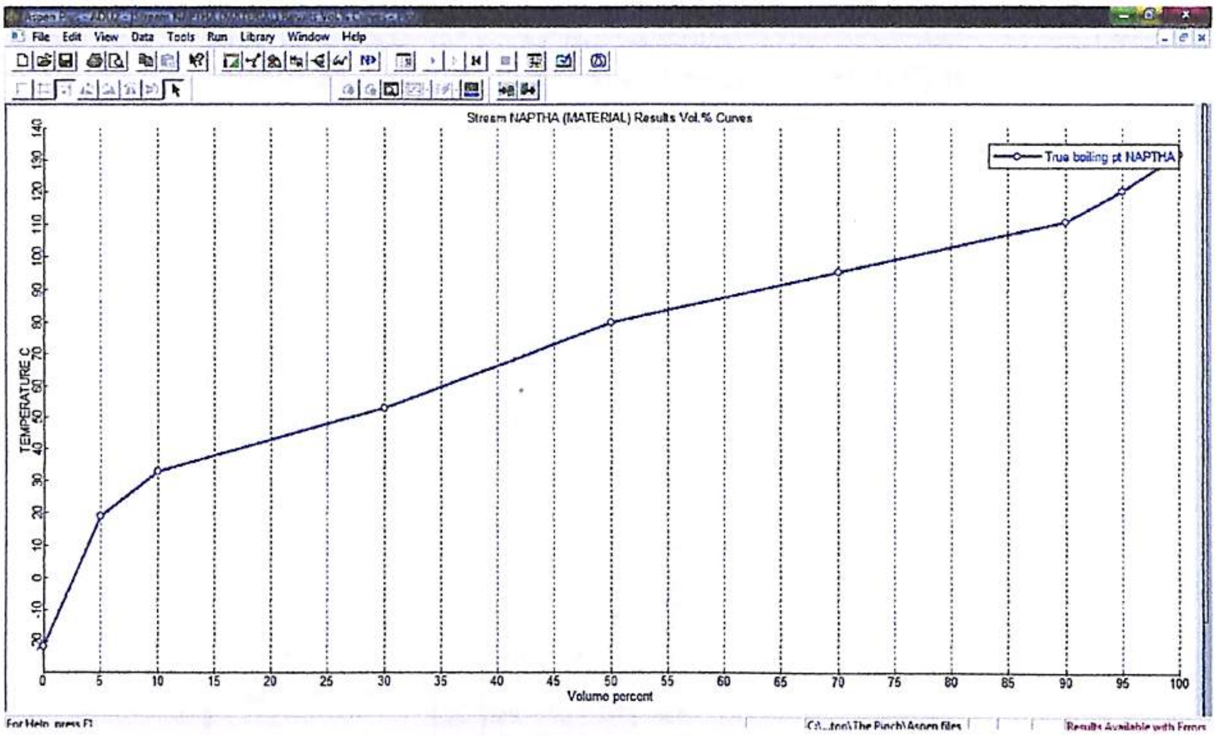
Fig. 63 **Results from NAPTHA stream (*ASPEN Simulation)***

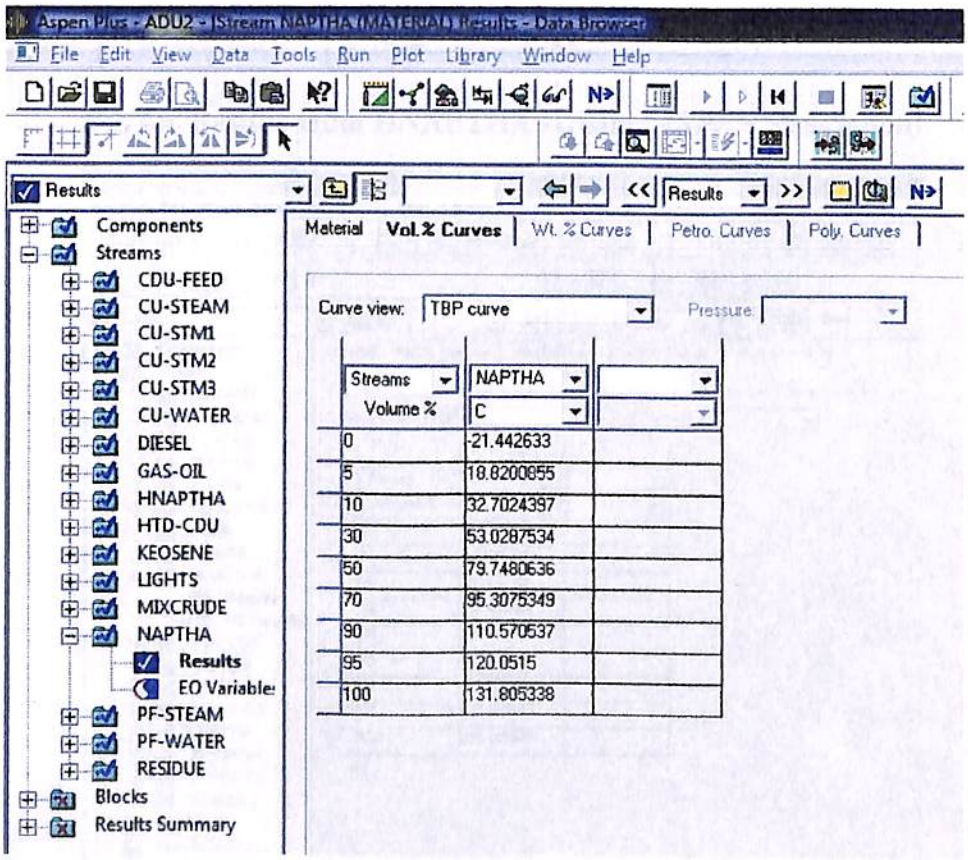


Display: Streams Format: PETRO_E

	NAPTHA
Temperature F	179.0
Pressure psi	39.7
Mass Flow lb/hr	12151.4
Enthalpy MMBtu/hr	-10.1
Vapor Frac	0.000
Average MW	84.8
Liq Vol 60F	
H20	1.3
C1	0.1
C2	1.3
C3	4.3
IC4	13.0
NC4	37.9
IC5	23.1
NC5	139.0
PC100F	108.8
PC138F	98.5
PC163F	143.9

Fig. 64 Plot of TBP data of NAPTHA stream (*ASPEN Simulation)*

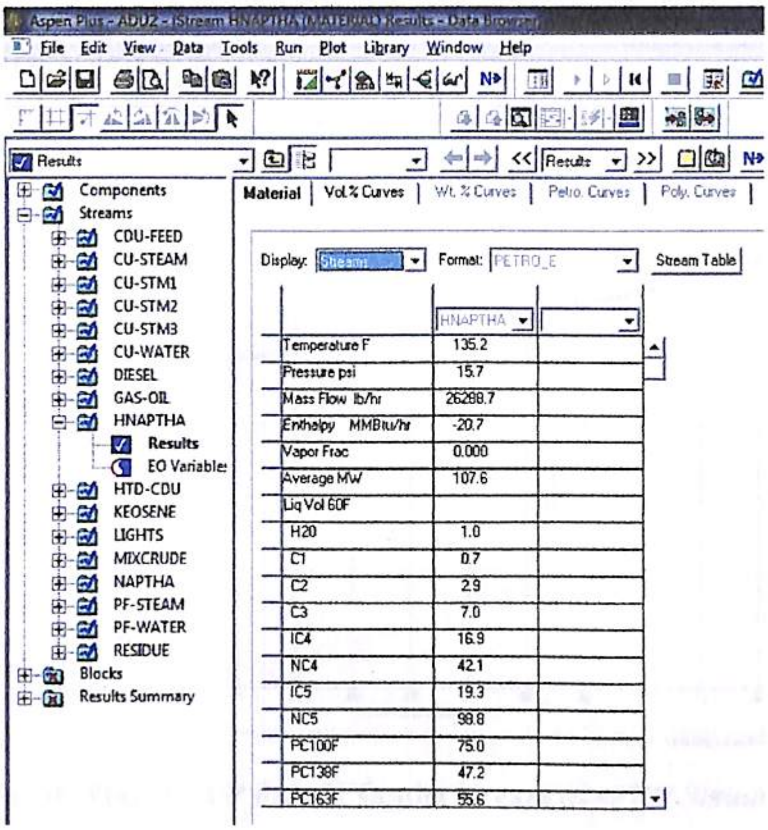




Curve view: TBP curve

Streams Volume %	NAPTHA C
0	-21.442633
5	18.8200855
10	32.7024397
30	53.0287534
50	79.7480636
70	95.3075349
90	110.570537
95	120.0515
100	131.805338

Fig. 65 TBP data of NAPTHA stream (*ASPEN Simulation)*

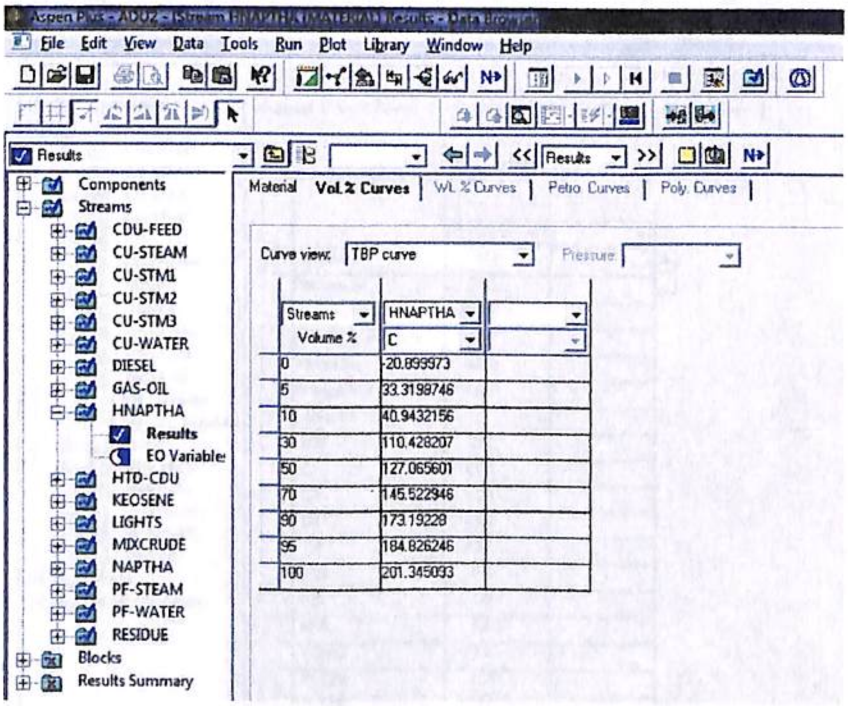


Display: Streams

Format: PETRO_E

	HNAPTHA	
Temperature F	135.2	
Pressure psi	15.7	
Mass Flow lb/hr	26288.7	
Enthalpy MMBtu/hr	-20.7	
Vapor Frac	0.000	
Average MW	107.6	
Liq Vol 60F		
H20	1.0	
C1	0.7	
C2	2.9	
C3	7.0	
IC4	16.9	
NC4	42.1	
IC5	19.3	
NC5	98.8	
PC100F	75.0	
PC138F	47.2	
PC163F	55.6	

Fig. 66 Results from HNAPTHA stream (*ASPEN Simulation)*



Curve view: TBP curve

Streams Volume %	HNAPTHA C	
0	-20.899973	
5	33.3198746	
10	40.9432156	
30	110.428207	
50	127.065601	
70	145.522946	
90	173.19228	
95	184.826246	
100	201.345093	

Fig. 67 TBP data of HNAPTHA stream (*ASPEN Simulation)*

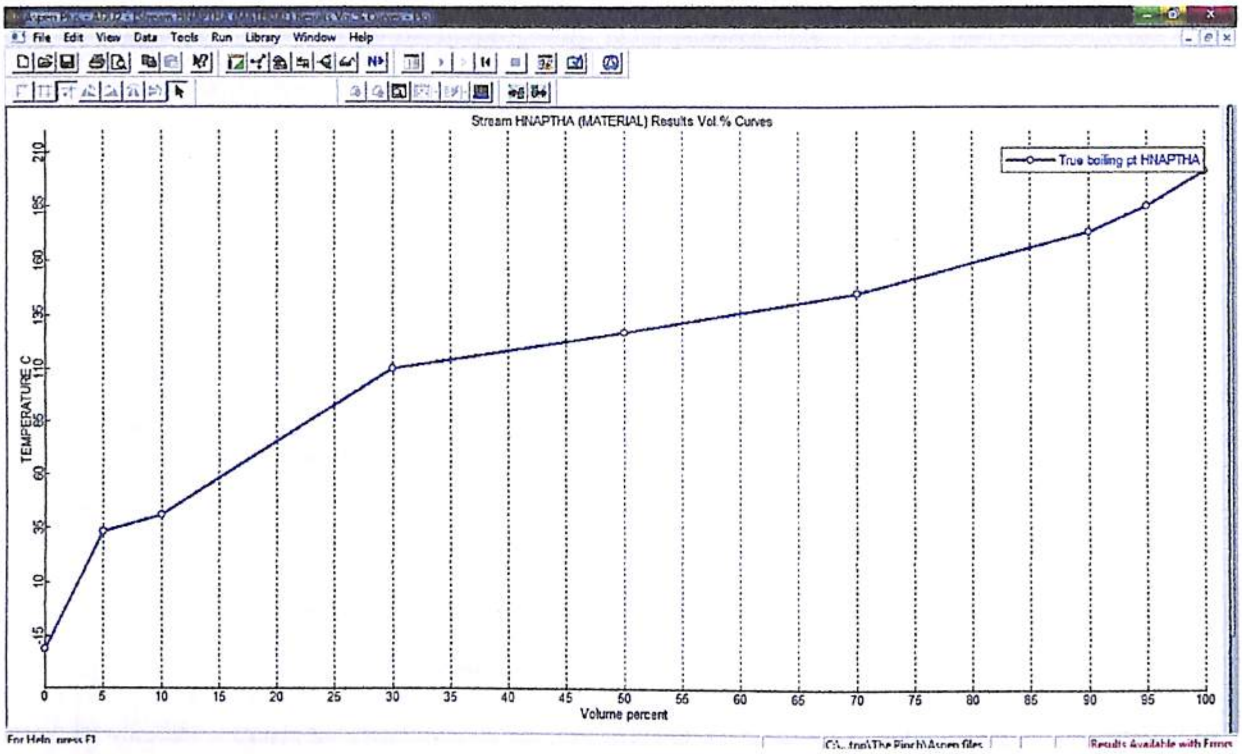
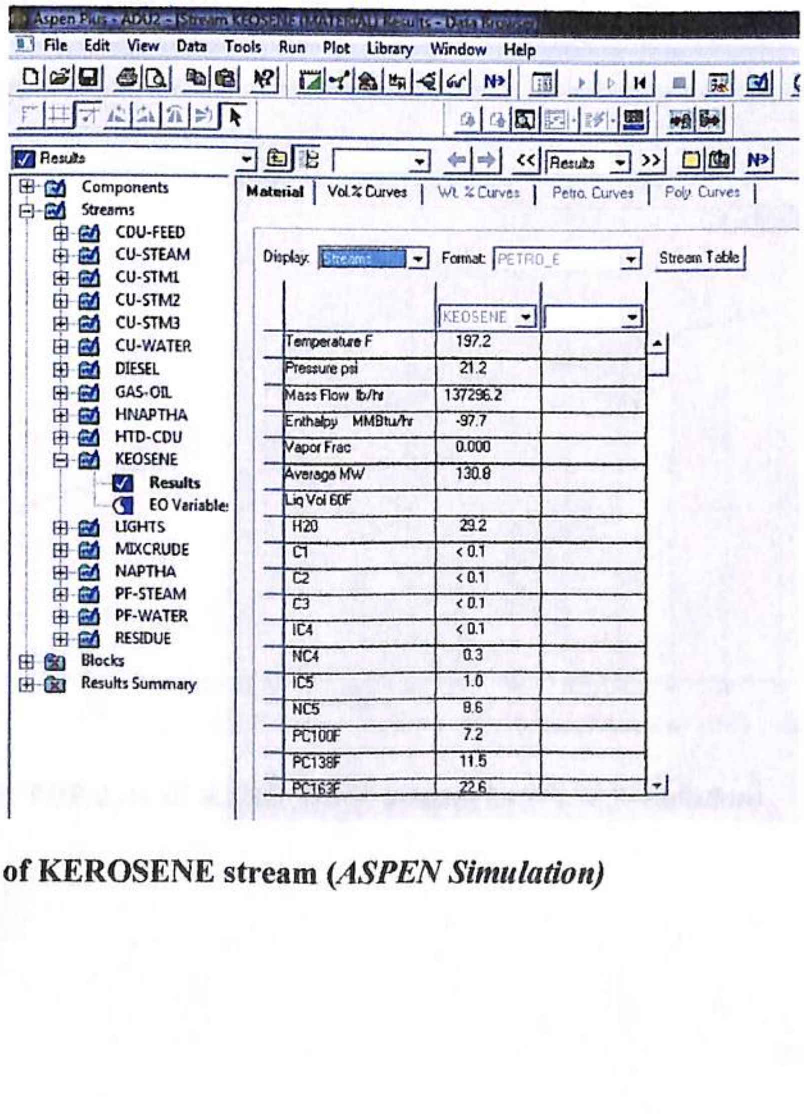


Fig. 68 Plot of TBP data HNaptha stream (*ASPEN Simulation*)

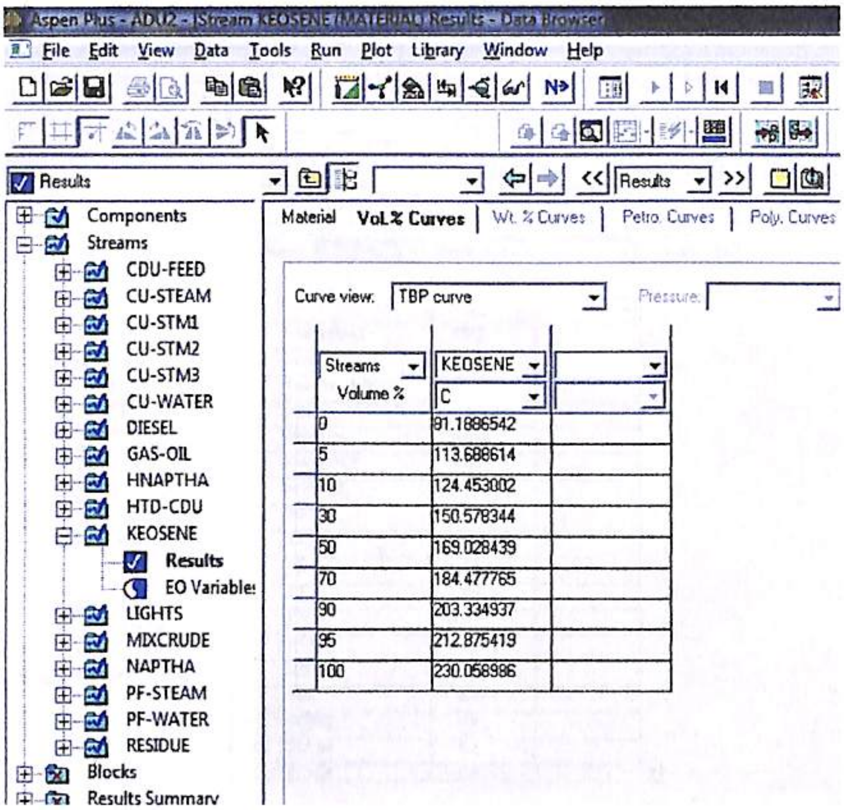


Display: Streams

Format: PETRO_E

	KEOSENE	
Temperature F	197.2	
Pressure psi	21.2	
Mass Flow lb/hr	137296.2	
Enthalpy MMBtu/hr	-97.7	
Vapor Frac	0.000	
Average MW	130.8	
Liq Vol 60F		
H2O	29.2	
C1	< 0.1	
C2	< 0.1	
C3	< 0.1	
IC4	< 0.1	
NC4	0.3	
IC5	1.0	
NC5	8.6	
PC100F	7.2	
PC138F	11.5	
PC163F	22.6	

Fig. 69 Results of KEROSENE stream (*ASPEN Simulation*)



Curve view: TBP curve

Streams	KEOSENE	
Volume %	C	
0	91.1886542	
5	113.688614	
10	124.453002	
30	150.578344	
50	169.028439	
70	184.477765	
90	203.334937	
95	212.875419	
100	230.058986	

Fig. 70 TBP data of KERO**SENE stream (*ASPEN Simulation)***

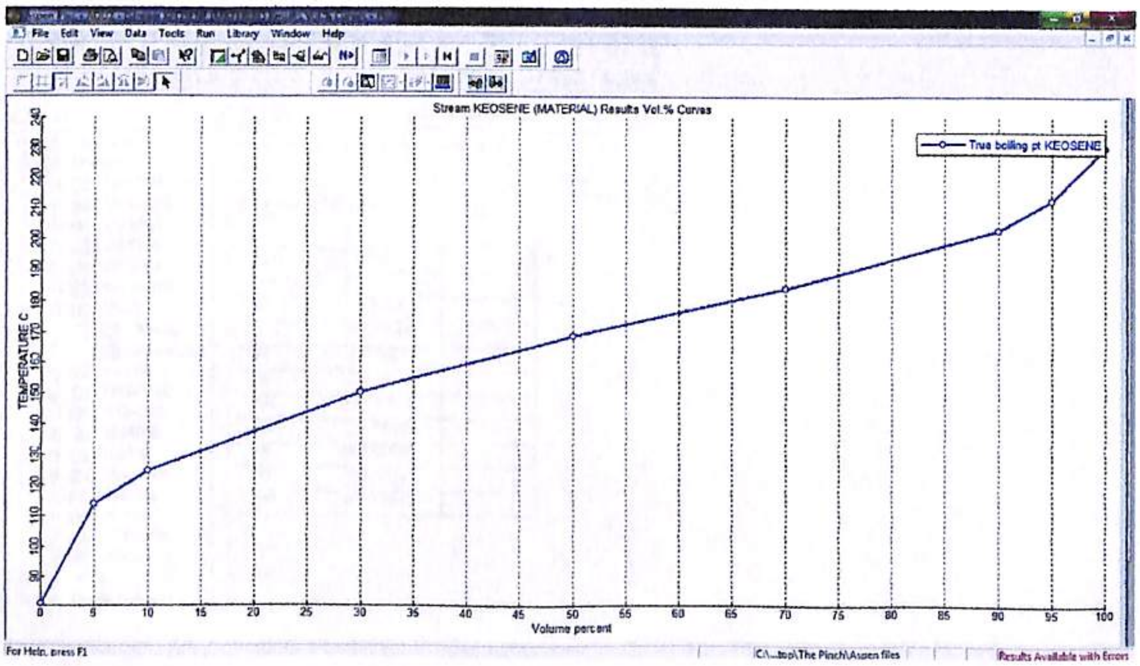
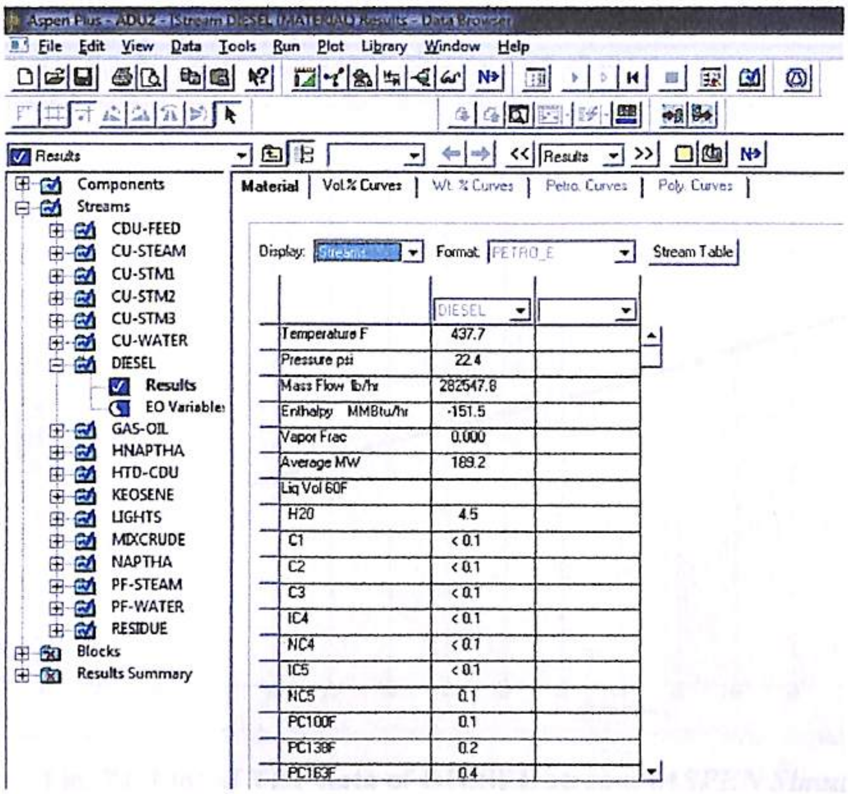


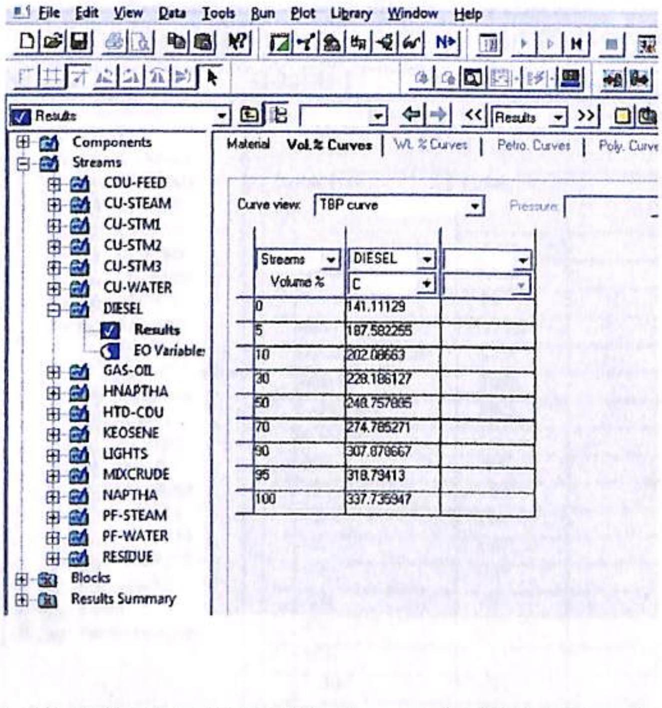
Fig. 71 Plot of TBP data of KEROSENE stream (*ASPEN Simulation)*



Display: Streams
Format: PETRO_E

	DIESEL	
Temperature F	437.7	
Pressure psi	22.4	
Mass Flow lb/hr	282547.8	
Enthalpy MMBtu/hr	-151.5	
Vapor Frac	0.000	
Average MW	189.2	
Liq Vol 60F		
H20	4.5	
C1	< 0.1	
C2	< 0.1	
C3	< 0.1	
IC4	< 0.1	
NC4	< 0.1	
IC5	< 0.1	
NC5	0.1	
PC100F	0.1	
PC138F	0.2	
PC163F	0.4	

Fig. 72 Results from DIESEL stream (*ASPEN Simulation)*



Curve view: TBP curve

Streams Volume %	DIESEL C	
0	141.11129	
5	187.582255	
10	202.08663	
30	228.186127	
50	248.757805	
70	274.785271	
90	307.878667	
95	318.79413	
100	337.735947	

Fig. 73 TBP data DIESEL stream (*ASPEN Simulation)*

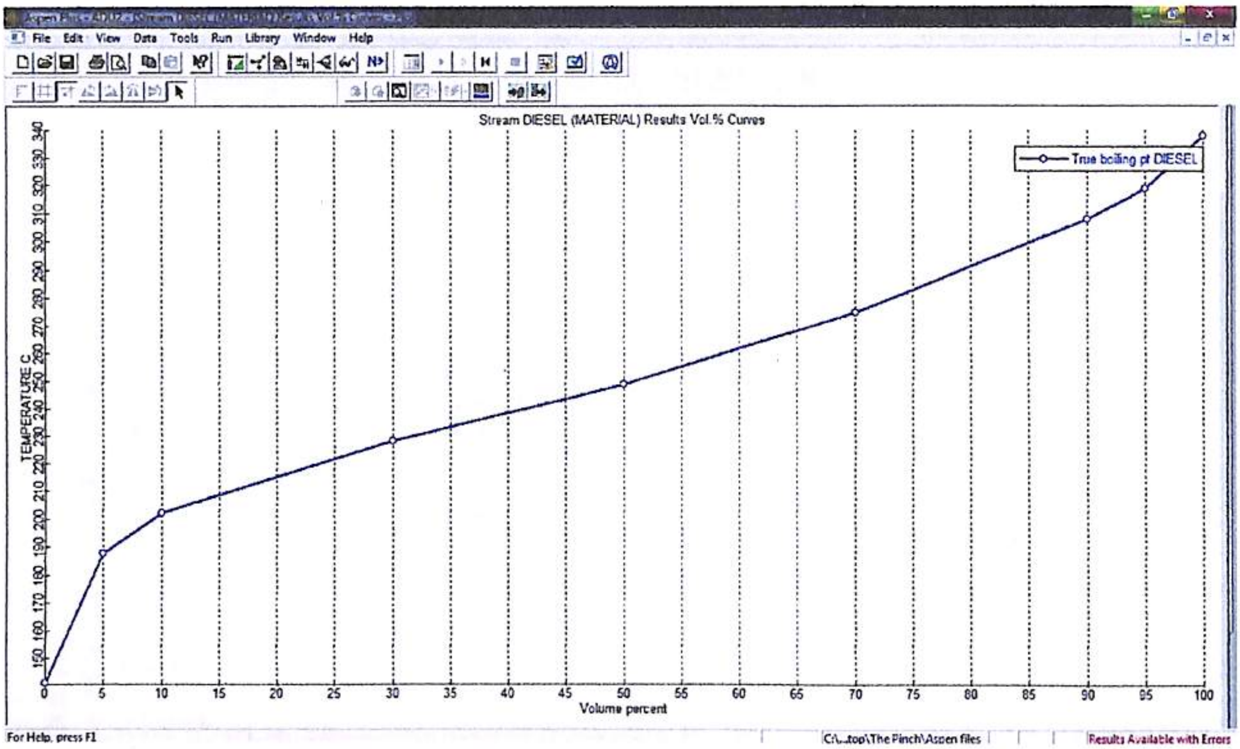
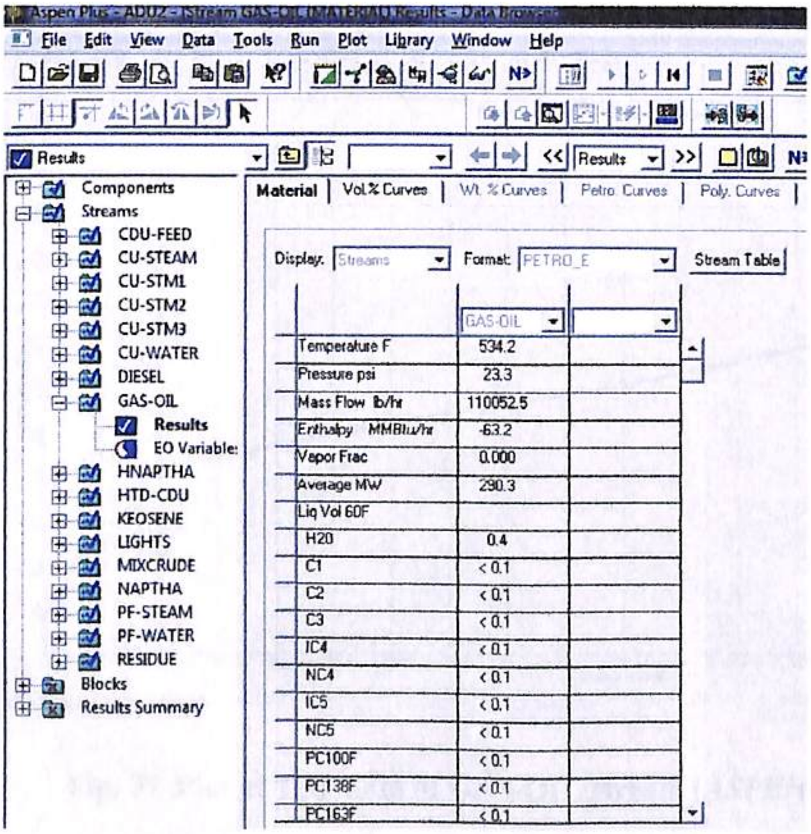


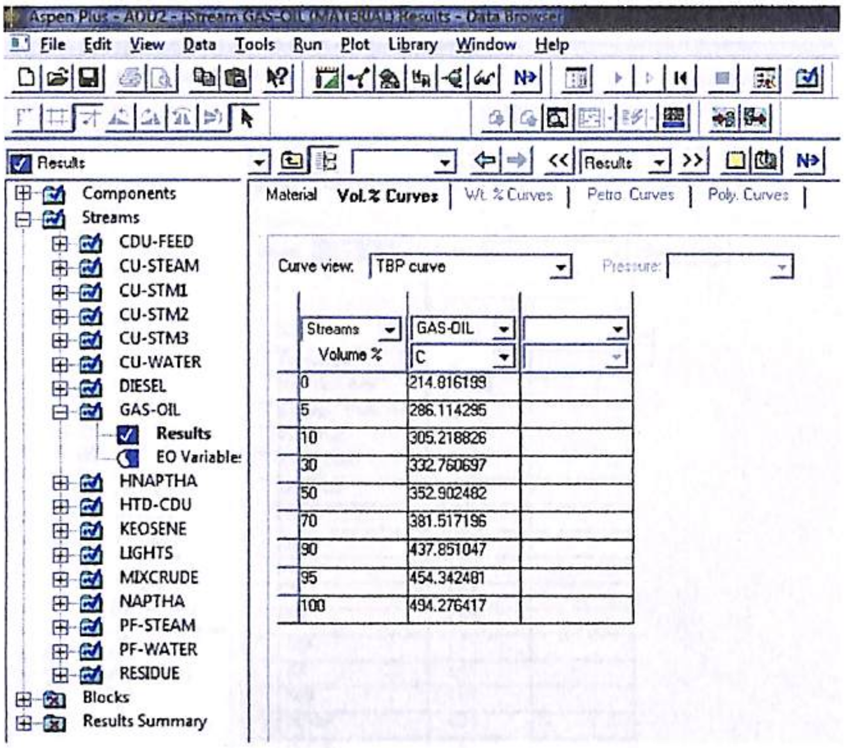
Fig. 74 Plot of TBP data of DIESEL stream *(ASPEN Simulation)*



Display: Streams
Format: PETRO_E

	GAS-OIL	
Temperature F	534.2	
Pressure psi	23.3	
Mass Flow lb/hr	110052.5	
Enthalpy MMBtu/hr	-63.2	
Vapor Frac	0.000	
Average MW	290.3	
Liq Vol 60F		
H20	0.4	
C1	< 0.1	
C2	< 0.1	
C3	< 0.1	
IC4	< 0.1	
NC4	< 0.1	
IC5	< 0.1	
NC5	< 0.1	
PC100F	< 0.1	
PC138F	< 0.1	
PC163F	< 0.1	

Fig. 75 Plot of TBP data of GAS-OIL stream *(ASPEN Simulation)*



Curve view: TBP curve

Streams Volume %	GAS-OIL C
0	214.816199
5	286.114295
10	305.218826
30	332.760697
50	352.902482
70	381.517196
90	437.851047
95	454.342481
100	494.276417

Fig. 76 Results from GAS-OIL stream (*ASPEN Simulation)*

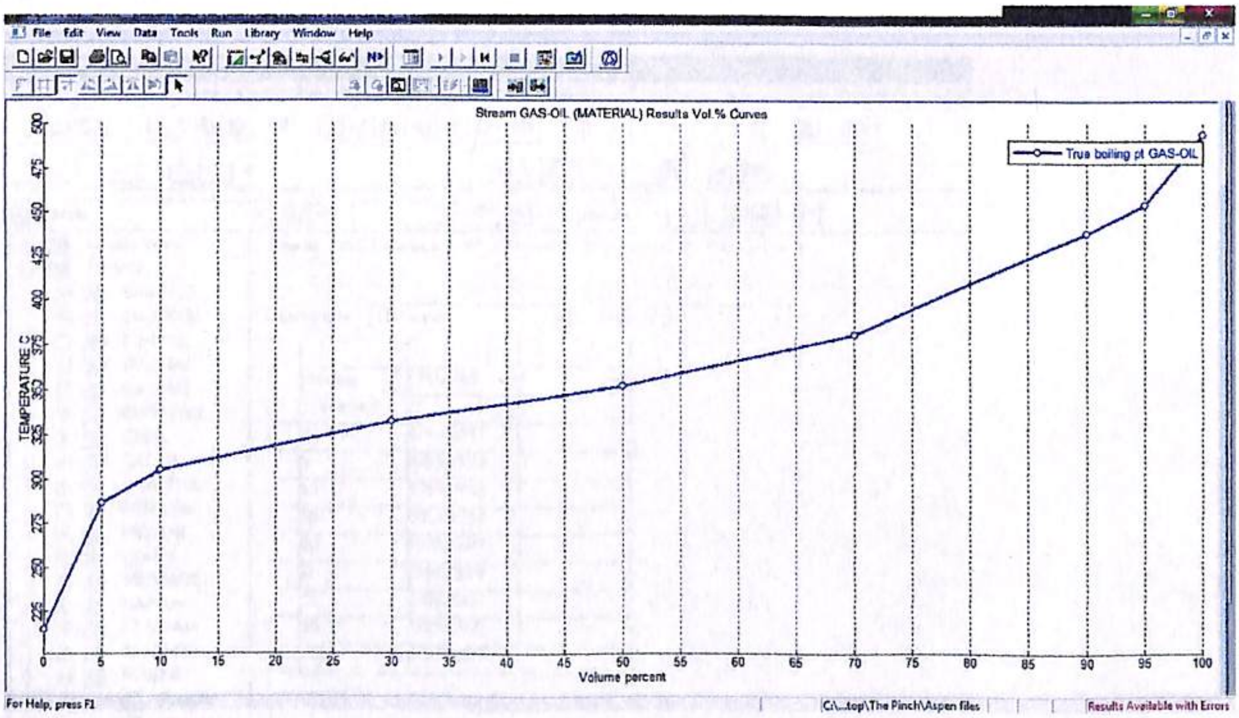
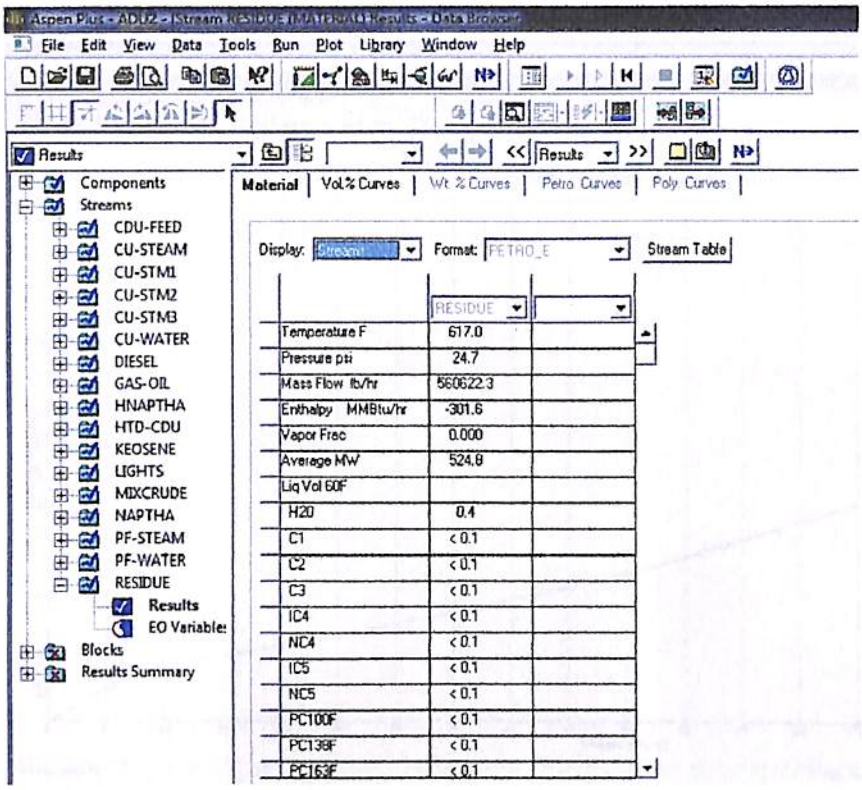


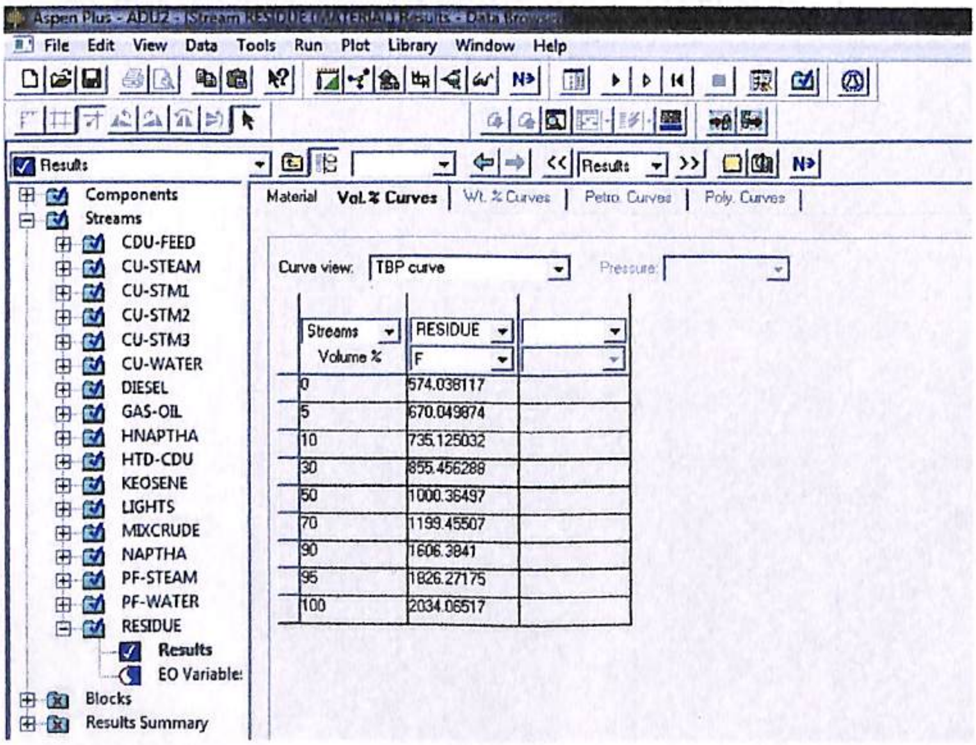
Fig. 77 Plot of TBP data of GAS-OIL stream (*ASPEN Simulation)*



Display: Streams Format: PETRO_E

	RESIDUE	
Temperature F	617.0	
Pressure psi	24.7	
Mass Flow lb/hr	560622.3	
Enthalpy MMBtu/hr	-301.6	
Vapor Frac	0.000	
Average MW	524.8	
Liq Vol 60F		
H20	0.4	
C1	< 0.1	
C2	< 0.1	
C3	< 0.1	
IC4	< 0.1	
NC4	< 0.1	
IC5	< 0.1	
NC5	< 0.1	
PC100F	< 0.1	
PC138F	< 0.1	
PC163F	< 0.1	

Fig. 78 **Results from RESIDUE stream (*ASPEN Simulation)***



Curve view: TBP curve

Streams	RESIDUE	
Volume %	F	
0	574.038117	
5	670.049874	
10	735.125032	
30	855.456288	
50	1000.36497	
70	1199.45507	
90	1606.3841	
95	1826.27175	
100	2034.06517	

Fig. 79 **Results from GAS-OIL stream (*ASPEN Simulation)***

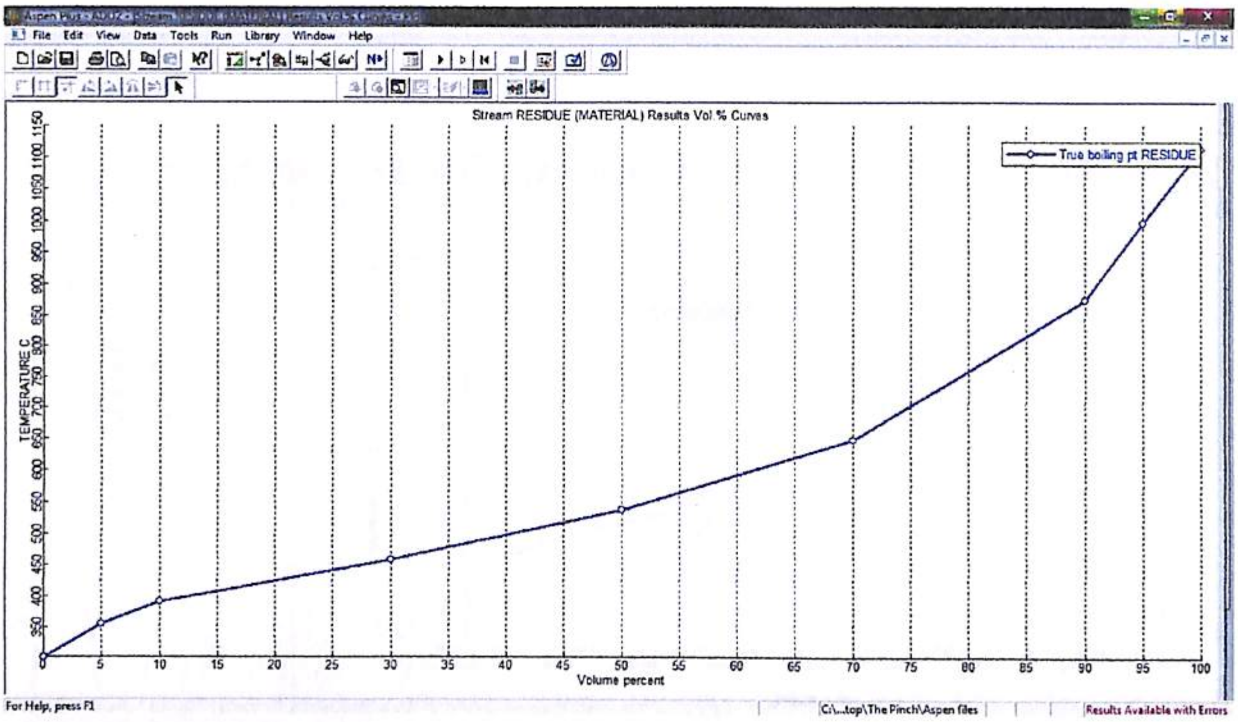
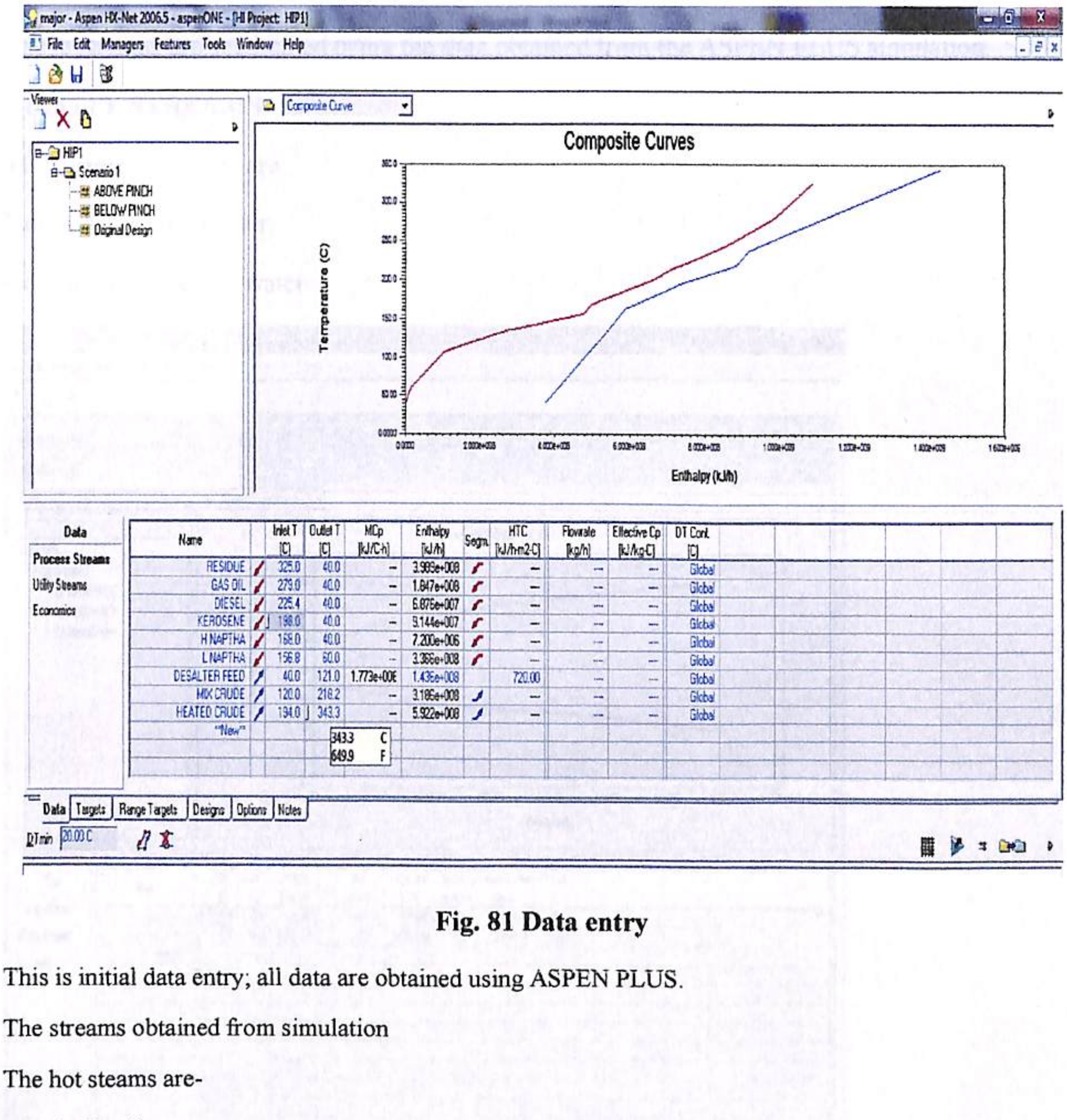


Fig. 80 Plot of TBP data of RESIDUE stream (*ASPEN Simulation*)

Chapter-4: NETWORK DESINGING USING ASPEN HX-NET.

DATA ENTRY



Name	Inlet T [C]	Outlet T [C]	MCp [kJ/C-h]	Enthalpy [kJ/h]	Segm.	HTC [kJ/h-m2-C]	Flowrate [kg/h]	Effective Cp [kJ/kg-C]	DT Cont. [C]
RESIDUE	325.0	40.0	--	3.989e+008		--	---	---	Global
GAS OIL	279.0	40.0	--	1.847e+008		--	---	---	Global
DIESEL	225.4	40.0	--	6.876e+007		--	---	---	Global
KEROSENE	198.0	40.0	--	9.144e+007		--	---	---	Global
H NAPTHA	168.0	40.0	--	7.200e+006		--	---	---	Global
L NAPTHA	156.8	60.0	--	3.366e+008		--	---	---	Global
DESALTER FEED	40.0	121.0	1.773e+006	1.436e+008		720.00	---	---	Global
MIX CRUDE	120.0	218.2	--	3.186e+008		--	---	---	Global
HEATED CRUDE	194.0	343.3	--	5.922e+008		--	---	---	Global
New									

Fig. 81 Data entry

This is initial data entry; all data are obtained using ASPEN PLUS.

The streams obtained from simulation

The hot steams are-

1) Residue
2) Gas oil
3) Diesel
4) Kerosene

5) Heavy Naptha

6) Light Naptha

The cold stream is-

1) Crude

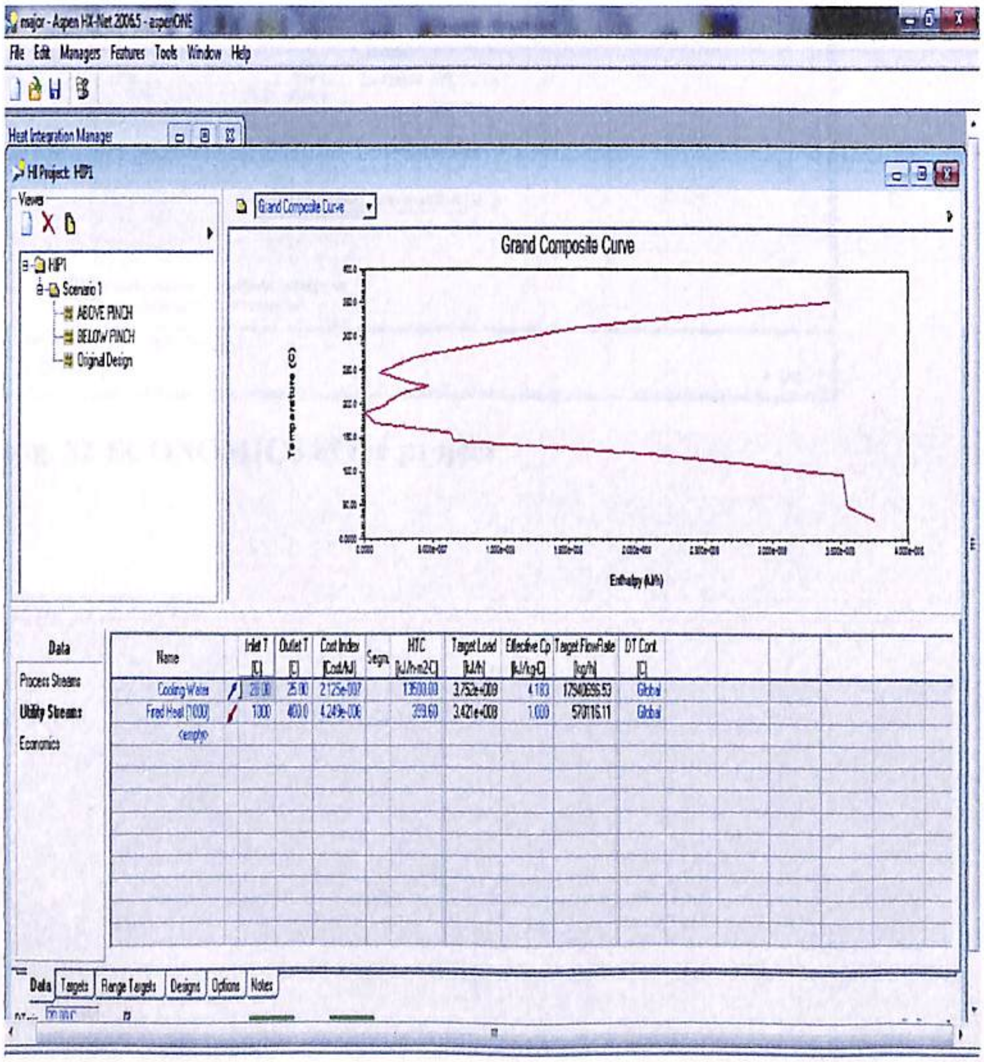
These streams are segmented using the data obtained from the ASPEN PLUS simulation.

ULITITY STREAMS

The different utilities are

Hot utility- Fired heater

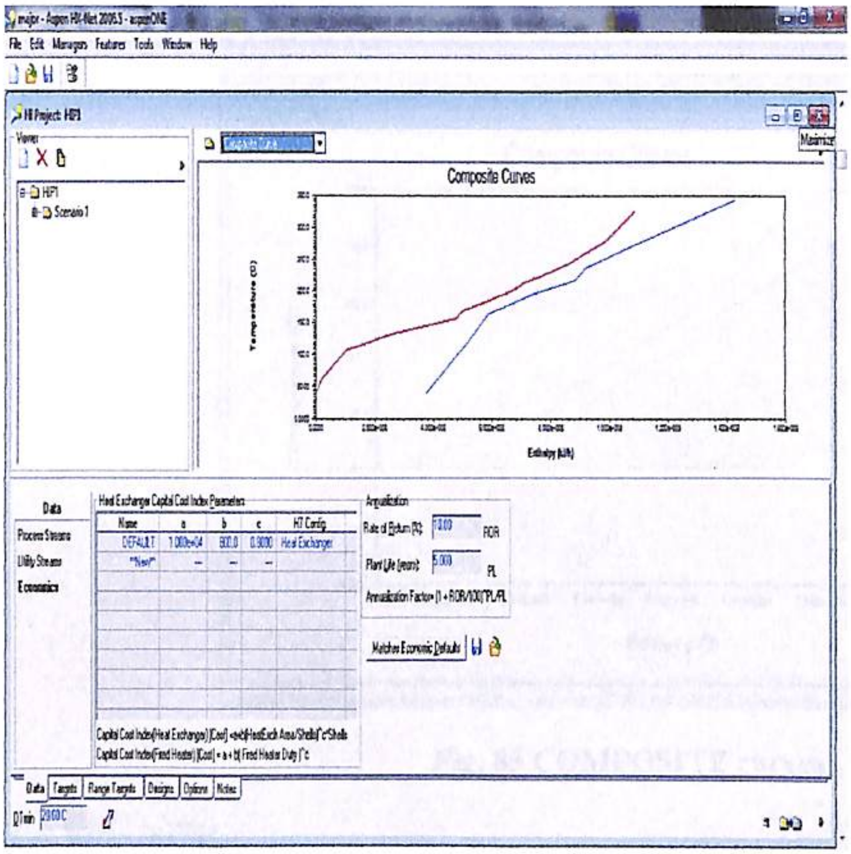
Cold utility- Cooling water



Name		Inlet T [C]	Outlet T [C]	Cost Index [Cost/kJ]	Segm.	HTC [kJ/h-m2-C]	Target Load [kJ/h]	Effective Cp [kJ/kg-C]	Target FlowRate [kg/h]	DT Cont. [C]
Cooling Water		20.00	25.00	2.125e-007		13500.00	3.752e+008	4.183	17940696.53	Global
Fired Heat (1000)		1000	400.0	4.249e-006		399.60	3.421e+008	1.000	570116.11	Global
<empty>										

Figure- Different utilities

These presents about the economics of the project-



Heat Exchanger Capital Cost Index Parameters

Name	a	b	c	HT Config
DEFAULT	1.000e+04	800.0	0.8000	Heat Exchanger
New	---	---	---	

Capital Cost Index(Heat Exchanger) [Cost] = a+b(HeatExch Area/Shells)^c*Shells
Capital Cost Index(Fired Heater) [Cost] = a + b(Fired Heater Duty)^c

Annualization
Rate of Return (%): 10.00 ROR
Plant Life (years): 5.000 PL
Annualization Factor= (1 + ROR/100)^PL/PL

DTmin 20.00 C

Fig. 82 ECONOMICS of the project

This is the graph of composite curves-

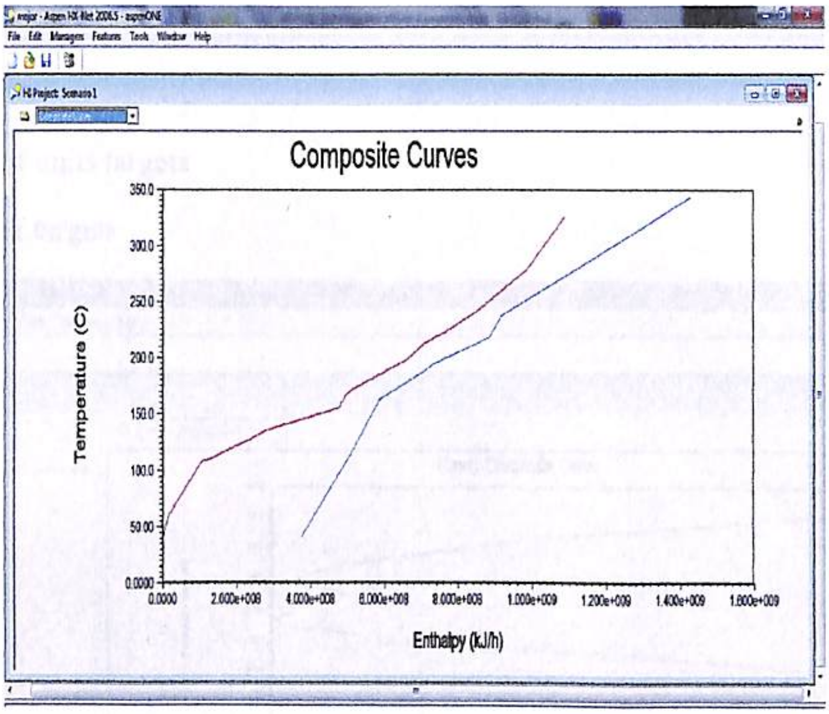


Fig. 83 COMPOSITE curves

The GCC curve-

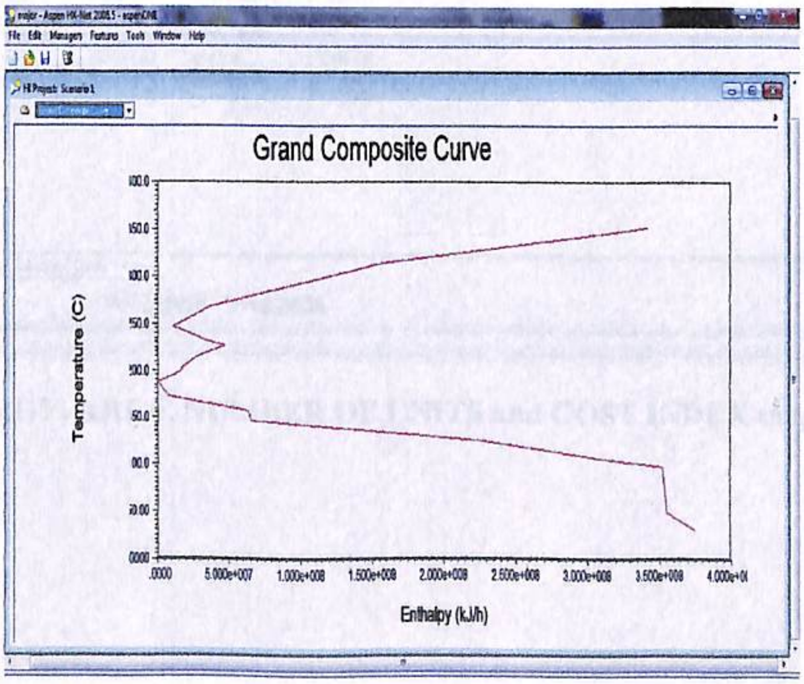
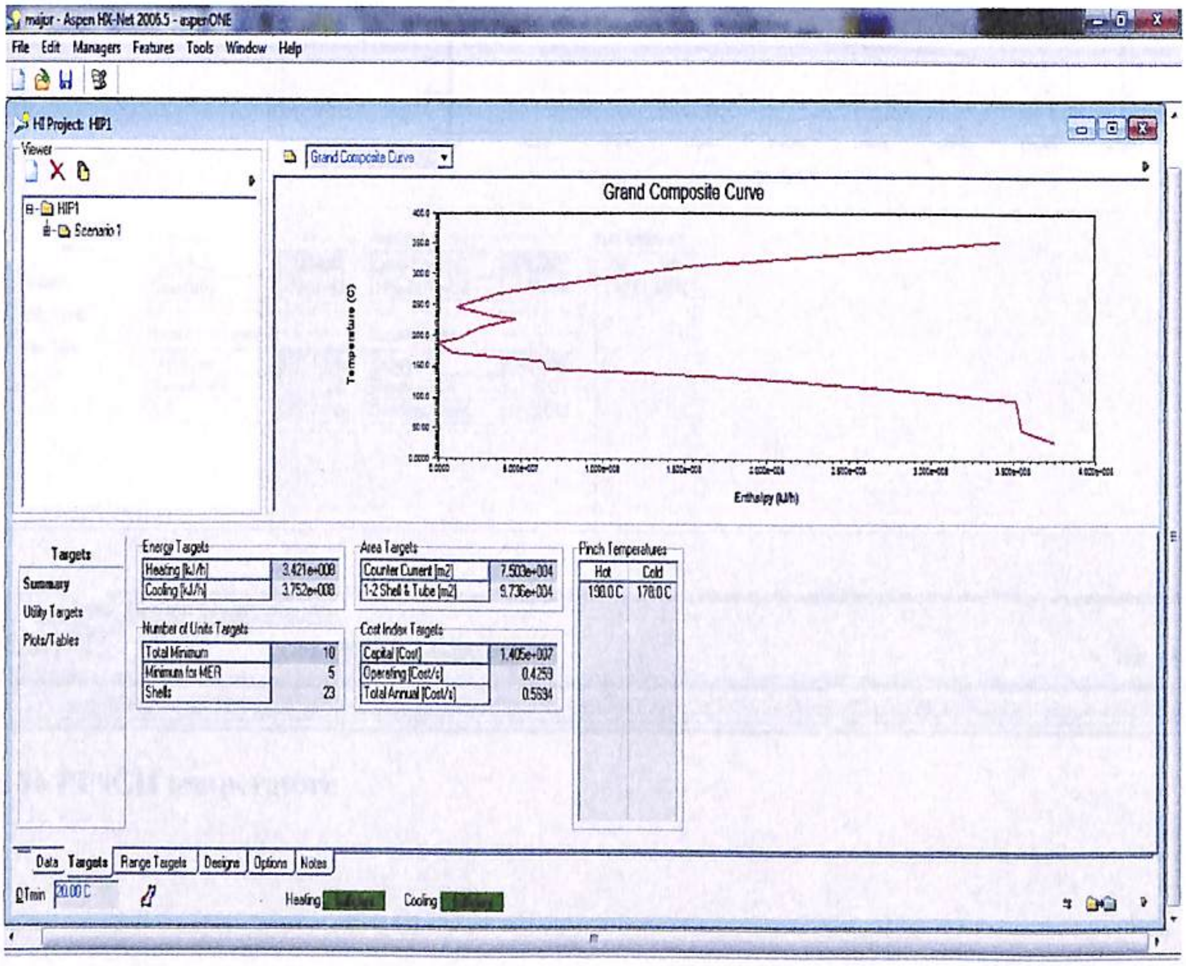


Fig. 84 GRAND COMPOSITE curve

This screenshot gives us the all target-

1) Energy targets
2) Area targets
3) Number of units targets
4) Cost index targets



Energy Targets

Heating [kJ/h]	3.421e+008
Cooling [kJ/h]	3.752e+008

Area Targets

Counter Current [m2]	7.503e+004
1-2 Shell & Tube [m2]	9.736e+004

Number of Units Targets

Total Minimum	10
Minimum for MER	5
Shells	23

Cost Index Targets

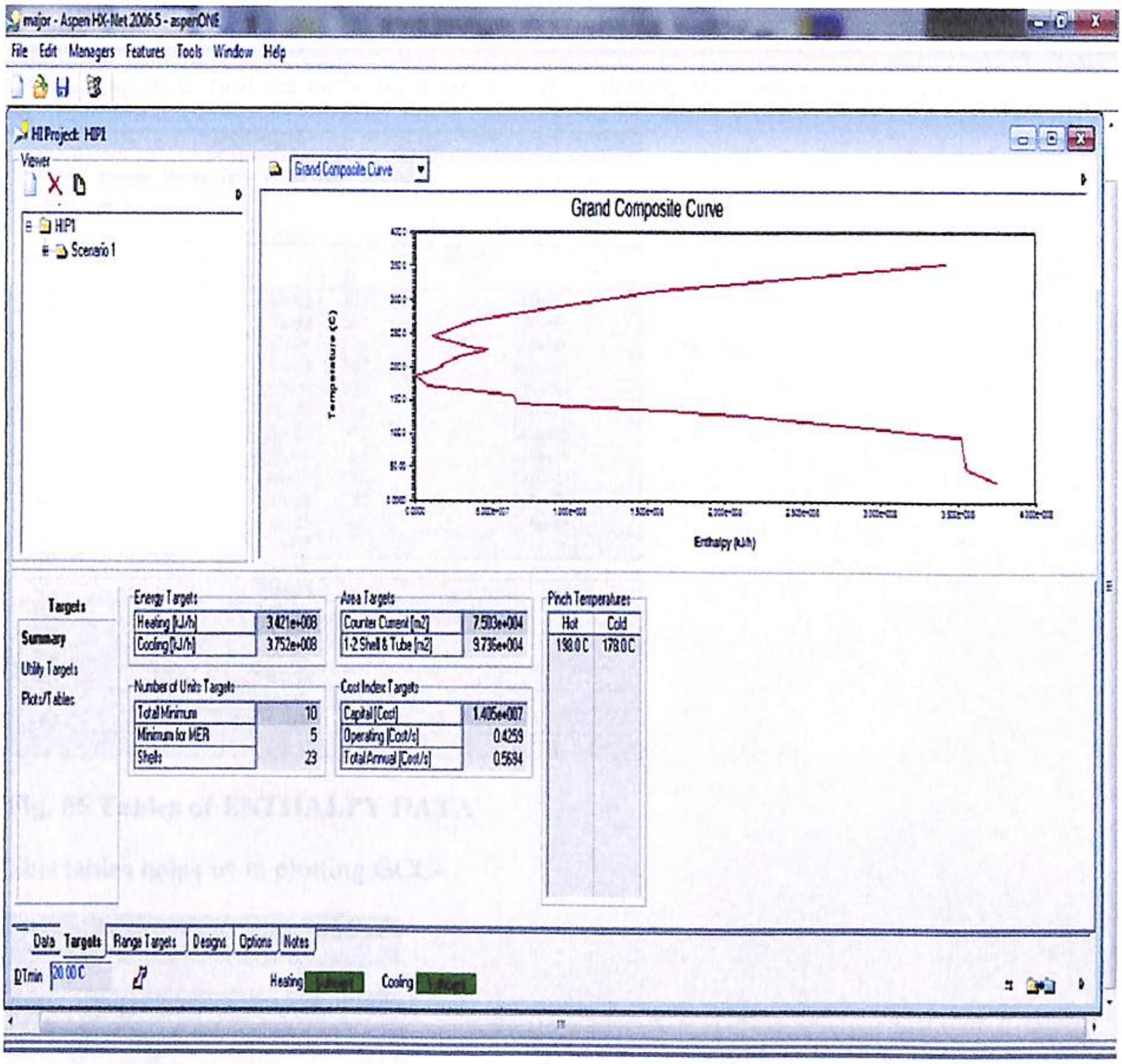
Capital [Cost]	1.405e+007
Operating [Cost/s]	0.4259
Total Annual [Cost/s]	0.5634

Pinch Temperatures

Hot	Cold
198.0 C	178.0 C

DTmin 20.00 C

Fig. 85 ENERGY, AREA, NUMBER OF UNITS and COST INDEX targets



DTmin 20.00 C

Energy Targets

Heating [kJ/h]	3.421e+008
Cooling [kJ/h]	3.752e+008

Area Targets

Counter Current [m2]	7.503e+004
1-2 Shell & Tube [m2]	9.736e+004

Number of Units Targets

Total Minimum	10
Minimum for MER	5
Shells	23

Cost Index Targets

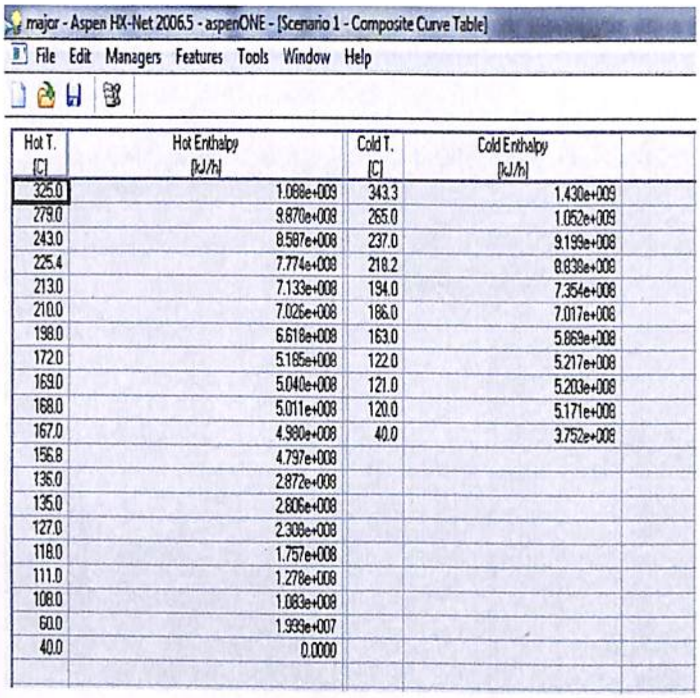
Capital [Cost]	1.405e+007
Operating [Cost/s]	0.4259
Total Annual [Cost/s]	0.5694

Pinch Temperatures

Hot	Cold
198.0 C	178.0 C

Fig. 86 PINCH temperature

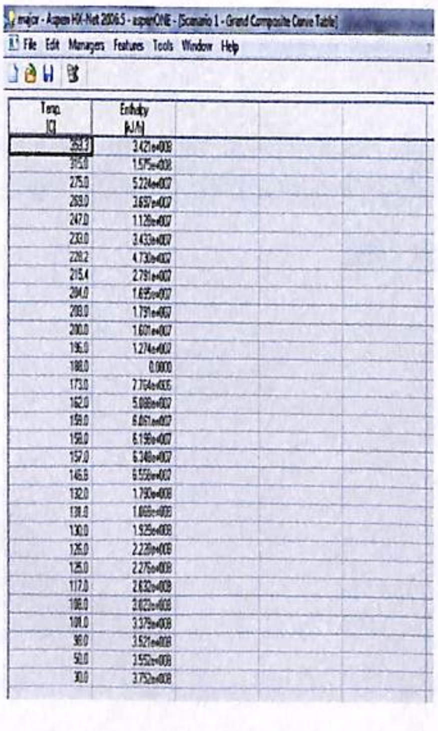
This table help us to find the enthalpy relation and in plotting the composite curves-


major - Aspen HX-Net 2006.5 - aspenONE - [Scenario 1 - Composite Curve Table]

Hot T. [C]	Hot Enthalpy [kJ/h]	Cold T. [C]	Cold Enthalpy [kJ/h]	
325.0	1.088e+009	343.3	1.430e+009	
279.0	9.870e+008	265.0	1.052e+009	
243.0	8.587e+008	237.0	9.199e+008	
225.4	7.774e+008	218.2	8.838e+008	
213.0	7.133e+008	194.0	7.354e+008	
210.0	7.026e+008	186.0	7.017e+008	
198.0	6.618e+008	163.0	5.869e+008	
172.0	5.185e+008	122.0	5.217e+008	
169.0	5.040e+008	121.0	5.203e+008	
168.0	5.011e+008	120.0	5.171e+008	
167.0	4.980e+008	40.0	3.752e+008	
156.8	4.797e+008			
136.0	2.872e+008			
135.0	2.806e+008			
127.0	2.308e+008			
118.0	1.757e+008			
111.0	1.278e+008			
108.0	1.083e+008			
60.0	1.999e+007			
40.0	0.0000			

Fig. 86 Tables of ENTHALPY DATA

This tables helps us in plotting GCC-


major - Aspen HX-Net 2006.5 - aspenONE - [Scenario 1 - Grand Composite Curve Table]

Temp. [C]	Enthalpy [kJ/h]			
353.3	3.421e+008			
315.0	1.575e+008			
275.0	5.224e+007			
269.0	3.697e+007			
247.0	1.126e+007			
233.0	3.433e+007			
228.2	4.730e+007			
215.4	2.791e+007			
204.0	1.635e+007			
203.0	1.791e+007			
200.0	1.601e+007			
196.0	1.274e+007			
188.0	0.0000			
173.0	7.764e+005			
162.0	5.088e+007			
159.0	6.061e+007			
158.0	6.196e+007			
157.0	6.340e+007			
146.8	6.556e+007			
132.0	1.790e+008			
131.0	1.866e+008			
130.0	1.925e+008			
126.0	2.226e+008			
125.0	2.275e+008			
117.0	2.632e+008			
108.0	3.022e+008			
101.0	3.379e+008			
98.0	3.521e+008			
50.0	3.552e+008			
30.0	3.752e+008			

Fig. 87 ENTHALPY DIFFERENCE data

This is the most important table in pinch analysis

This table helps us in finding delta T minimum-

This is known as SUPERTARGETING

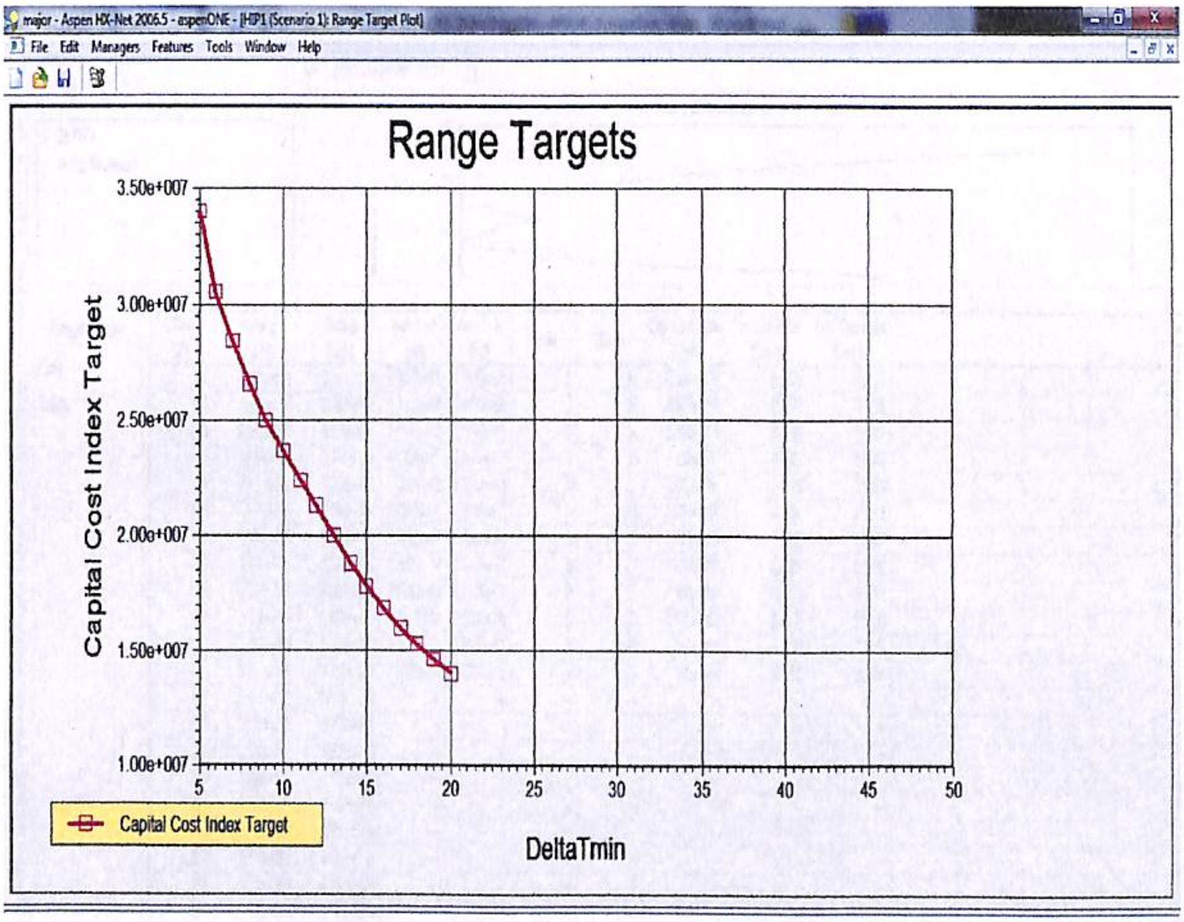
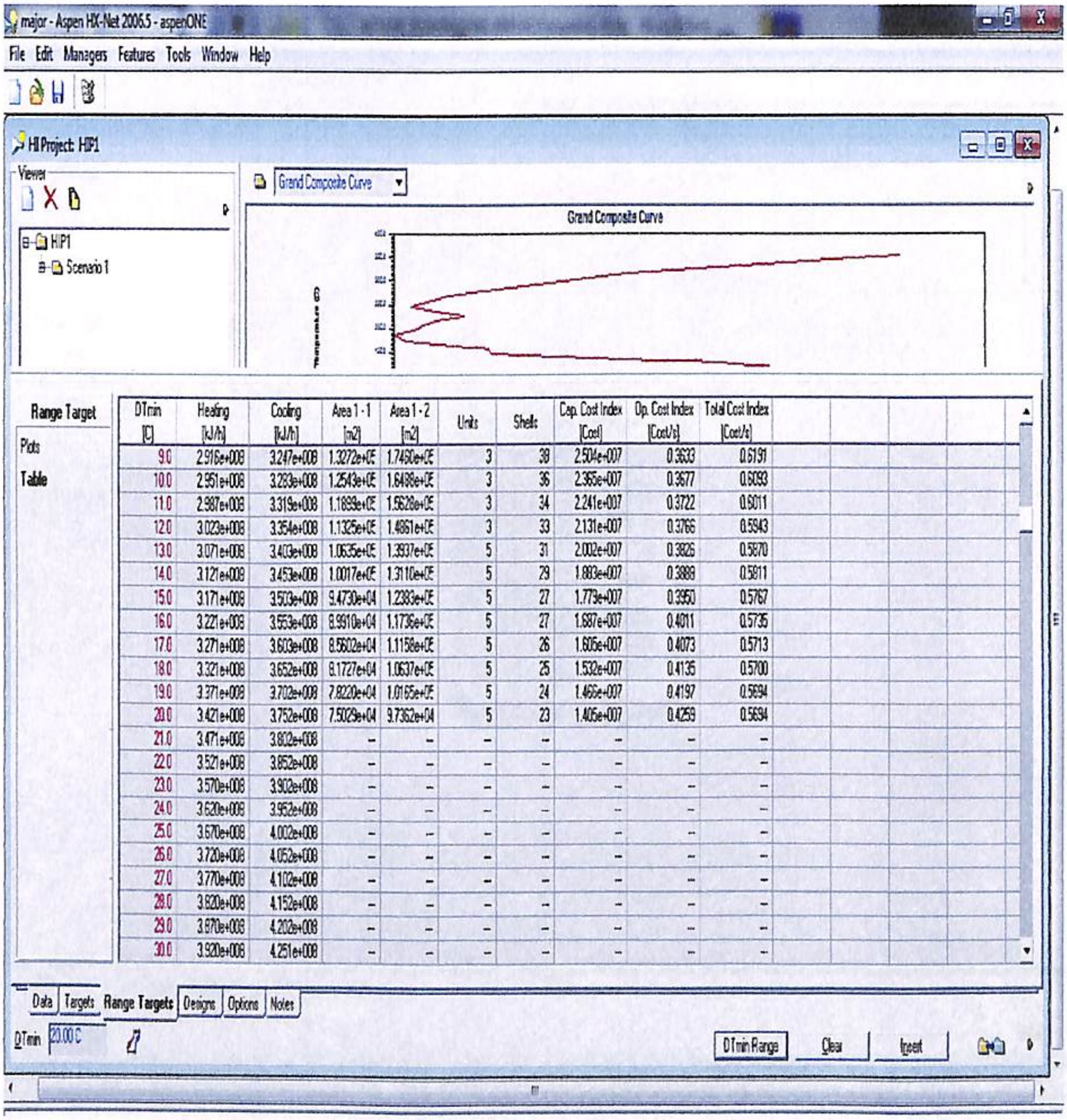


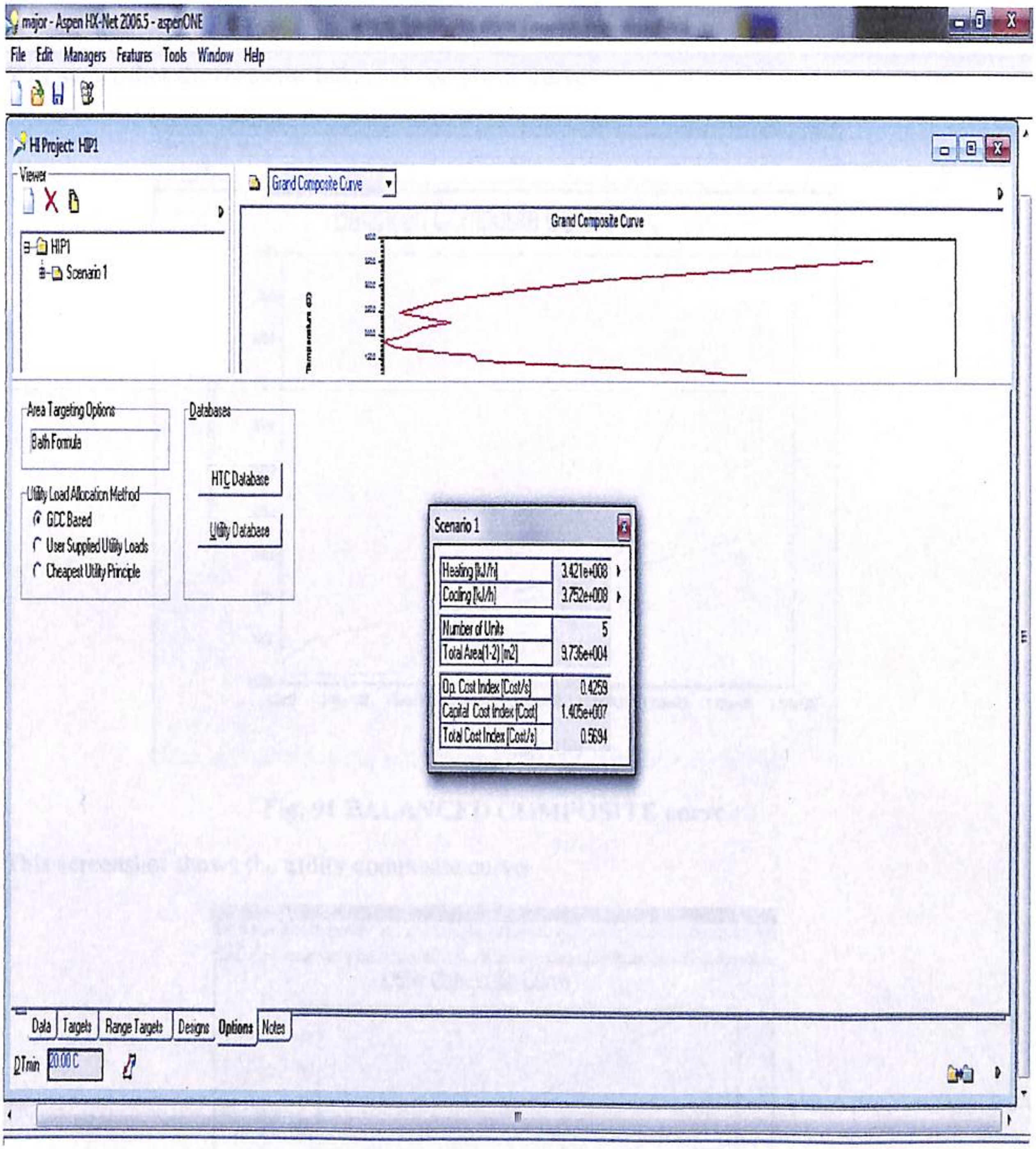
Fig. 88 SUPERTARGETING Curve

This is table used for SUPERTARGETING-



DTmin [C]	Heating [kJ/h]	Cooling [kJ/h]	Area 1 - 1 [m2]	Area 1 - 2 [m2]	Units	Shells	Cap. Cost Index [Cost]	Op. Cost Index [Cost/s]	Total Cost Index [Cost/s]
9.0	2.916e+008	3.247e+008	1.3272e+0E	1.7460e+0E	3	38	2.504e+007	0.3633	0.6191
10.0	2.951e+008	3.283e+008	1.2543e+0E	1.6488e+0E	3	36	2.365e+007	0.3677	0.6093
11.0	2.987e+008	3.319e+008	1.1899e+0E	1.5628e+0E	3	34	2.241e+007	0.3722	0.6011
12.0	3.023e+008	3.354e+008	1.1325e+0E	1.4861e+0E	3	33	2.131e+007	0.3766	0.5943
13.0	3.071e+008	3.403e+008	1.0635e+0E	1.3937e+0E	5	31	2.002e+007	0.3826	0.5870
14.0	3.121e+008	3.453e+008	1.0017e+0E	1.3110e+0E	5	29	1.883e+007	0.3888	0.5811
15.0	3.171e+008	3.503e+008	9.4730e+04	1.2383e+0E	5	27	1.779e+007	0.3950	0.5767
16.0	3.221e+008	3.553e+008	8.9910e+04	1.1736e+0E	5	27	1.687e+007	0.4011	0.5735
17.0	3.271e+008	3.603e+008	8.5602e+04	1.1158e+0E	5	26	1.605e+007	0.4073	0.5713
18.0	3.321e+008	3.652e+008	8.1727e+04	1.0637e+0E	5	25	1.532e+007	0.4135	0.5700
19.0	3.371e+008	3.702e+008	7.8220e+04	1.0165e+0E	5	24	1.466e+007	0.4197	0.5694
20.0	3.421e+008	3.752e+008	7.5029e+04	9.7362e+04	5	23	1.405e+007	0.4259	0.5694
21.0	3.471e+008	3.802e+008	-	-	-	-	-	-	-
22.0	3.521e+008	3.852e+008	-	-	-	-	-	-	-
23.0	3.570e+008	3.902e+008	-	-	-	-	-	-	-
24.0	3.620e+008	3.952e+008	-	-	-	-	-	-	-
25.0	3.670e+008	4.002e+008	-	-	-	-	-	-	-
26.0	3.720e+008	4.052e+008	-	-	-	-	-	-	-
27.0	3.770e+008	4.102e+008	-	-	-	-	-	-	-
28.0	3.820e+008	4.152e+008	-	-	-	-	-	-	-
29.0	3.870e+008	4.202e+008	-	-	-	-	-	-	-
30.0	3.920e+008	4.251e+008	-	-	-	-	-	-	-

Fig. 89 SUPETARGETTING data



Area Targeting Options: Bath Formula

Utility Load Allocation Method
- ● GDC Based
- ○ User Supplied Utility Loads
- ○ Cheapest Utility Principle

DTmin 20.00 C

Scenario 1

Heating [kJ/h]	3.421e+008
Cooling [kJ/h]	3.752e+008
Number of Units	5
Total Area(1-2) [m2]	9.736e+004
Op. Cost Index [Cost/s]	0.4259
Capital Cost Index [Cost]	1.405e+007
Total Cost Index [Cost/s]	0.5694

Fig. 90 Shows scenario

This screenshot shows us the balanced composite curves-

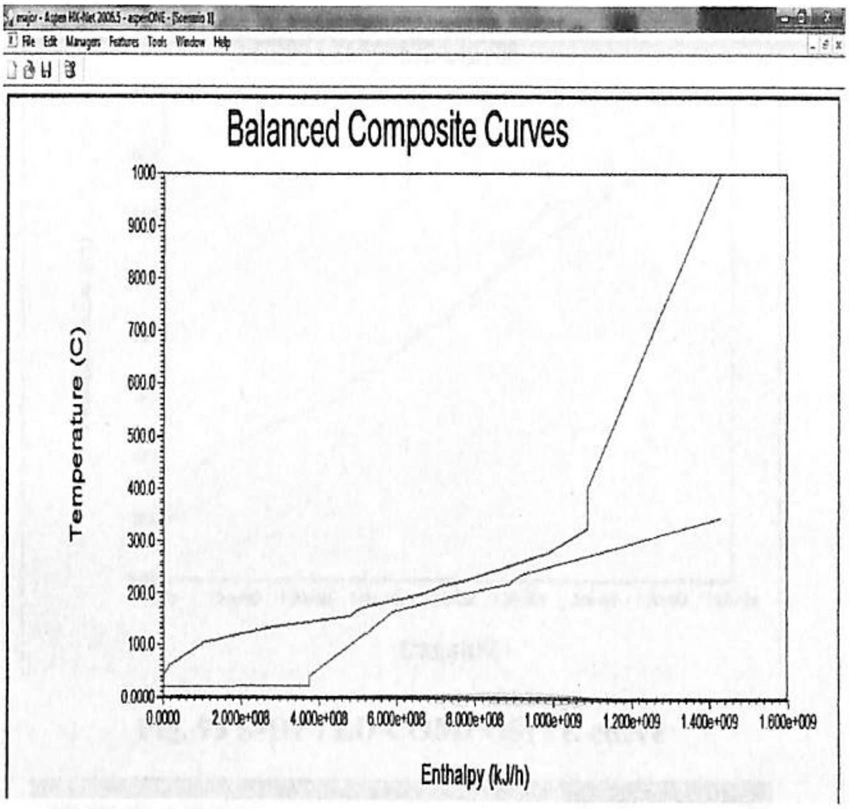


Fig. 91 BALANCED COMPOSITE curve

This screenshot shows the utility composite curve-

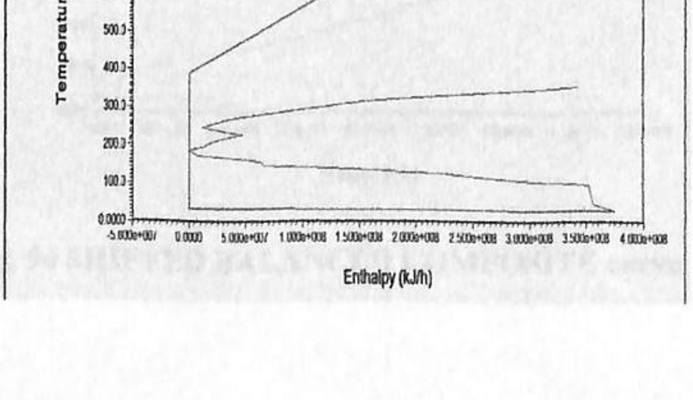


Fig. 92 UTILITY COMPOSITE curve

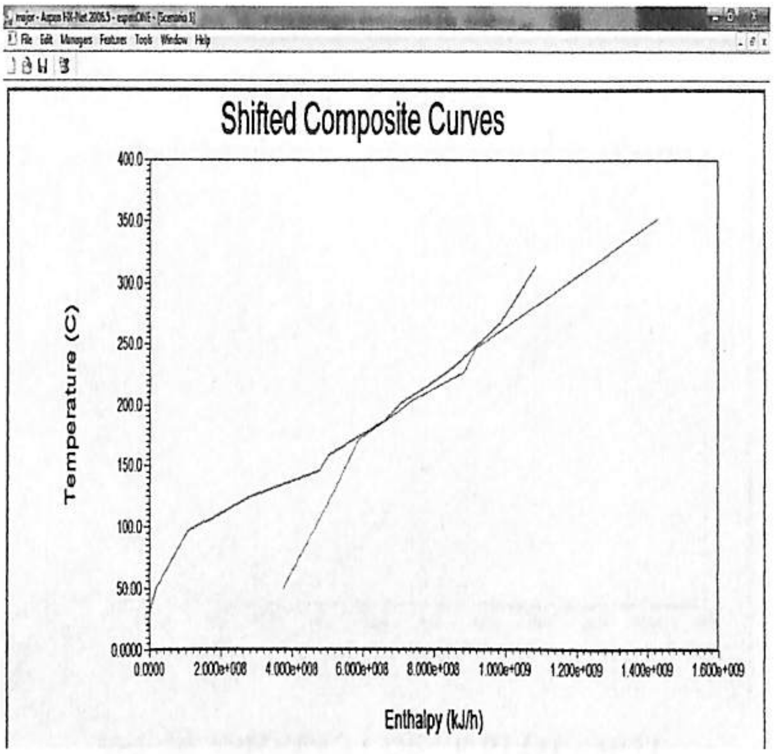


Fig. 93 SHIFTED COMPOSITE curve

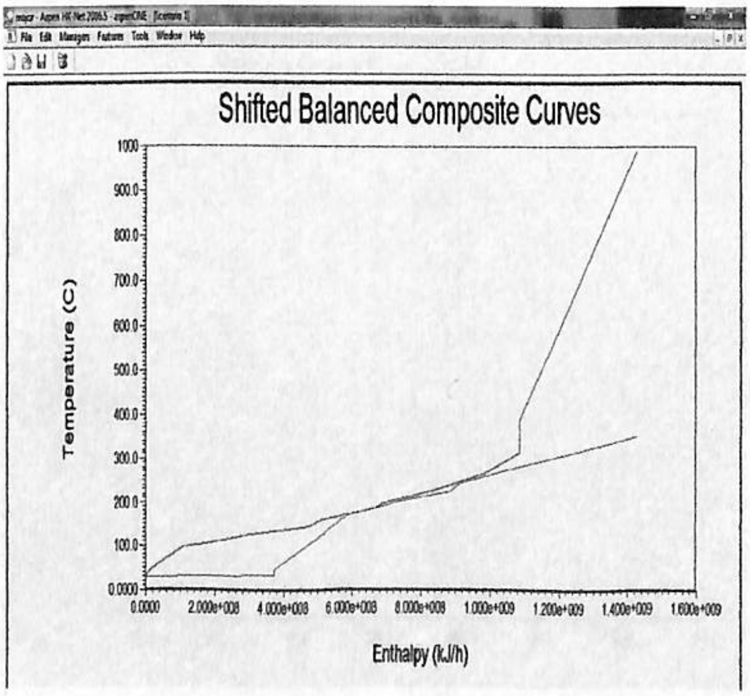


Fig. 94 SHIFTED BALANCED COMPOSITE curve

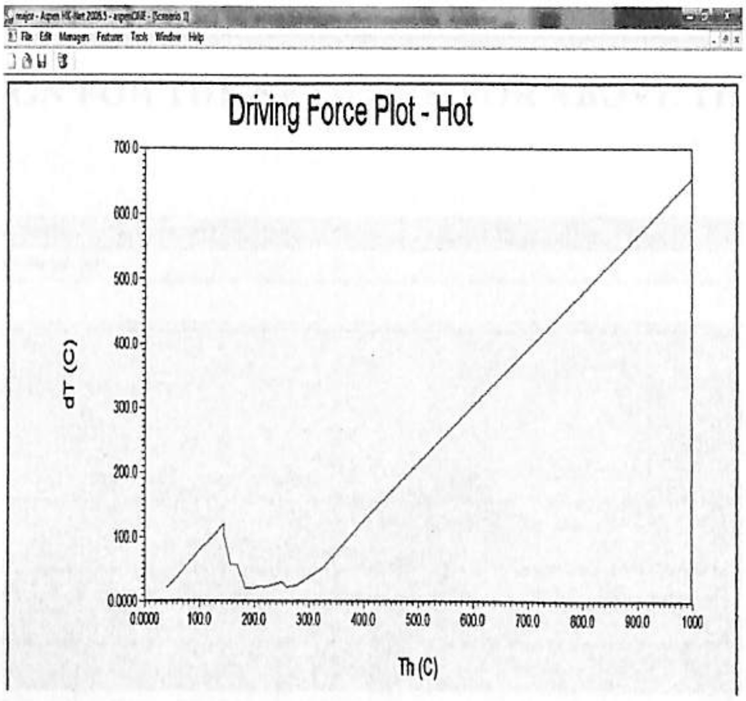


Fig. 95 DRIVING FORCE PLOT - HOT

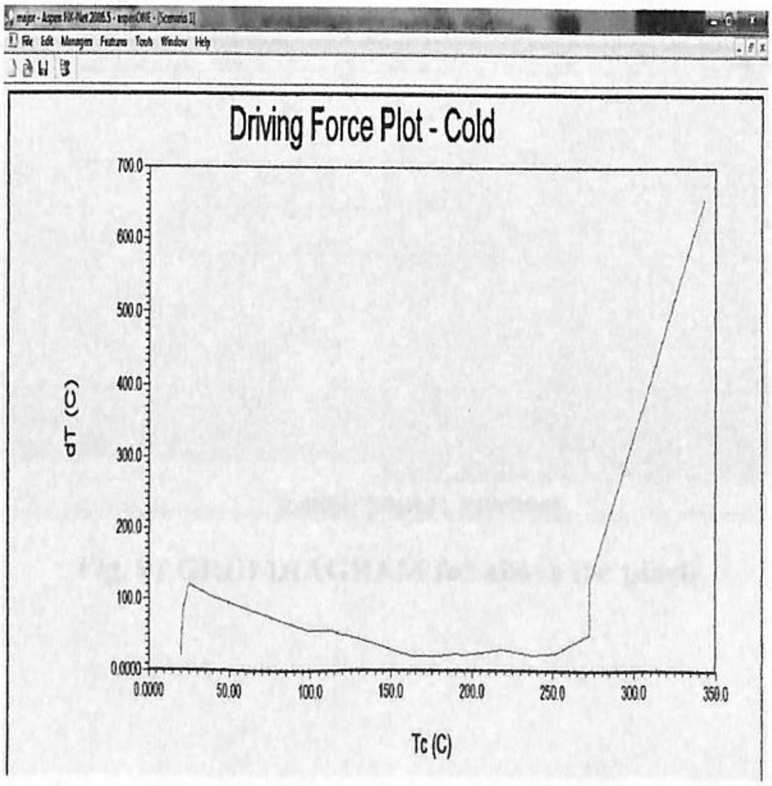
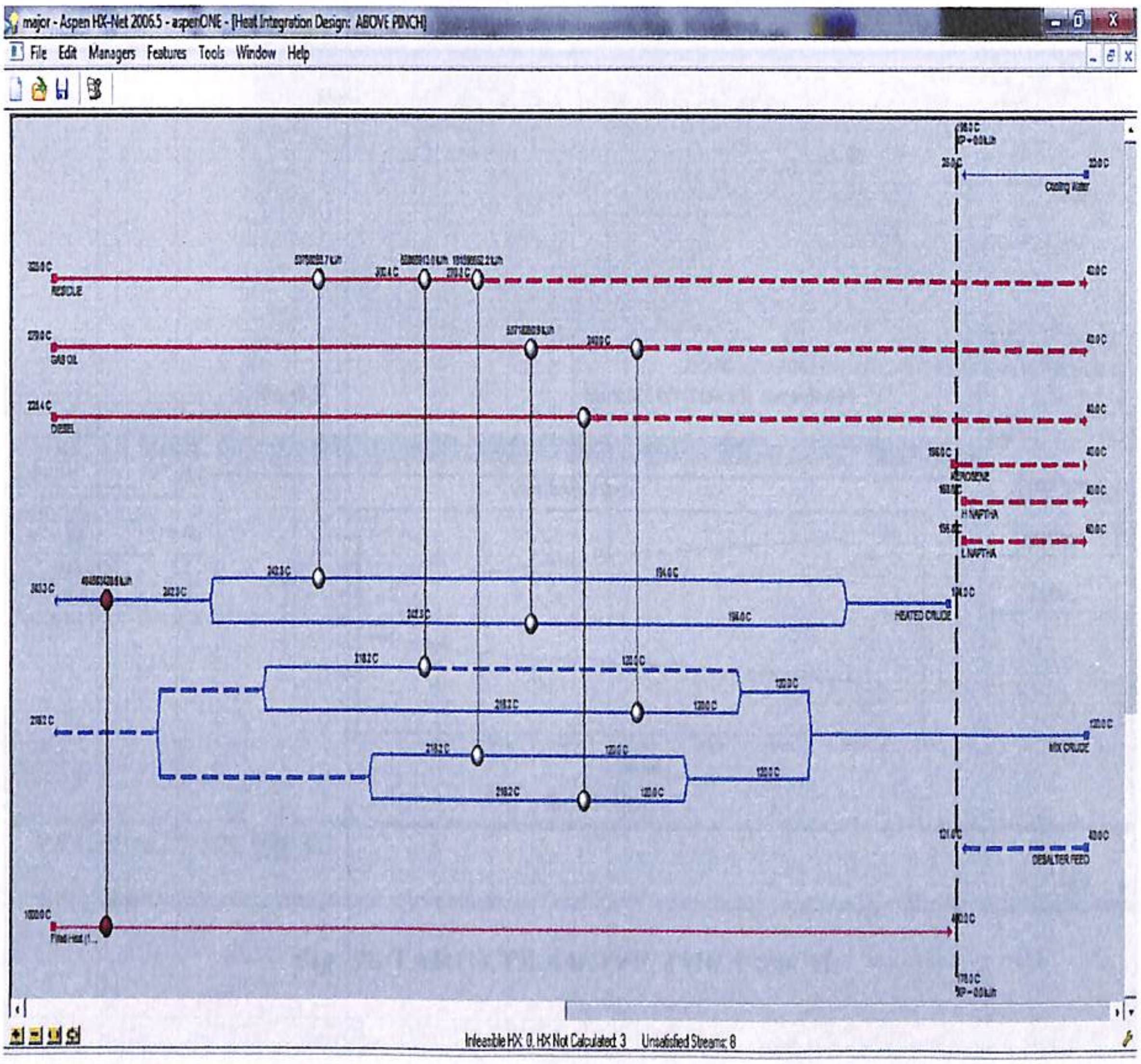


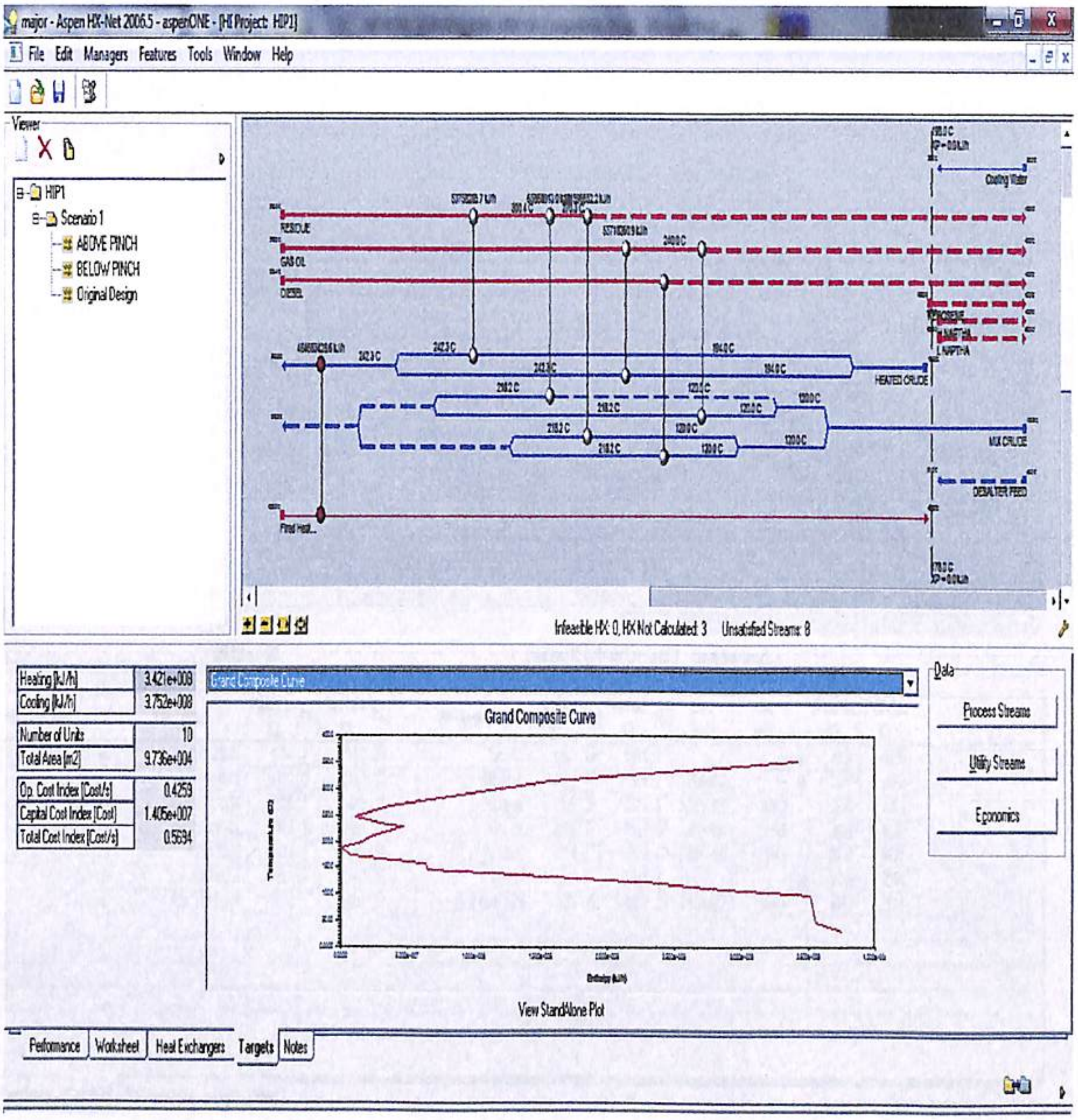
Fig. 96 DRIVING FORCE plot for cold stream

THE DESIGN FOR THE NETWORK FOR ABOVE THE PINCH-



Infeasible HX: 0, HX Not Calculated: 3 Unsatisfied Streams: 8

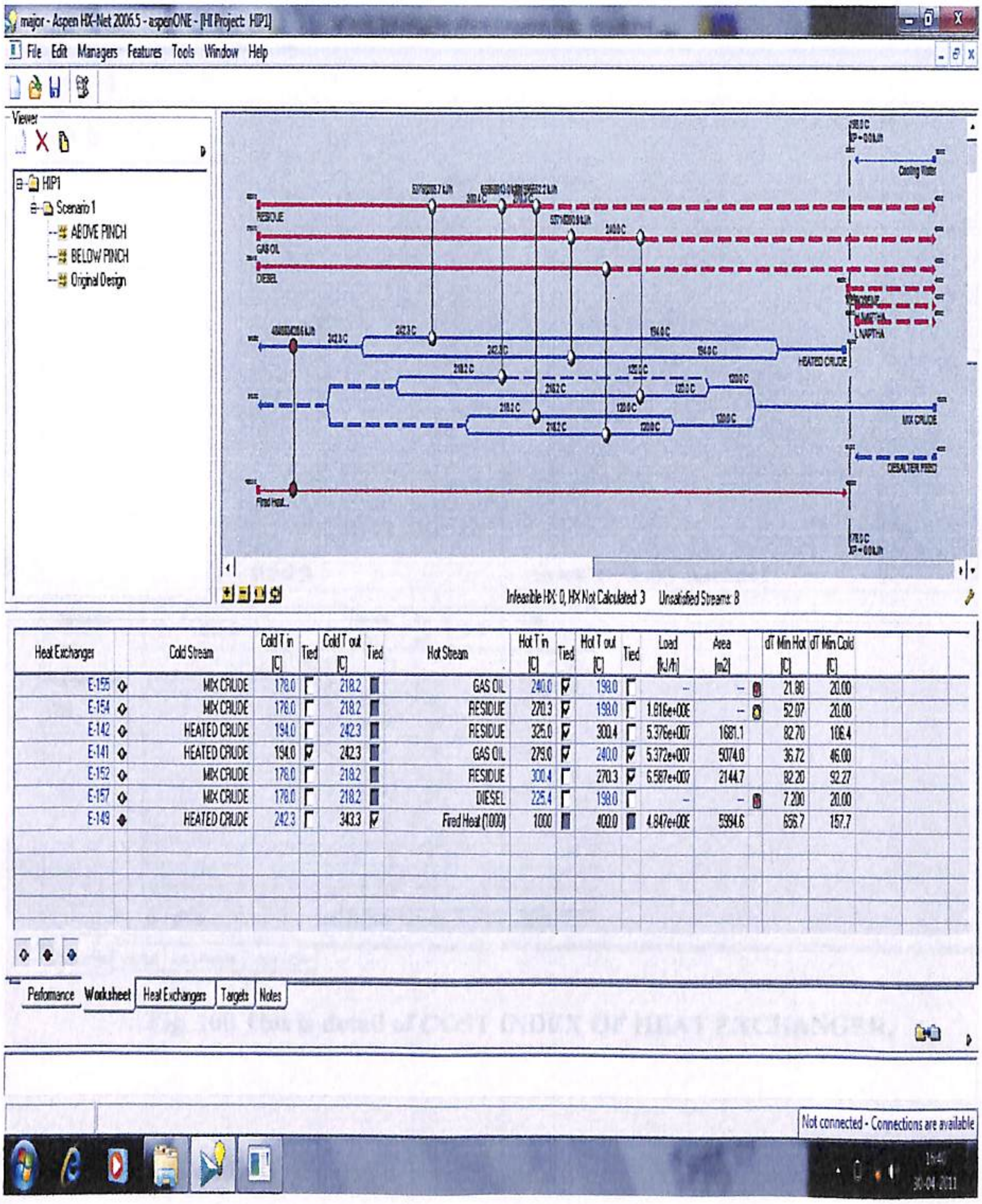
Fig. 97 GRID DIAGRAM for above the pinch



Infeasible HX: 0, HX Not Calculated: 3   Unsatisfied Streams: 8

Heating [kJ/h]	3.421e+008
Cooling [kJ/h]	3.752e+008
Number of Units	10
Total Area [m2]	9.736e+004
Op. Cost Index [Cost/s]	0.4259
Capital Cost Index [Cost]	1.405e+007
Total Cost Index [Cost/s]	0.5694

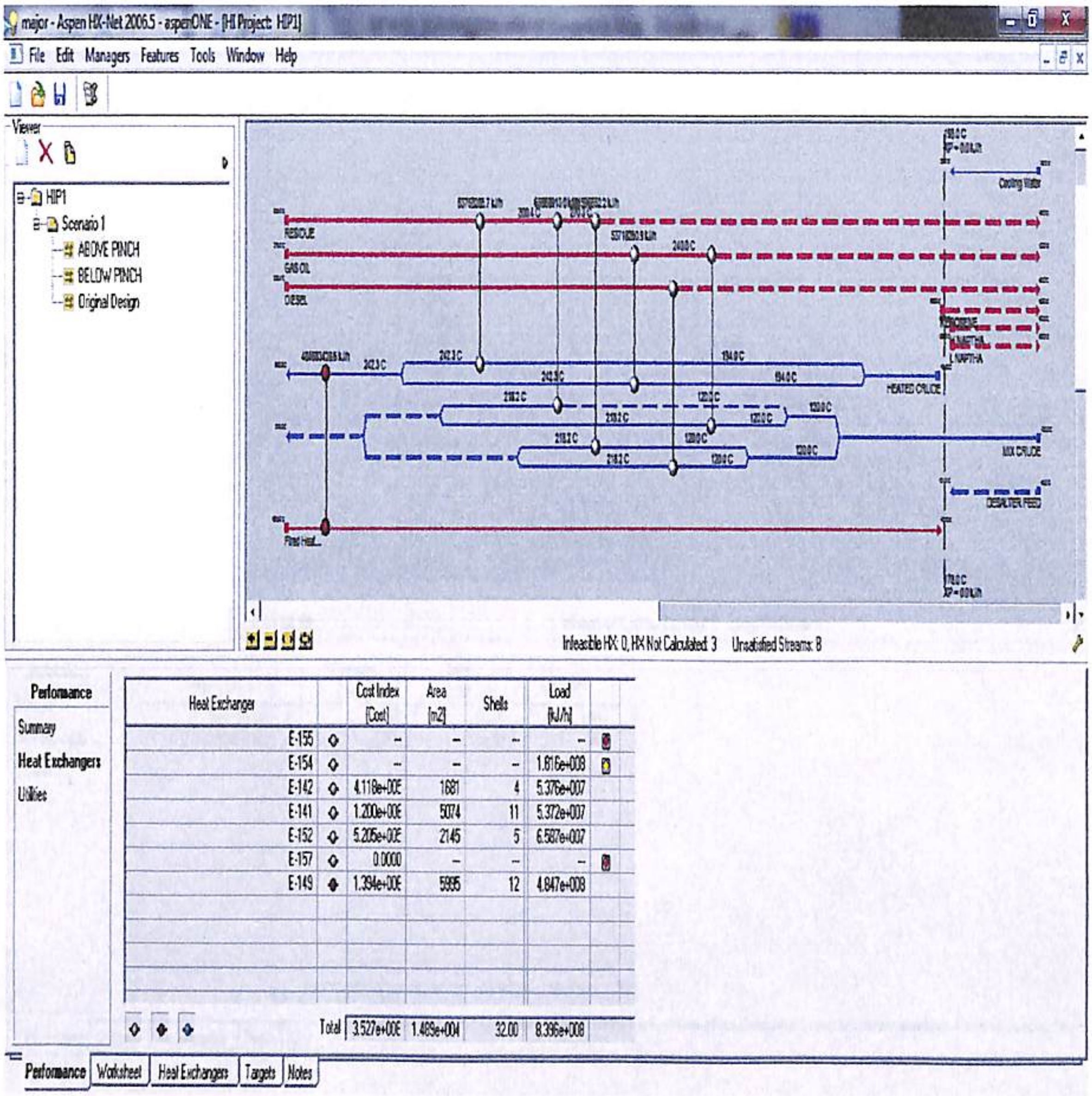
Fig. 98 TARGETS ABOVE THE PINCH.



Infeasible HX: 0, HX Not Calculated: 3 Unsatisfied Streams: 8

Heat Exchanger		Cold Stream	Cold T in [C]	Tied	Cold T out [C]	Tied	Hot Stream	Hot T in [C]	Tied	Hot T out [C]	Tied	Load [kJ/h]	Area [m2]		dT Min Hot [C]	dT Min Cold [C]
E-155	◇	MIX CRUDE	178.0	☐	218.2	■	GAS OIL	240.0	☑	198.0	☐	--	--	●	21.80	20.00
E-154	◇	MIX CRUDE	178.0	☐	218.2	■	RESIDUE	270.3	☑	198.0	☐	1.816e+006	--	●	52.07	20.00
E-142	◇	HEATED CRUDE	194.0	☐	242.3	■	RESIDUE	325.0	☑	300.4	☐	5.376e+007	1681.1		82.70	106.4
E-141	◇	HEATED CRUDE	194.0	☑	242.3	■	GAS OIL	279.0	☑	240.0	☑	5.372e+007	5074.0		36.72	46.00
E-152	◇	MIX CRUDE	178.0	☐	218.2	■	RESIDUE	300.4	☐	270.3	☑	6.587e+007	2144.7		82.20	92.27
E-157	◇	MIX CRUDE	178.0	☐	218.2	■	DIESEL	225.4	☐	198.0	☐	--	--	●	7.200	20.00
E-149	◆	HEATED CRUDE	242.3	☐	343.3	☑	Fired Heat (1000)	1000	■	400.0	■	4.847e+006	5994.6		656.7	157.7

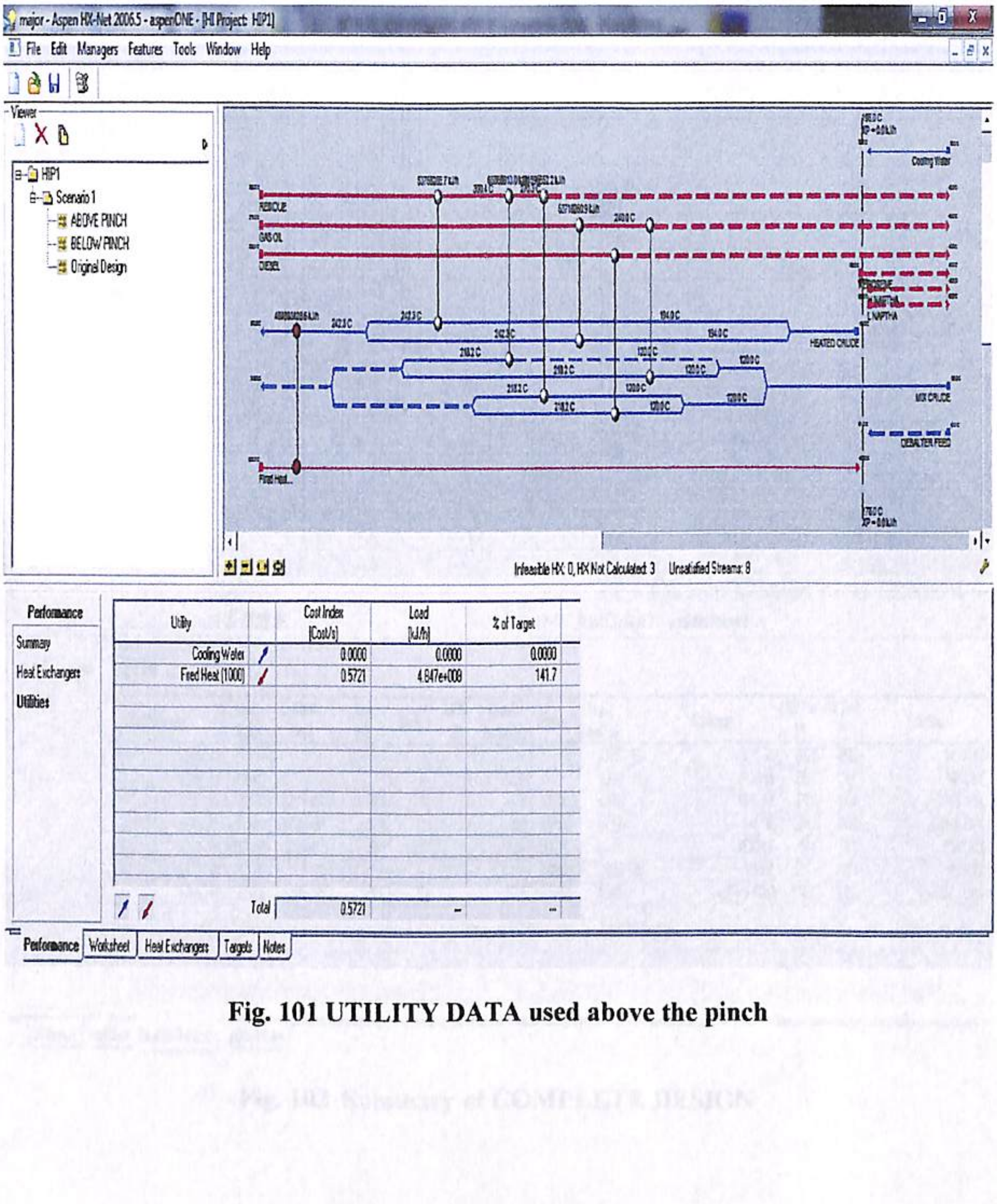
Fig. 99 Heat exchanger data



Infeasible HX: 0, HX Not Calculated: 3   Unsatisfied Streams: 8

Heat Exchanger		Cost Index [Cost]	Area [m2]	Shells	Load [kJ/h]	
E-155	◇	--	--	--	--	🟥
E-154	◇	--	--	--	1.816e+008	🟨
E-142	◇	4.118e+00E	1681	4	5.376e+007	
E-141	◇	1.200e+00E	5074	11	5.372e+007	
E-152	◇	5.205e+00E	2145	5	6.587e+007	
E-157	◇	0.0000	--	--	--	🟥
E-149	◆	1.394e+00E	5995	12	4.847e+008	
Total		3.527e+00E	1.489e+004	32.00	8.396e+008	

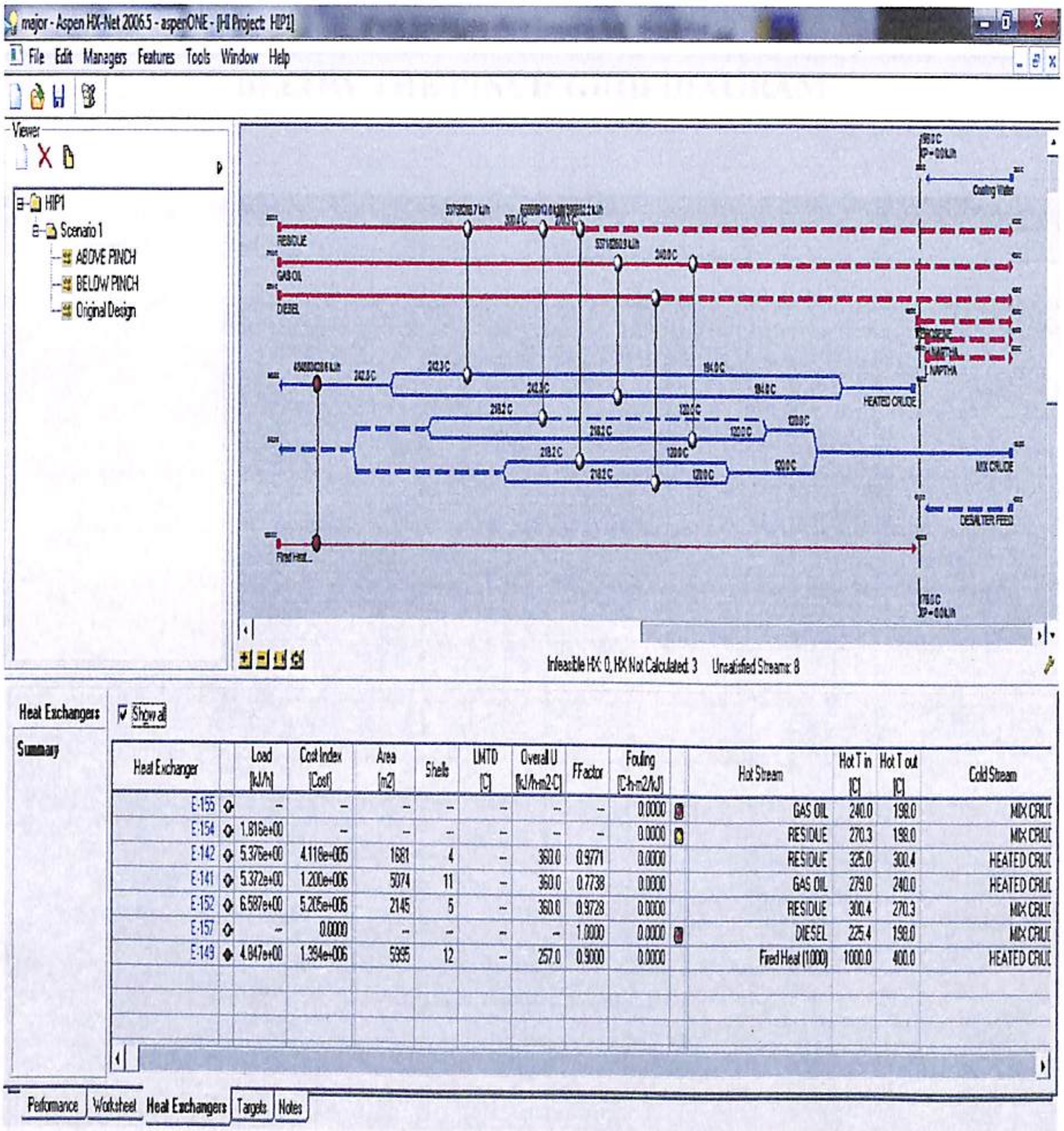
Fig. 100 This is detail of COST INDEX OF HEAT EXCHANGER.



Infeasible HX: 0, HX Not Calculated: 3 Unsatisfied Streams: 8

Utility		Cost Index [Cost/s]	Load [kJ/h]	% of Target
Cooling Water	/	0.0000	0.0000	0.0000
Fired Heat (1000)	/	0.5721	4.847e+008	141.7
Total		0.5721	---	---

Fig. 101 UTILITY DATA used above the pinch



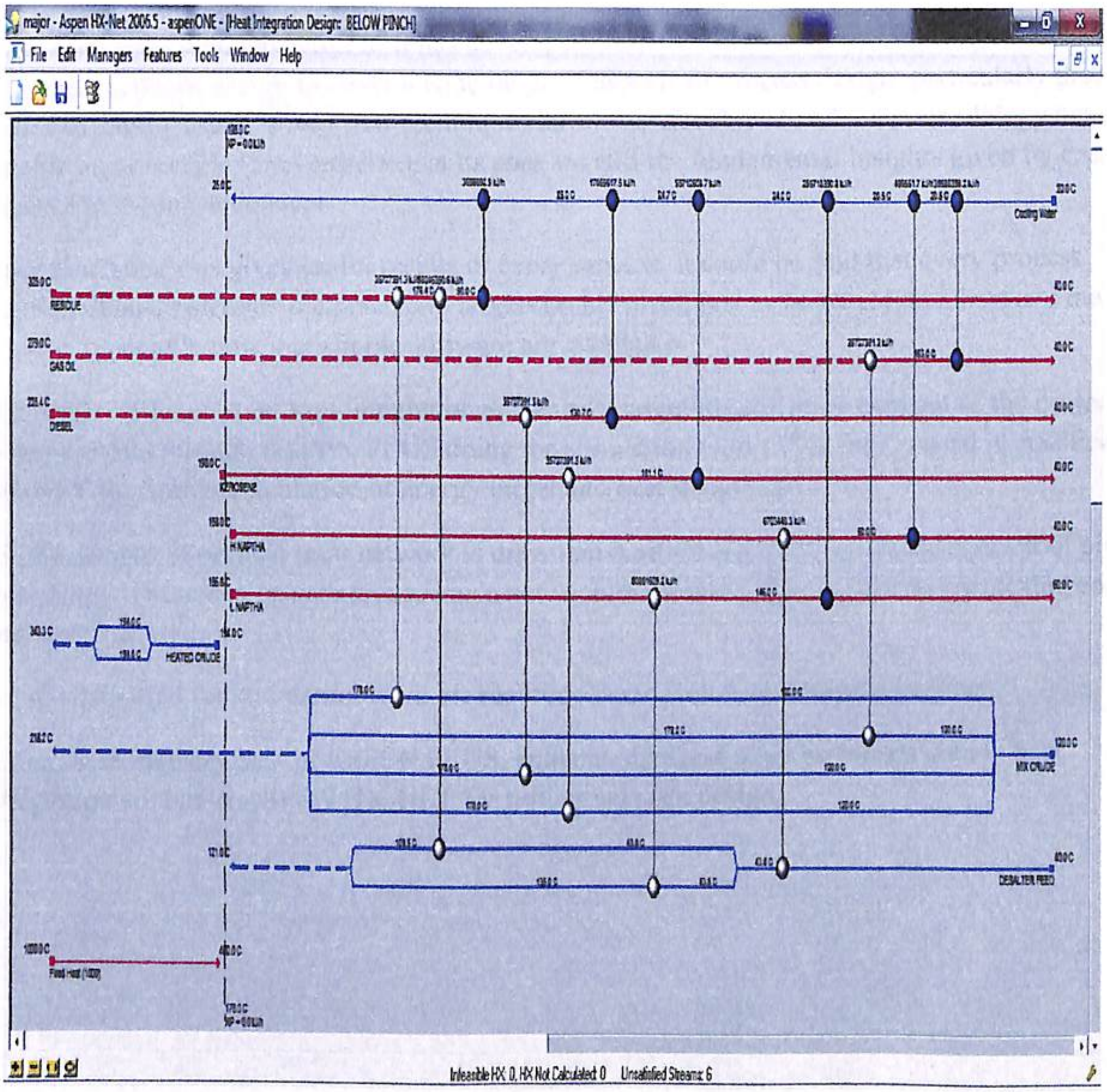
Infeasible HX: 0, HX Not Calculated: 3 Unsatisfied Streams: 8

☑ Show all

Heat Exchanger		Load [kJ/h]	Cost Index [Cost]	Area [m2]	Shells	LMTD [C]	Overall U [kJ/h-m2-C]	FFactor	Fouling [C-h-m2/kJ]		Hot Stream	Hot T in [C]	Hot T out [C]	Cold Stream
E-155	◇	--	--	--	--	--	--	--	0.0000	🟥	GAS OIL	240.0	198.0	MIX CRU
E-154	◇	1.816e+00	--	--	--	--	--	--	0.0000	🟨	RESIDUE	270.3	198.0	MIX CRU
E-142	◇	5.376e+00	4.118e+005	1681	4	--	360.0	0.9771	0.0000		RESIDUE	325.0	300.4	HEATED CRU
E-141	◇	5.372e+00	1.200e+006	5074	11	--	360.0	0.7738	0.0000		GAS OIL	279.0	240.0	HEATED CRU
E-152	◇	6.587e+00	5.205e+005	2145	5	--	360.0	0.9728	0.0000		RESIDUE	300.4	270.3	MIX CRU
E-157	◇	--	0.0000	--	--	--	--	1.0000	0.0000	🟥	DIESEL	225.4	198.0	MIX CRU
E-149	◆	4.847e+00	1.394e+006	5995	12	--	257.0	0.9000	0.0000		Fired Heat (1000)	1000.0	400.0	HEATED CRU

Fig. 102 Summary of COMPLETE DESIGN

BELOW THE PINCH GRID DIAGRAM



Infeasible HX: 0, HX Not Calculated: 0   Unsatisfied Streams: 6

Fig. 102 The grid diagram (BELOW THE PINCH)

CONCLUSION

Pinch analysis is a mature subject. It has developed from the early work on targeting and heat exchanger network design to cover a wide range of aspects of process design, particularly those related to energy usage. Many new techniques have been developed and the methodology has become more complex; nevertheless, at its core are still the fundamental insights given by energy targets and the pinch concept.

Since pinch analysis gives useful results of every process, it could be said that every process engineer should calculate the pinch and targets on his plant, just as he would do a heat and mass balance, especially now that simple software are available.

The project is focused on heat integration and energy targeting; the basic concept of the project is to acquire data through ASPEN PLUS doing the simulation work. This data is used in ASPEN HX-NET for further calculation of energy target and heat integration.

All the designs of preheat train network is drawn on ASPEN HX-NET using the concept of pinch technology. These designs are focused on a new commissioning plant where no retrofitting cost and labour is used.

All the data used for simulation work are real time data taken from industry persons.

Using these industry data in ASPEN PLUS, enthalpy data and other important data in heat integration are put in ASPEN HX-NET for further network design.

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