Eng. Essa M. A. Alruwaieh. International Journal of Engineering Research and Applications
www.ijera.com
ISSN: 2248-9622, Vol. 14, Issue 4, April, 2024, pp: 109-142

RESEARCH ARTICLE OPEN ACCESS

Save Energy by Using a Heat Exchanger Network (Aspen Energy Analyzer)

Eng. Essa M. A. Alruwaieh
Engineer in the Public Authority for Applied Education & Training.

Assisted Eng. Tareq Ibrahim Alnkhailan.
Mechanical Engineer in the Public Authority for Applied Education & Training.
Specialized trainer member in the Instate of Civil Structural Training.

Date of Submission: 05-04-2024 Date of acceptance: 17-04-2024

Thermal radiation is the third way that heat is transferred.
All cool surfaces give out electromagnetic waves as a kind of energy.
Afterward, when there is no state.
 various net temperatures. (Ahmed F. Zobaa, 2011)

2. Heat transfer application
the investigation of thermodynamics, the flow of energy via a system's interactions with it.
These things are referred to as "heat," and the circumstances of the contract are entwined with the imagery.
This article aims to investigate heat transport and extend the dynamic analysis.
Welcome to engineers has become the norm for engineers. with the growth of the population and their standard of living, the need for energy has increased exponentially. Strangely enough, energy is abundant in nature. We must discover its source, release it, and then control its release. After firing, heat energy needs to be transferred to the medium where it will be used. From this point of view, the determination of heat transfer is the most critical point that needs special attention.

Engineers will have to perform a detailed analysis of the electrical current expenditure generated by the mains. Depends on the transmission model under typical conditions.
These elevated temperatures and flavors are just an opportunity to enjoy engineering.

It is not only in energy use when we are involved in heat transfer studies. There may be other instances of decline during a certain period, or with equipment. In this case, restore the temperature from the temperature. In some cases, gas turbine blades, engine combustion walls, and the exterior

I. Introduction

The investigation of thermodynamics, the flow of energy via a system's interactions with it.
These things are referred to as "heat," and the circumstances of the contact are entwined with the imagery.
This article aims to investigate heat transport and extend the dynamic analysis.
Win therefore by asking questions How does heat transfer work? How can heat travel? Why is studying it important?
I started to consider the physics that underlies heat transfer mechanisms and their significance in our industrial and environmental challenges in the questions that followed.
Case, the first and second laws of thermodynamics apply to all transactions of moveable matter that include the transmission and conversion of energy. The rules of heat transport can initially appear to be. However, equilibrium is not a topic covered by thermodynamics. Quantitative analysis can be developed based on data from another scientific field, or utter heat as a result of heat imbalance. The fields of thermodynamics and fluid mechanics are strongly based on the study of heat.
How and what?

A sufficient response to the query is provided by a brief but comprehensive definition. How does heat transfer work?
heat transfer.

The medium or media has a temperature differential, which causes the heat to spread.
On modes, we discuss several heat transfer methods kinds.
when the temperature is different.

these particles is transferred from one area to another. This process is convection. leans, loads, sets, bras, tables, heat energy, and foods with the bras from the acid atmosphere. This type of transmission is known as radiation. We feel the cheapest and most popular of this product. . While the real load needs express transportation as well. The result of heat transfer is why so many three ways of transportation. be the reason behind making a relevant decision. (Geankoplis, 2003)

surface of a vehicle, their durability in rapid heat removal of its surfaces.

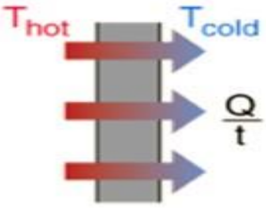
3. Heat transfer methods

Birds are responsible for transferring energy from one place to another. Conduction, convection, and radiation are the terms used to describe these different ways of transferring heat.

Heat flow is a result of internal energy transfer from a vacuum molecule. Heat transfer is possible e. in a sleep state. The heat energy generated by their random translational motion. A transfer of energy from the more energetic to the less energetic molecules must take place when neighboring molecules collide since greater temperatures are linked to higher molecular energies. Energy transfer by conduction must then take place in the direction of decreasing temperature when there is a temperature gradient.

Conduction (1)

$$\frac{Q}{t} = \frac{\kappa A(T_{hot} - T_{cold})}{d}$$



Q = heat transferred in time = t
κ = thermal conductivity of the barrier
A = area
T = temperature
d = thickness of barrier

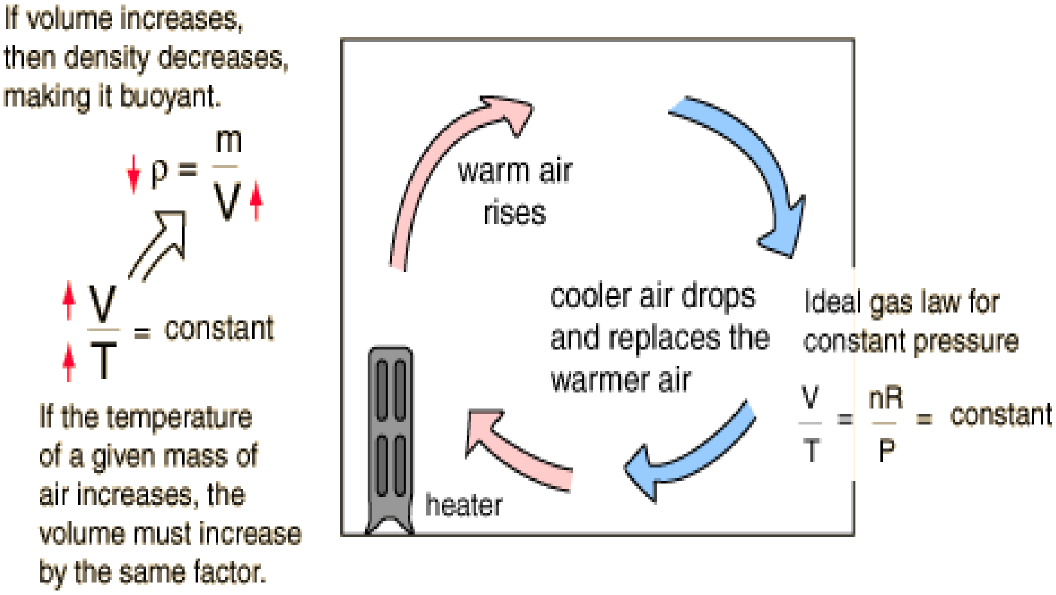
In liquids, the situation is the same. Even though molecules are placed closer together there are more frequent and powerful chemical interactions. Similarly, lattice vibrations caused by atomic activity can be linked to solid conduction. The current theory attributes the energy transfer caused by atomic motion to lattice waves. In a conductor, in addition to these lattice waves, the translational side motion of these electrons is also responsible for the energy transfer. (Forsberg, 2020)

When the word "conduction" is mentioned, we should instantly think of atomic and molecular activity because this mechanism of heat transmission is sustained by processing at these levels. Conduction can be thought of as the energy transfer from a substance's more energetic particles to its less energetic ones as a result of interactions between the particles.

The physical mechanism of conduction is best understood by studying gas and applying concepts from your expertise in thermodynamics. Suppose that there is no bulk motion and consider a gas with a temperature gradient. The area between two surfaces that are kept at differing temperatures may be filled with gas.

We relate the energy of the gas molecules nearby to the temperature at any given position. This energy is connected to the molecules' intrinsic rotational and vibrational motion in addition to

Convection (2)



between conduction and bulk fluid motion. Typically, the energy being transmitted is the fluid's sensible or internal thermal energy. However, other convection processes also involve latent heat transfer. The phase change between liquid and steam liquid states is usually associated with this hidden heat exchange. (Lavine, 2007)

Radiation (3)

The energy released by matter at a specific temperature is known as thermal radiation. Although radiation from solid surfaces receives most of our attention, emission can also come from liquids and gases.

Irrespective of the type of matter, the emission can be traced to alterations in the atoms' or molecules' constituent electron configurations. The energy of the radiation field is transported via electromagnetic waves (or photons). Radiation does not require the presence of a material medium, whereas the transmission of energy by conduction or convection does. In a vacuum, radiation is most effective. (Lienhard & Lienhard, 2019)

Heat Exchanger (4)

Heat exchangers serve a purpose:

Control the temperature of a substance by adding or removing thermal energy.

Although capital letters, evolution theories, distinct kinds of heat exchangers, and the usage of letters in the shape of letters or letters in the shape of letters or letters can all be used, their attitude can result in the transfer of heat energy to another. Heat exchangers are used in home heating systems to convert heat of gas into water or air, which then

Two mechanisms make up the convection heat transfer mode. The bulk, or macroscopic, motion of the fluid also contributes to the transmission of energy in addition to the random motion of molecules (diffusion). This fluid motion is related to the fact that several molecules are moving collectively or in aggregates at any given time. Heat transfer will result from this action when there is a temperature gradient. The overall heat transfer is caused by a superposition of energy transport by the random motion of the molecules and by the bulk motion of the fluid because the aggregation of molecules keeps its random motion. Convection is often used to describe this cumulative transport and advection to describe the transport caused by bulk liquid movement.

Convection heat transfer, which happens when a fluid in motion and a surrounding surface are at different temperatures, is of particular importance to us.

Random molecule motion, bulk fluid motion, and fluid motion inside the boundary layer all support the convection heat transfer mode.

Depending on the type of flow, convection heat transfer can be divided into distinct categories.

When a flow is prompted by an outside source, such as a fan, a pump, or atmospheric winds, we speak about forced convection. In contrast, buoyant forces within the fluid cause the flow in the case of free (or spontaneous) convection. These forces result from changes in fluid temperature-induced density fluctuations.

According to our definition of the convection heat transfer mode, energy is transferred inside a fluid because of the interaction

Although a manufacturer will often calculate the pressure drop, it can be helpful to anticipate the pressure dips that might happen with altered flow rates. The least loss, which rises linearly with flow velocity, is produced by laminar flow. For instance, increasing flow velocity also increases pressure loss. The pressure loss is a function of flow velocity raised to a power in the range of 1.6-2.0 for Reynolds numbers above the laminar area. In other words, doubling the flow could lead to a fourfold increase in pressure loss. (Rennie, 2004)

Balance and effectiveness

The properties of fluids influence the heat transfer rate, a crucial aspect of heat exchangers (Q). According to the following equation, the heat transferred from the hotter fluid to the colder fluid must be equal:

$$\dot{Q} = [\dot{m} \times c_p \times (T_{\text{out}} - T_{\text{in}})]_{\text{cold}}$$
$$= -[\dot{m} \times c_p \times (T_{\text{out}} - T_{\text{in}})]_{\text{hot}}$$

Where the mass flow rate (m) is expressed as a function of time. Therefore, the product of mass flow per unit of time, specific heat and temperature change is the heat transmitted over time.

You should perform this simple calculation before specifying any heat exchanger. The heat transfer rate is the most crucial factor, even though heat exchangers are frequently only specified with desired temperatures.

The efficiency of an exchanger (e) is the ratio of heat that is transmitted to heat that an exchange of unlimited size could transfer. Efficiency is the most useful measure for comparing different heat exchanger systems.

As an illustration, the figure below depicts a counter-flow heat exchanger where a hot fluid stream is cooled by a cold fluid stream. When a hot stream is present in the exchanger, it must be warmer than the cold stream's input temperature. With e=1, the temperature of the incoming cold stream and the temperature of the departing hot stream are identical in a perfect heat exchanger. In addition, the hot stream's entrance temperature is lower than the cold stream's exit temperature in this heat exchanger. circulates throughout the building. Steam from the turbines is condensed in large heat exchangers using locally available water or ambient air in power plants. Small heat exchangers are used in many industrial applications to create or maintain the desired temperature. Heat exchangers are used in the industry to perform a variety of functions, from cooling lasers to creating a controlled temperature of the sample before chromatography.

Anyone looking to employ a heat exchanger must first clearly define the issue at hand, which necessitates knowledge of the fluid's thermodynamic and transport properties. Such information can be used to define a particular heat-transfer problem and choose the best heat exchanger by combining it with a few straightforward calculations. (Al-Sammarraie & Vafai, 2017)

Fluid fundamentals

The physical properties of the fluids involved, especially their density, specific heat, thermal conductivity, and dynamic viscosity, play a significant role in how heat is transmitted from one fluid to another.

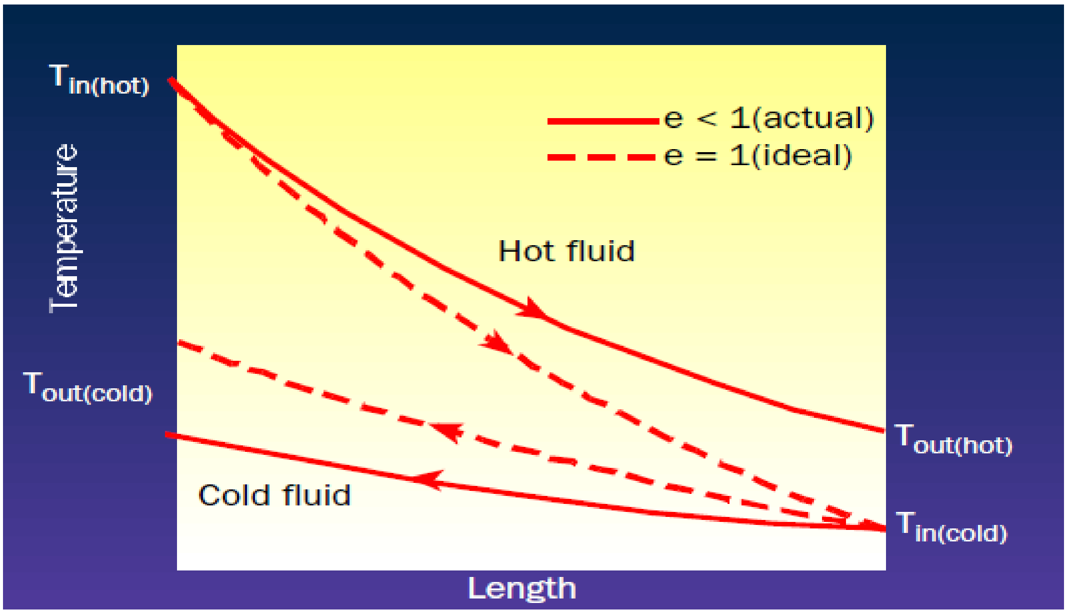
Either turbulent or laminar fluid flow occurs within a heat exchanger. Better heat transmission results from turbulent movement because it mixes the fluid. Laminar-flow heat transfer transfers heat from within a stream to a heat exchanger wall purely based on the fluid's thermal conductivity.

The fluid flow through an exchanger can be calculated using its Reynolds number:

$$N_{Re} = \frac{\rho \times V \times D}{\mu}$$

Where V represents the flow velocity and D represents the tube's diameter. Laminar fluid flow occurs when the Reynolds number is less than 2,000; turbulent fluid flow occurs when the Reynolds number exceeds 6,000. As the number of Reynolds increases, the area where the flow of laminar and turbulent meets produces rapid thermal performance.

How much pressure a fluid loses as it passes through a heat exchanger depends on the flow type. This is crucial since greater pressure decreases call for stronger pumping.



Stream temperatures through a heat exchanger (counter current flow)

The heat balance equation can be used to solve this issue as follows:

$$\varepsilon = \frac{(\dot{m}\,c_p)_{\text{hot}}(T_{\text{in}} - T_{\text{out}})_{\text{hot}}}{(\dot{m}\,c_p)_{\text{min}}(T_{\text{in hot}} - T_{\text{in cold}})}$$

$$= \frac{(\dot{m}\,c_p)_{\text{cold}}(T_{\text{out}} - T_{\text{in}})_{\text{cold}}}{(\dot{m}\,c_p)_{\text{min}}(T_{\text{in hot}} - T_{\text{in cold}})}$$

The minimal thermal-capacity rate, also known as the denominator, is based on the stream with the smallest mass-flow rate and specific heat product, denoted by the subscript "min.""Due to the necessary heat-transfer rate balance, the temperature drop on the hot stream in this example is greater than the temperature gain in the cold stream."

Exchanger equation

The design of the exchanger and the characteristics of the fluid streams determine the heat-transfer rate (Q) for a certain exchanger. This quality can be described as:

$$\dot{Q} = UA\Delta T_{\text{log mean}}$$

Where A is the heat transfer area of the heat exchanger, which is the total area of the wall that separated the two fluid streams, U is the overall heat-transfer coefficient, or the capacity to transfer heat between the fluid streams, and delta T log mean is the average effective temperature difference between the two fluid streams over the heat exchanger's length.

By estimating the overall heat transfer coefficient (U) and the area, a heat exchanger's performance may be anticipated (A). The two streams' input temperatures can be measured, leaving the two exit temperatures, the heat transfer rate, and three other unknowns. Three equations—the one used earlier to calculate the delta T log mean using an arithmetic average and the heat balance equation for each stream—can be used to determine these unknowns:

$$\dot{Q} = U\,A\,\frac{(T_{\text{in hot}} - T_{\text{out cold}}) + (T_{\text{out hot}} - T_{\text{in cold}})}{2}$$

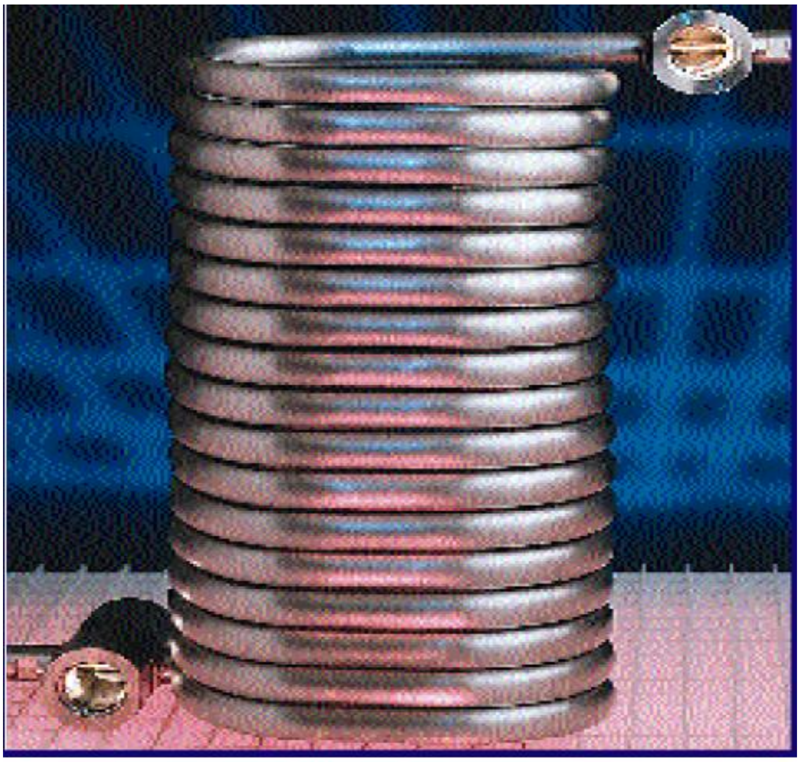
$$= [\dot{m} \times \dot{Q}\,c_p \times (T_{\text{out}} - T_{\text{in}})]_{\text{cold}}$$

$$= -\,[\dot{m} \times c_p \times (T_{\text{out}} - T_{\text{in}})]_{\text{hot}}$$

In most cases, iteration is necessary to solve these equations simultaneously. In any event, a heat exchanger is typically finished by the manufacturer. (E. M. Greitzer, 2022)

Exchanger varieties: (5)
There are many assorted sizes and types of heat exchangers. Here are some of the most typical examples.

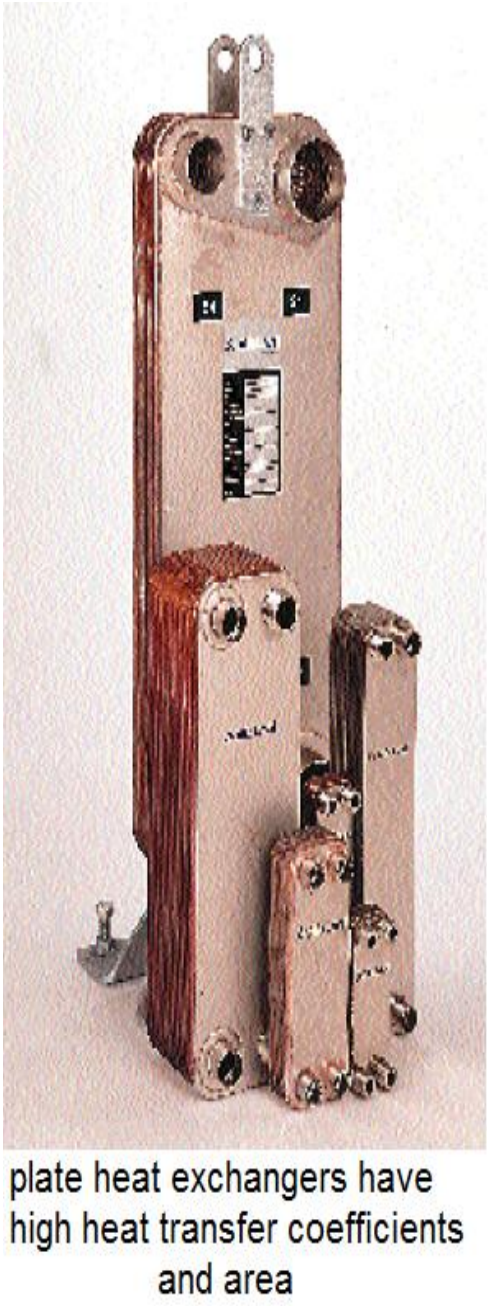
1-Coil heat exchangers
have a long, thin tube positioned closely inside a bigger tube, the two tubes being coiled or curved into a helix. The outer tube is permeable to one fluid. This type of heat exchanger is strong and able to withstand high pressures and large temperature changes. These exchangers frequently cost little, but because of their limited heat transfer surface, they offer very subpar thermal performance. However, due to the higher flow speed and higher Reynolds number, a coil heat exchanger may be the best option for low-flow scenarios. These exchangers are frequently used to set a process-stream sample's temperature to a fixed value before taking measurements. High-temperature stream samples can also be condensed using these exchangers.



Coil heat exchangers are capable of handling
high pressures and wide temperature differences

2-Plate heat exchangers:

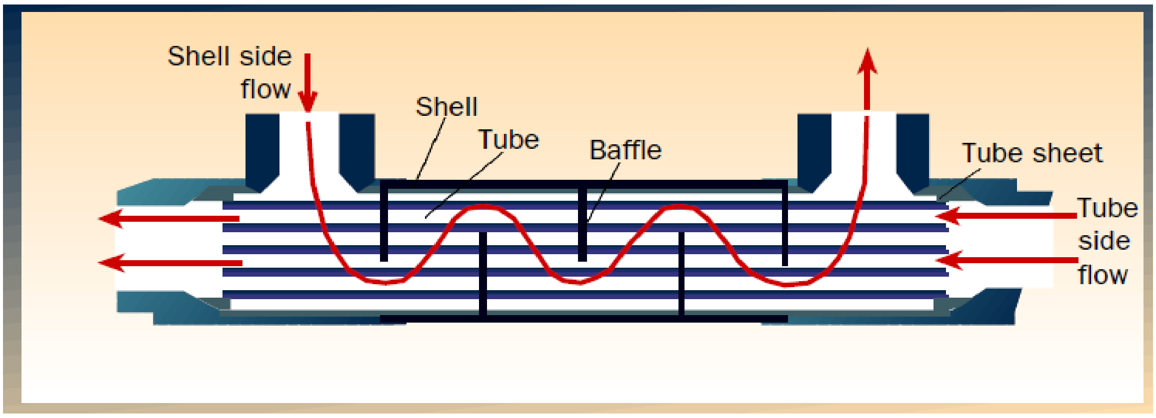
comprise a stack of thin, parallel plates sandwiched by heavier endplates. As each fluid stream alternately moves between adjacent plates in the stack, heat is transferred between the plates. For strength and to improve heat transfer by guiding the flow and increasing turbulence, the plates are corrugated. These exchangers frequently offer extremely high efficacy due to their high heat-transfer coefficients, large surface areas, and modest pressure drops. They can only handle relatively low pressures, however.



3-Shell and tube heat exchangers

consist of a collection of parallel tubes that act as a heat-transfer surface to divide the streams of fluid. Shell-side fluid flows over the outside of the tubes while tube-side fluid travels axially into the tubes' interior. The flow is directed through the tubes and supported by external and perpendicular deflectors. Process fluids are usually placed in tubes for easy cleaning or to use higher pressure capacity inside tubes. Tube sheets seal the ends of the tubes; assuring separation of the two streams. Such heat exchanger typically outperforms coil types while falling short of plate types in terms of thermal performance. Exchangers with shells and tubes often have a higher pressure capacity than plate exchangers, but less capacity than coil exchangers.

Thermal performance of shell-and-tube exchangers are high

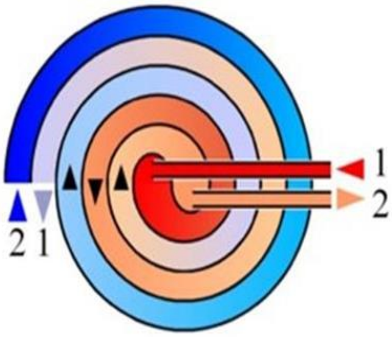


Shell-and-tube heat exchanger with counter current flow

Fluid inside Tube
Corrosive fluid
High-pressure fluid
Scale fluid
Any fouling material

Fluid inside shell

viscous fluid
two-phase fluid
fluid has a low heat transfer coefficient



● Keep in mind that the primary criterion—not merely the transfer area—is the product of the total heat-transfer coefficient and the transfer area (U A). In laminar flow tubes, the total tube length, not the transfer area, is typically what matters; hence, 10 feet of 1/4-inch tubing or 10 feet of 1-inch tubing function equally well.

● For tube-type heat exchangers, the smallest tubing possible should be specified because it provides the highest thermal performance with the least amount of volume. Be mindful of the impact of fouling or other particles that can clog small tubes.

● Aim for turbulent flow, even if it can be challenging with viscous fluids and low flow rates, to improve heat transmission.

● When choosing the cooling or heating fluid, consider the thermal conductivity of the fluid. Unexpectedly, water frequently provides the best results.

● Align the inlet-port size with the anticipated piping diameters for the remainder of the system.

● Consider the maintenance requirements and lifetime of an exchanger. Select a material kind and thickness that will lessen failure brought on by corrosion and erosion. A system's ease of mechanical or chemical cleaning, as well as the filtration of the fluid streams, should also be taken into account.

●Give the heat-exchanger seller as much information as you can about the entire system. You should be able to define a heat-exchange problem and take into account potential heat-exchanger solutions with the help of these technical hints, fundamental ideas, and equations. Consult manufacturer catalogs for data on specific exchanges, which offer further information on what may be achieved with various heat exchanger kinds. (Richardson, 1999)

4-Spiral Tube Heat Exchanger
These are made up of a shell and one or more spirally coiled coils. Compared to a straight tube, a spiral tube has a faster heat transfer rate.
Additionally, spiraling allows for the fitting of a sizable number of surfaces into a particular area.
Thermal expansion is not an issue; however, cleaning is challenging.
The SHE's primary benefit is its extremely effective utilization of available space.
For uses like pasteurization, digester heating, heat recovery, pre-heating, and effluent chilling, the SHE is effective. SHEs are typically smaller than other kinds of heat exchangers for sludge treatment. (Liu, 2004)

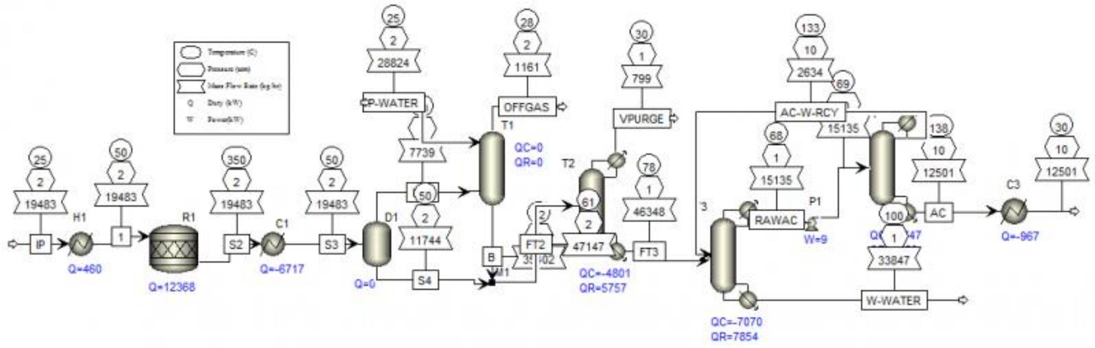
Technical tips (6)
The following advice is beneficial for every heat-exchanger application:
Prior to creating a system, think about heat exchangers.●

● When defining performance standards, avoid being overly cautious. A temperature exchanger's size and expense can easily be doubled by requesting a higher flow rate, more temperature variation, and other just-in-case options. Consider the necessary effectiveness values, but keep in mind that as effectiveness gets closer to 1, an exchanger's size asymptotically approaches infinity. Therefore, increasing efficiency from 0.8 to 0.9 requires a significantly greater heat-exchanger area than doing so from 0.7 to 0.8. Higher than 0.9 efficacy can be quite expensive.

● Instead of expanding an exchanger's size, think about increasing pumping power. Turbulence can be created or exacerbated by higher flow velocity, which increases the pressure drop and necessitates the use of greater pumping power. However, turbulence also boosts the heat-transfer coefficient, which reduces the size of the necessary heat exchanger. Instead of increasing size, it might be more practical to accept the higher pressure drop.

(such as those that produce oil, gas, petrochemicals, and electricity) save energy. (Aspen Energy Analyzer, 2022)

Case study (7)
Using the example of heat transmission, conserve energy (heat exchanger network) Utilizing the Aspen Energy Analyzer can help process plants



1-Crude oil Distillation Unit of a refinery

Fig. 1 displays the refinery's process map:

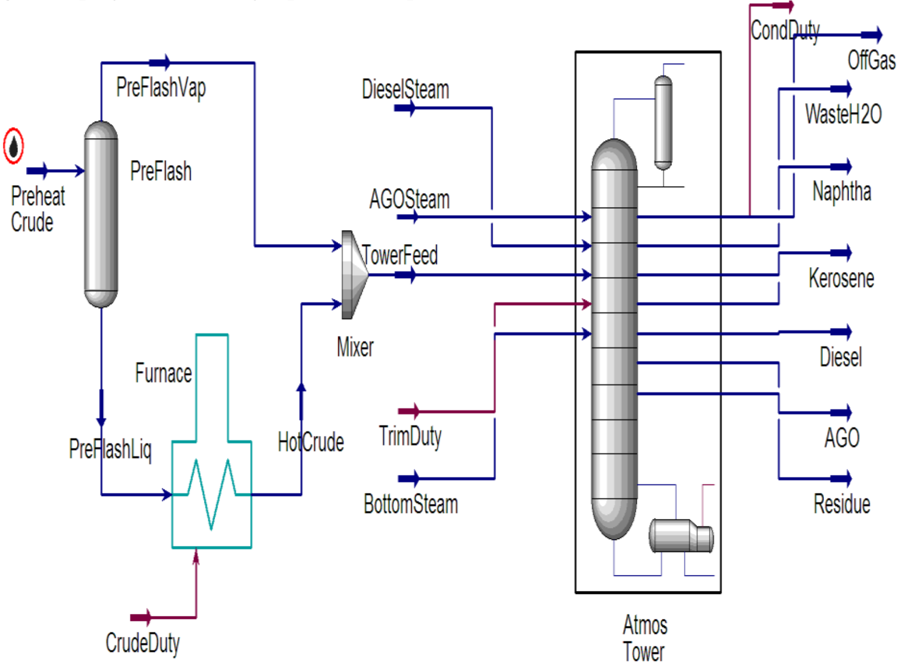


Figure 1

Table 1 Extracted Process Streams Data [21]

Process Stream Data						
Name	Inlet Temp (^{0}C)	Outlet Temp (^{0}C)	Density (Kg/m^3)	Flow rate M^3/hr	Flow Rate Kg/H	Specific Heat Capacity (Kcal/kg)
Pump Around	152.4	96.7	788	747	588636	0.5919
Kerosene	226.3	184	833	451	375683	0.6413
	184	154.9	833	451	375683	0.6038
LDO	278.7	233.6	858	152	130416	0.6777
Stripped Kerosene	227.9	168	828	96	79488	0.6447
Stripped	168	35.6	828	96	79488	0.5913
LDO	280	207	863	158	136354	0.6769
Stripped	207	38.9	863	158	136354	0.6132
HDO	316	65.6	898	18	16164	0.6943
Atmospheric Residue	328	204	944	150	141600	0.6872
	204	164	944	150	141600	0.5838
	164	95.4	944	150	141600	0.5505
	241	222	927	10	9270	0.6203
HVGO	29.9	134.9	841	310	260710	0.4648
Crude from Storage	134	212	841	306	257346	0.5567
Desalted Crude	212	344	841	529	444889	0.6256
Pre-flashed Crude						

Table 2 Utility Streams Data [21]

Utility Stream Data					
Name	Inlet Temp (^{0}C)	Outlet Temp (^{0}C)	Heat Transfer Coeff. (Kj/hm^2 ^{O}C)	Flow Rate Kg/H	Specific Heat Capacity (Kcal/kg)
Air	25	30	399.60	43074232.05	0.5919
Cooling Water	20	25	13500.00	84786.75	0.6777
Fuel Oil	400	350	720.00	479529.21	0.6256

2.2. Heat Exchanger Network Analysis

The examination of the heat exchanger network made use of the data from the process streams and utility streams. The heating process streams used in crude preheating at different temperatures were divided into four categories: atmospheric residue, stripped kerosene, stripped LDO, and kerosene pump around.

Determine the targets using the data from the imputed process streams and utility streams as part of the analysis of the heat exchanger network. I am using the information on the energy requirement that has been provided.

Composite curves are used to compute the energy targets. Figures 2 and 3 depict the composite and grand composite curves. The composite curve provides a countercurrent representation of heat transfer and can be used to determine the minimum energy target of the process.

According to Table 3, the heating and cooling processes' energy targets are 7.759*107 Kj/h and 2.196*107 Kj/h, respectively, while the shell and tube heat exchanger's area target is 3.223*104 m2.

The calculation also indicates that at least 13 units are needed to build the heat exchanger network, but the process flow diagram shows that the network uses 23 heat exchangers, exceeding the unit requirements.

Since cost and operations information for the case study could not be acquired, the cost index targets are based on Aspen Energy Analyzer default ®'s cost and economic factors.

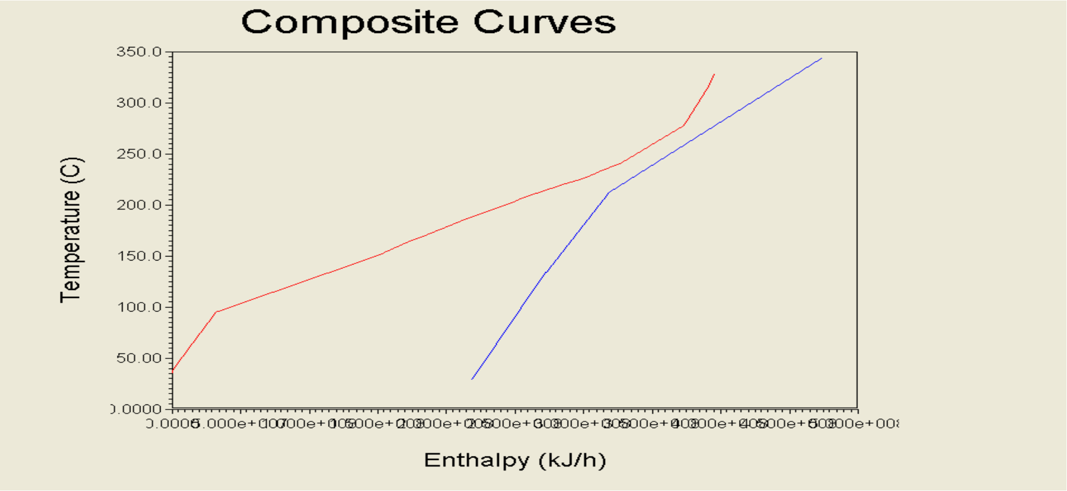


Figure 2 Composite Curve showing Temperature – Enthalpy Relationship

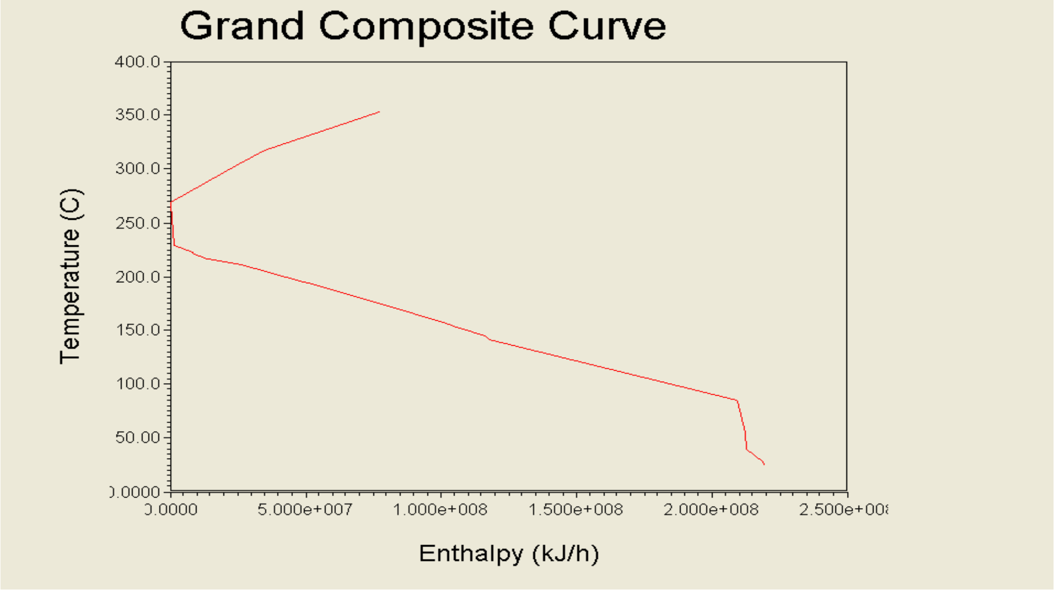
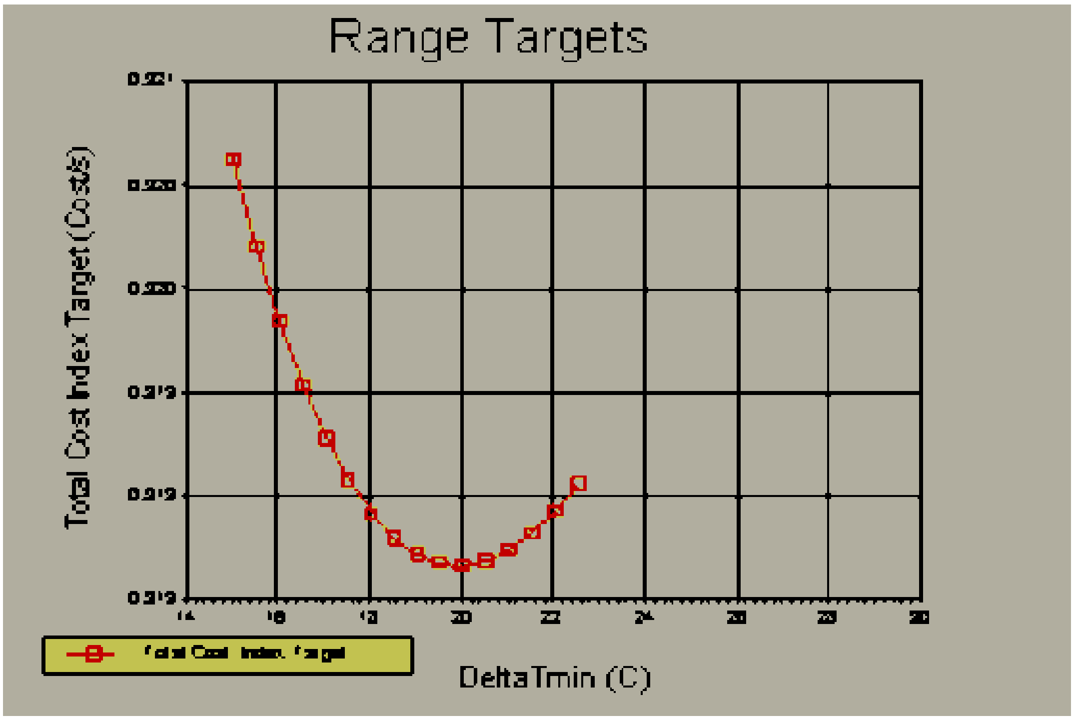


Figure 3 Grand Composite Curve used for Utility Targeting



ΔT_{min} ΔT_{min}

Figure 4 Curve to Determine the Optimal Value

The simulation led to the conclusion that a value of 20.5 was the best choice for the case study. This falls within the 20–40 range for oil refining that is mentioned in the literature [22]. In the case study's analysis, this value was employed.

2.3 Building the Grid Diagram for the Heat Exchanger Network:

A grid diagram is used to describe the heat exchanger network, as seen in Figure 5. Care was made to accurately depict the heat exchanger network as shown on the process flow diagram for the case studies to prevent a "type 3" error in which the incorrect problem is solved. To represent the case study design, the process streams were divided and heat exchangers were installed. The grid diagram's placement of heat exchangers was done after taking the streams' flow directions into account. Cold streams run from right to left, while hot streams move from left to right. This is crucial when positioning heat exchangers on streams before or after another heat exchanger. The steps for the materials and process are described in [23] in detail.

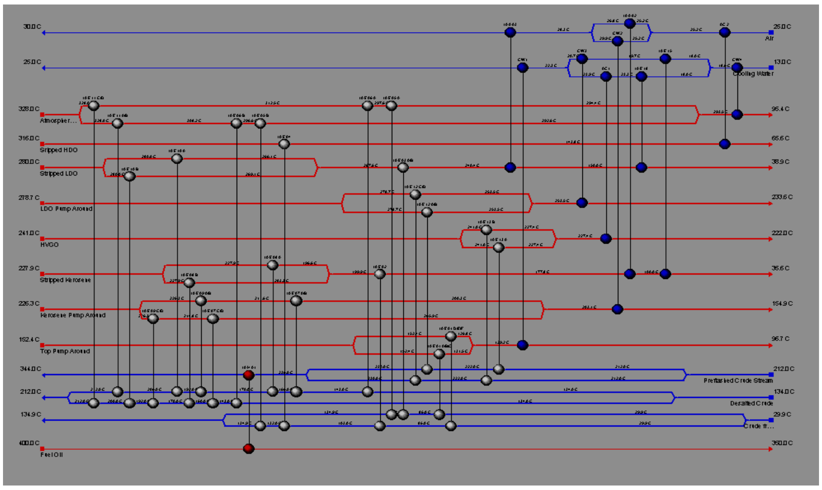


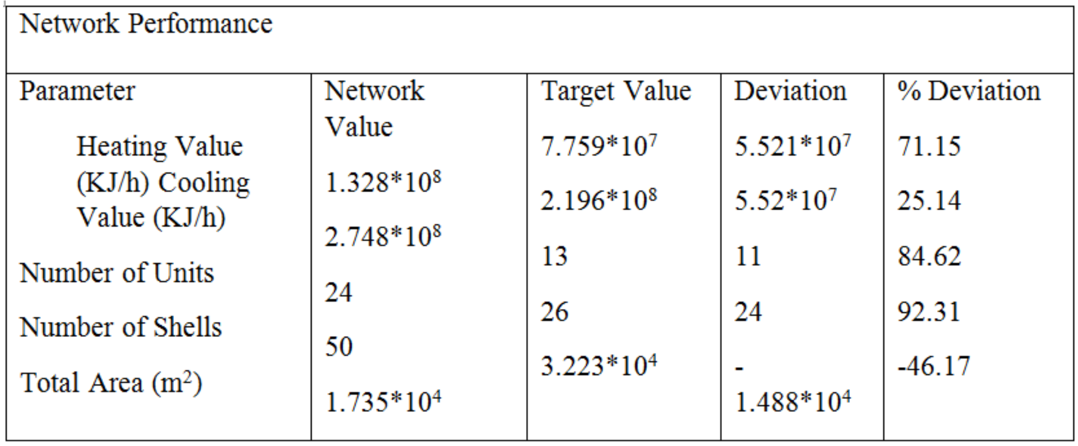
Figure 5 Grid Diagram Representations of the Heat Exchangers

III. Results and Discussion:

3.1. Heat Exchanger Network Performance:

Based on the objectives in Table 3, the performance of the heat exchanger network was assessed. Table 4 compares the performance of the heat exchanger network against the targets. As can be observed, pinch rule violations cause the heat exchanger performance to deviate significantly from the desired values.
(Aspen tech, maximize energy efficiency and cut emissions utilizing information and advice from pinch technology, 2022).

Table 4 Heat Exchanger Network Performance Data



Network Performance				
Parameter	Network Value	Target Value	Deviation	% Deviation
Heating Value (KJ/h)	$1.328*10^8$	$7.759*10^7$	$5.521*10^7$	71.15
Cooling Value (KJ/h)	$2.748*10^8$	$2.196*10^8$	$5.52*10^7$	25.14
Number of Units	24	13	11	84.62
Number of Shells	50	26	24	92.31
Total Area (m^2)	$1.735*10^4$	$3.223*10^4$	$-1.488*10^4$	-46.17

Table 5 Cross-Pinch Table

HEN Design Cross Pinch		
Heat Exchanger	278.70/ 258.20	45.50/25.00
E-249 (KJ/h)	$3.284*10^7$	
10 E 11 A-D (KJ/h)	$7.193*10^6$	
10 E 18 A/B	$6.013*10^6$	
10 E 06 A/B (KJ/h)	$5.395*10^6$	$7.263*10^7$
10 E 04 (KJ/h) E- 248	$1.752*10^6$	
(KJ/h)	$1.470*10^6$	
10 E 10 A-B (KJ/h)	$5.020*10^5$	
10 E 16 (KJ/h) CW 2		
(KJ/h) CW 1 (KJ/h) CW 3		
(KJ/h)		
10 E 15 (KJ/h) Total (KJ/h)		$3.656*10^7$
		$4.675*10^6$
		$3.972*10^7$
		$7.361*10^6$
		$1.072*10^7$
	$5.517*10^7$	$1.717*10^8$

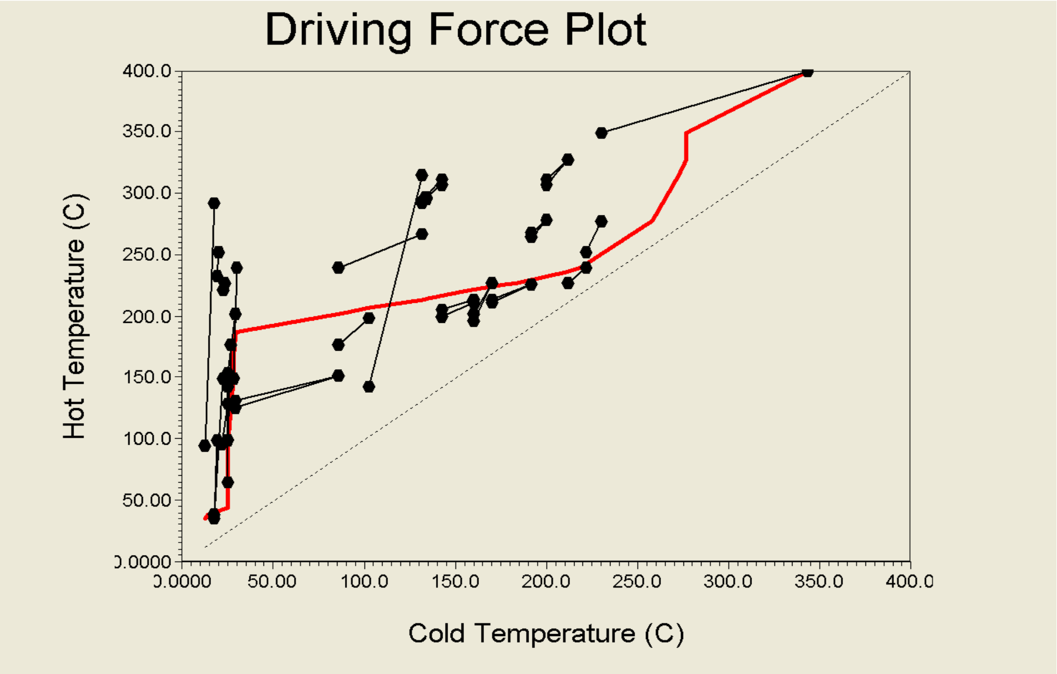


Figure 6 Driving Force Plot showing Hot Temperature – Cold Temperature Relationship

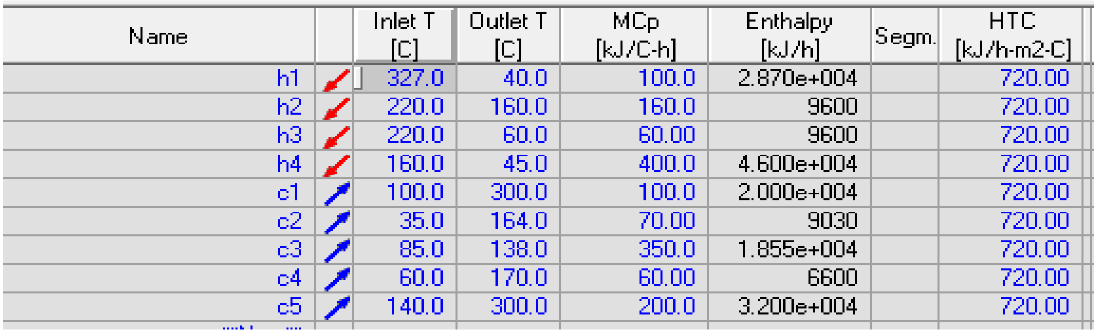
2. Aromatic Plant

Our case study unit has the following data:

Stream	**Supply temp (°C)**	**Target temp (°C)**	**MCP (Kw/°C)**
H1	327	40	100
H2	220	160	160
H3	220	60	60
H4	160	45	400
C1	100	300	100
C2	35	164	70
C3	85	138	350
C4	60	170	60
C5	140	300	200

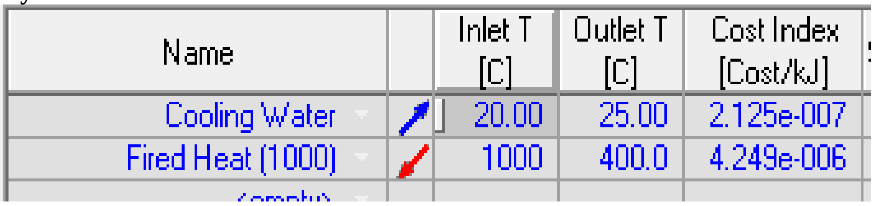
· **Heating cost = 60 $/KW.year**
· **Cooling water cost = 6 $/KW.year**
· **Heat transfer coefficient = 0.5 KW/m°C**
· **Installed unit cost = 10000 + 350 A** (Aspen Energy Analyzer, 2022)

1-Entering Process Stream Data:



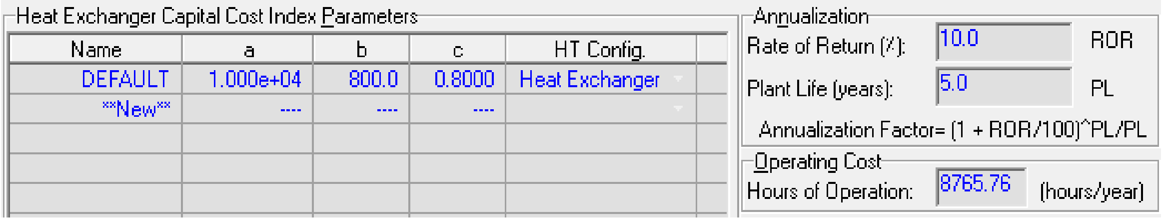
Name		Inlet T [C]	Outlet T [C]	MCp [kJ/C-h]	Enthalpy [kJ/h]	Segm.	HTC [kJ/h-m2-C]
h1	↙	327.0	40.0	100.0	2.870e+004		720.00
h2	↙	220.0	160.0	160.0	9600		720.00
h3	↙	220.0	60.0	60.00	9600		720.00
h4	↙	160.0	45.0	400.0	4.600e+004		720.00
c1	↗	100.0	300.0	100.0	2.000e+004		720.00
c2	↗	35.0	164.0	70.00	9030		720.00
c3	↗	85.0	138.0	350.0	1.855e+004		720.00
c4	↗	60.0	170.0	60.00	6600		720.00
c5	↗	140.0	300.0	200.0	3.200e+004		720.00

2-Entering Utility Stream Data:



Name		Inlet T [C]	Outlet T [C]	Cost Index [Cost/kJ]
Cooling Water	↗	20.00	25.00	2.125e-007
Fired Heat (1000)	↙	1000	400.0	4.249e-006

3-Click the Economics tab:



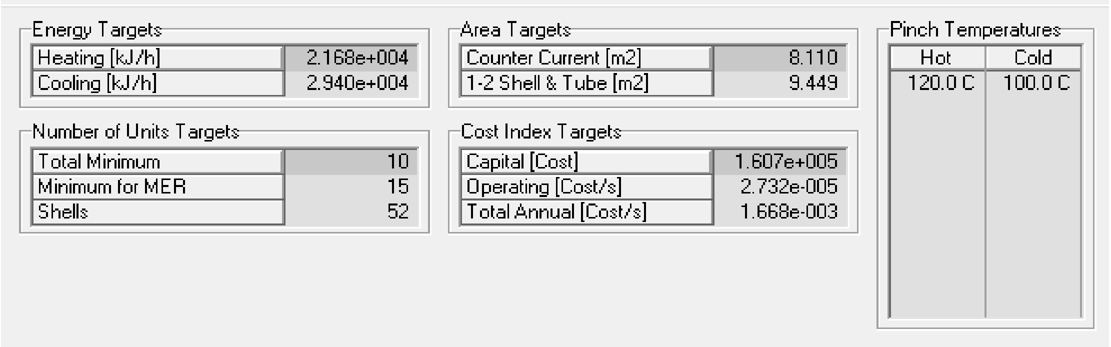
Heat Exchanger Capital Cost Index Parameters

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

Annualization
Rate of Return (%): 10.0 ROR
Plant Life (years): 5.0 PL
Annualization Factor= (1 + ROR/100)^PL/PL

Operating Cost
Hours of Operation: 8765.76 (hours/year)

4-Examining the Targets:



Energy Targets

Heating [kJ/h]	2.168e+004
Cooling [kJ/h]	2.940e+004

Area Targets

Counter Current [m2]	8.110
1-2 Shell & Tube [m2]	9.449

Pinch Temperatures

Hot	Cold
120.0 C	100.0 C

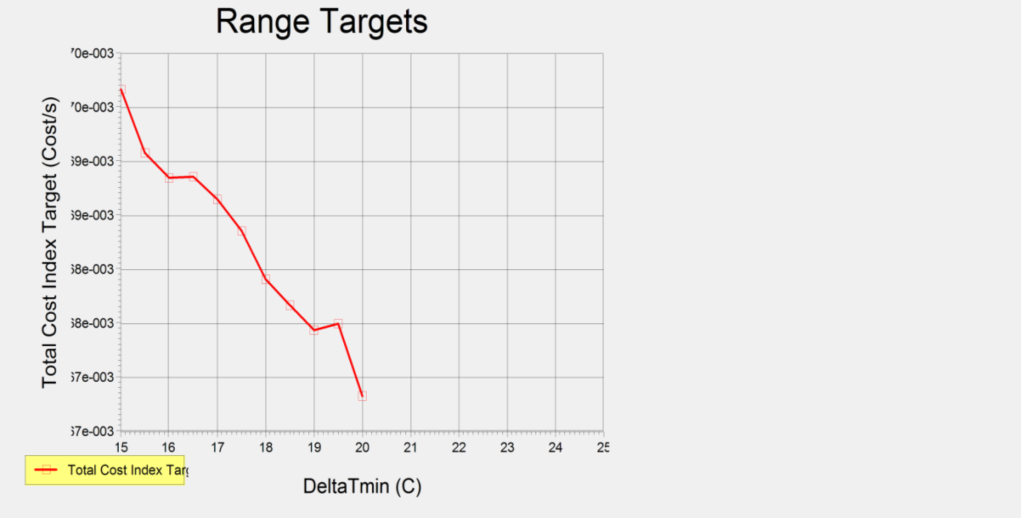
Number of Units Targets

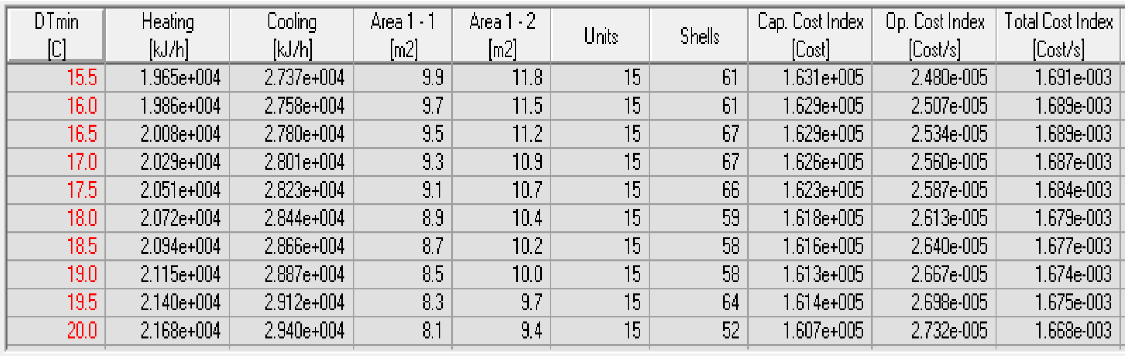
Total Minimum	10
Minimum for MER	15
Shells	52

Cost Index Targets

Capital [Cost]	1.607e+005
Operating [Cost/s]	2.732e-005
Total Annual [Cost/s]	1.668e-003

5-Range Targeting (Δt):





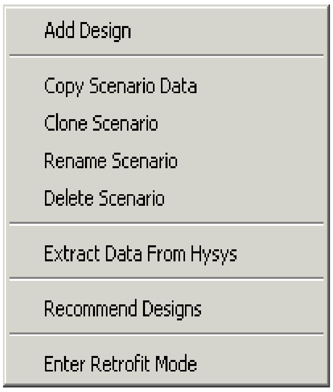
DTmin [C]	Heating [kJ/h]	Cooling [kJ/h]	Area 1 - 1 [m2]	Area 1 - 2 [m2]	Units	Shells	Cap. Cost Index [Cost]	Op. Cost Index [Cost/s]	Total Cost Index [Cost/s]
15.5	1.965e+004	2.737e+004	9.9	11.8	15	61	1.631e+005	2.480e-005	1.691e-003
16.0	1.986e+004	2.758e+004	9.7	11.5	15	61	1.629e+005	2.507e-005	1.689e-003
16.5	2.008e+004	2.780e+004	9.5	11.2	15	67	1.629e+005	2.534e-005	1.689e-003
17.0	2.029e+004	2.801e+004	9.3	10.9	15	67	1.626e+005	2.560e-005	1.687e-003
17.5	2.051e+004	2.823e+004	9.1	10.7	15	66	1.623e+005	2.587e-005	1.684e-003
18.0	2.072e+004	2.844e+004	8.9	10.4	15	59	1.618e+005	2.613e-005	1.679e-003
18.5	2.094e+004	2.866e+004	8.7	10.2	15	58	1.616e+005	2.640e-005	1.677e-003
19.0	2.115e+004	2.887e+004	8.5	10.0	15	58	1.613e+005	2.667e-005	1.674e-003
19.5	2.140e+004	2.912e+004	8.3	9.7	15	64	1.614e+005	2.698e-005	1.675e-003
20.0	2.168e+004	2.940e+004	8.1	9.4	15	52	1.607e+005	2.732e-005	1.668e-003

Click the Calculate button. Aspen Energy Analyzer initiates the new calculation automatically after shutting down the Range Target view. The results indicate that the optimal DTmin value is 20°C.

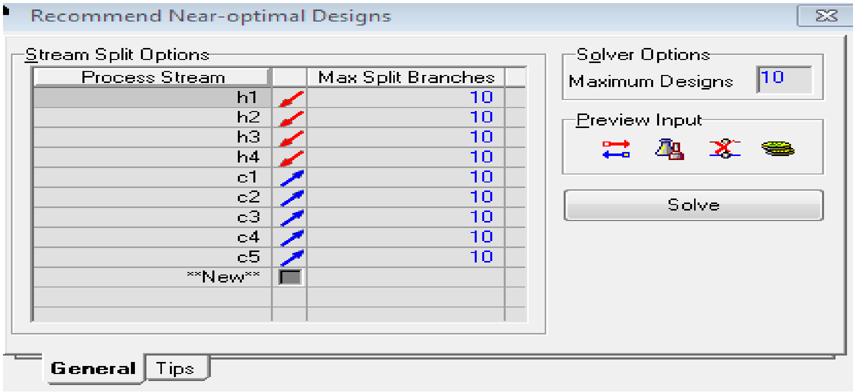
6-Generating HEN Designs:

This section explains how to use the Recommend Designs tool in Aspen Energy Analyzer to automatically create HEN designs. You have control over how many designs are generated using Aspen Energy Analyzer. You can then compare the design and make changes as needed.

1 In the Viewer group, click on the Scenario level.
2 Right-click the mouse button on the selected Scenario. The following menu appears



3 From this menu, select Recommend Designs. The Recommend Designs view appears as shown in the figure below. This view allows you to control certain aspects of the automatic design feature.



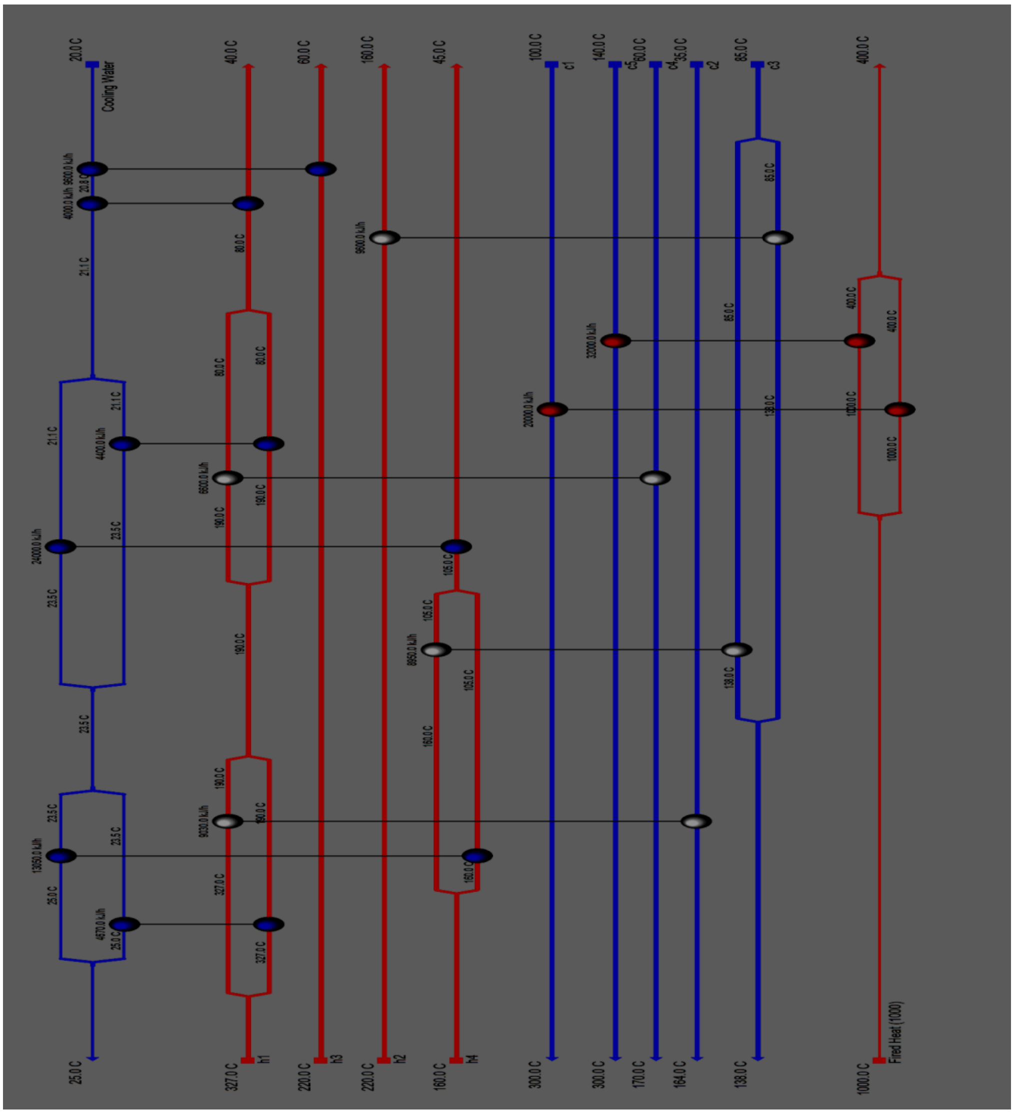
Recommend Near-optimal Designs

Stream Split Options

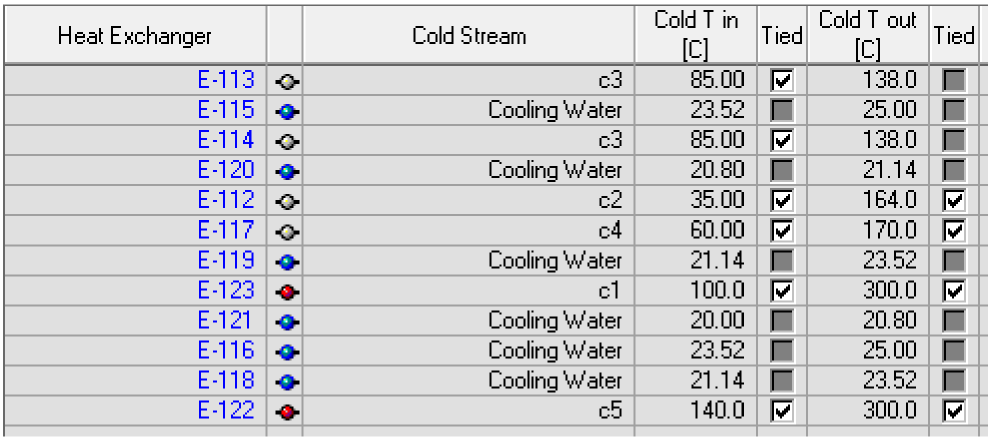
Process Stream		Max Split Branches
h1		10
h2		10
h3		10
h4		10
c1		10
c2		10
c3		10
c4		10
c5		10
New		

Solver Options
Maximum Designs: 10

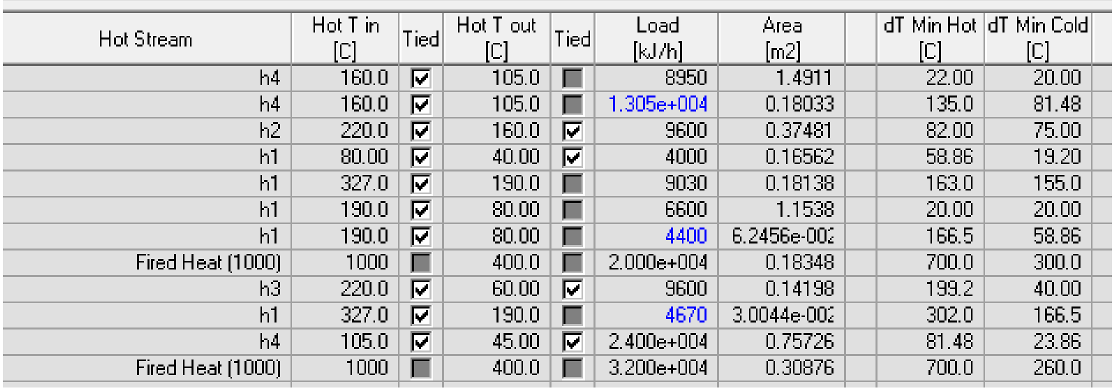
7-Building the Heat Exchanger Network:
Verify your heat exchanger using the worksheet and finished HEN diagram as shown in the pictures below.



8-worksheet:

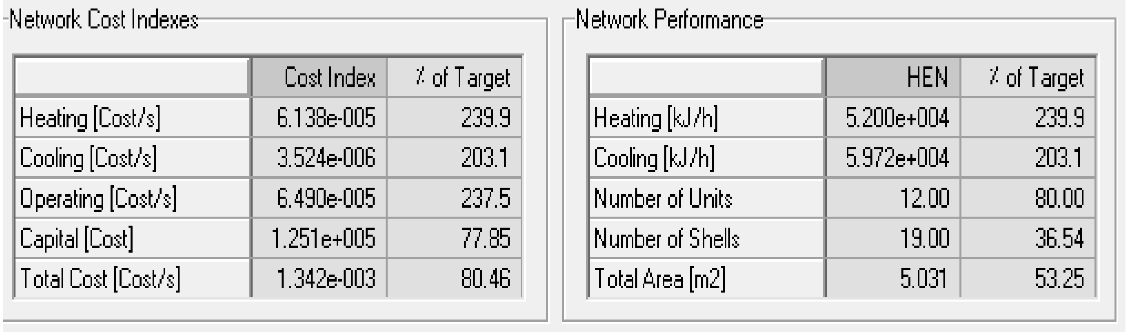


Heat Exchanger		Cold Stream	Cold T in [C]	Tied	Cold T out [C]	Tied
E-113		c3	85.00	☑	138.0	☐
E-115		Cooling Water	23.52	☐	25.00	☐
E-114		c3	85.00	☑	138.0	☐
E-120		Cooling Water	20.80	☐	21.14	☐
E-112		c2	35.00	☑	164.0	☑
E-117		c4	60.00	☑	170.0	☑
E-119		Cooling Water	21.14	☐	23.52	☐
E-123		c1	100.0	☑	300.0	☑
E-121		Cooling Water	20.00	☐	20.80	☐
E-116		Cooling Water	23.52	☐	25.00	☐
E-118		Cooling Water	21.14	☐	23.52	☐
E-122		c5	140.0	☑	300.0	☑



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]
h4	160.0	☑	105.0	☐	8950	1.4911		22.00	20.00
h4	160.0	☑	105.0	☐	1.305e+004	0.18033		135.0	81.48
h2	220.0	☑	160.0	☑	9600	0.37481		82.00	75.00
h1	80.00	☑	40.00	☑	4000	0.16562		58.86	19.20
h1	327.0	☑	190.0	☐	9030	0.18138		163.0	155.0
h1	190.0	☑	80.00	☐	6600	1.1538		20.00	20.00
h1	190.0	☑	80.00	☐	4400	6.2456e-00		166.5	58.86
Fired Heat (1000)	1000	☐	400.0	☐	2.000e+004	0.18348		700.0	300.0
h3	220.0	☑	60.00	☑	9600	0.14198		199.2	40.00
h1	327.0	☑	190.0	☐	4670	3.0044e-00		302.0	166.5
h4	105.0	☑	45.00	☑	2.400e+004	0.75726		81.48	23.86
Fired Heat (1000)	1000	☐	400.0	☐	3.200e+004	0.30876		700.0	260.0

9-Targets



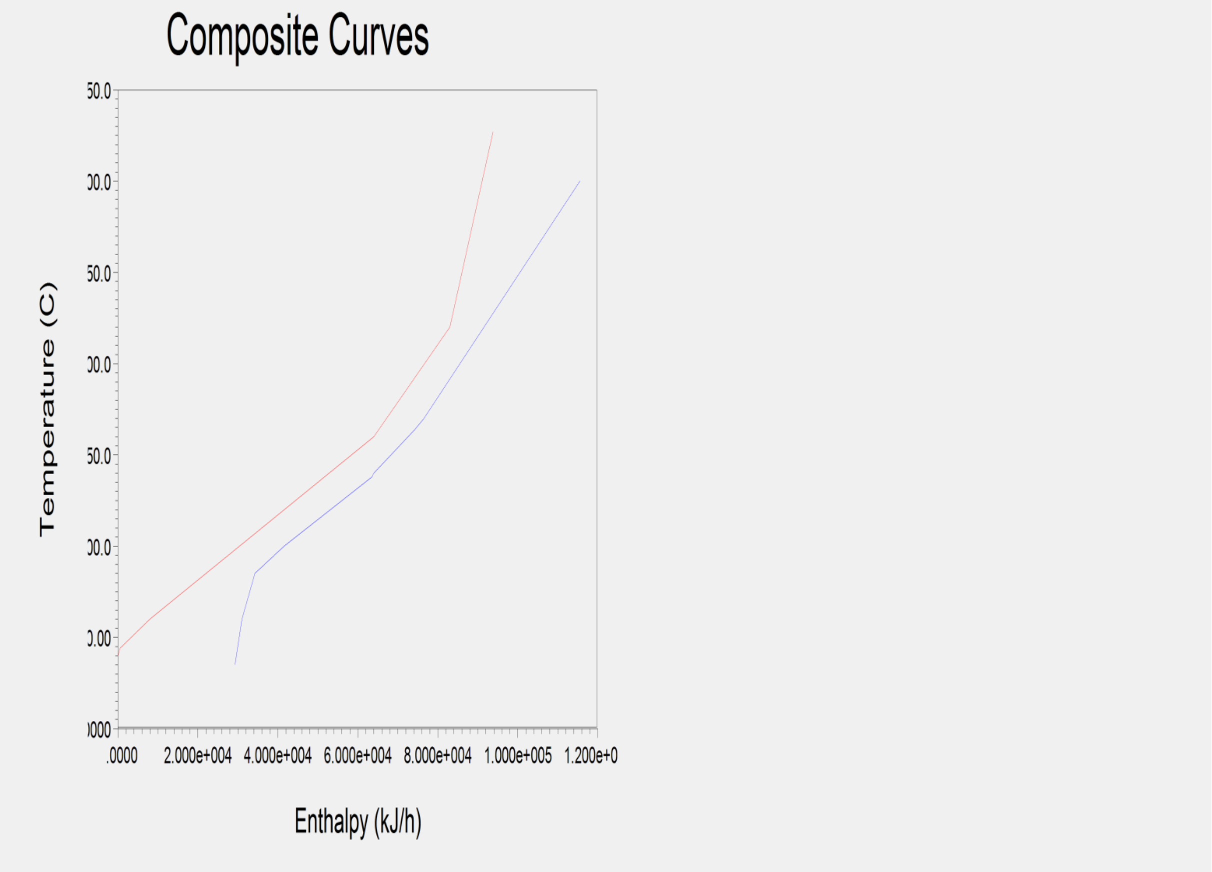
Network Cost Indexes

	Cost Index	% of Target
Heating [Cost/s]	6.138e-005	239.9
Cooling [Cost/s]	3.524e-006	203.1
Operating [Cost/s]	6.490e-005	237.5
Capital [Cost]	1.251e+005	77.85
Total Cost [Cost/s]	1.342e-003	80.46

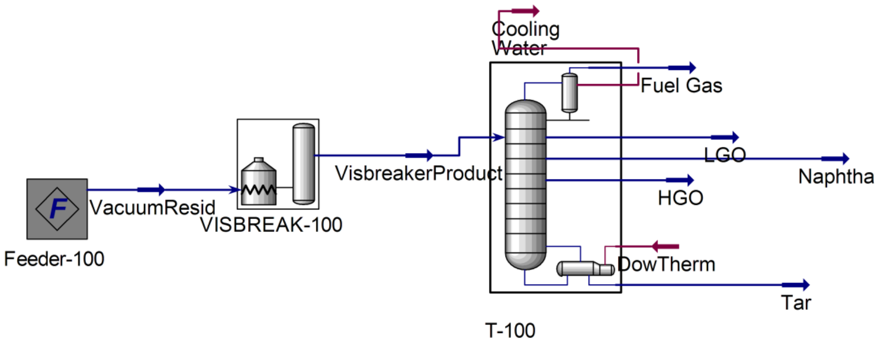
Network Performance

	HEN	% of Target
Heating [kJ/h]	5.200e+004	239.9
Cooling [kJ/h]	5.972e+004	203.1
Number of Units	12.00	80.00
Number of Shells	19.00	36.54
Total Area [m2]	5.031	53.25

10-Composite curves:



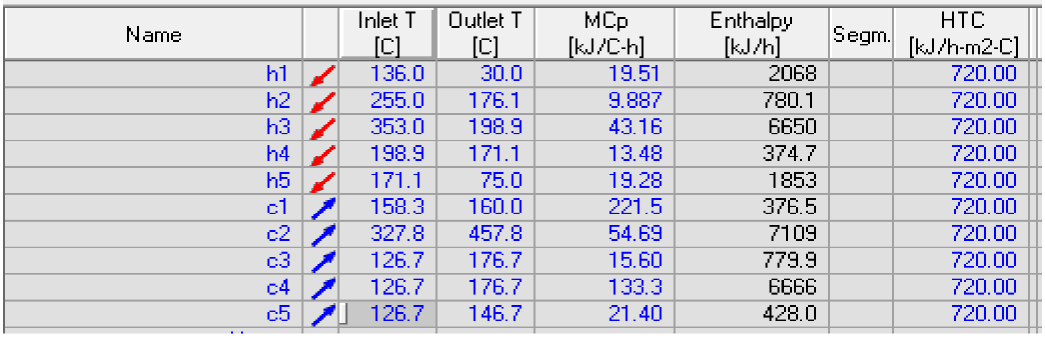
3-Visbreaking Unit



Streams	Supply temp (°C)	Target temp (°C)	MCP (Kw/°C)
H1	136	30	19.506
H2	255	176.1	9.887
H3	353	198.9	43.156
H4	198.9	171.1	13.477
H5	171.1	75	19.279
C1	327.8	457.8	54.685
C2	158.3	160	221.49
C3	126.7	176.7	15.599
C4	126.7	176.7	133.329
C5	126.7	146.7	21.364

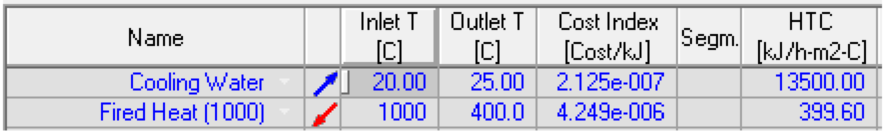
Our case study unit has the following data:
- **Heating cost = 86000 \$/MW.year**
- **Cooling water cost = 18800 \$/MW.year**
- **Heat transfer coefficient = 0.5 KW/m^2 °C**
- **Installed unit cost = 6480 A $^{0.65}$** (Aspen Energy Analyzer, 2022)

1-Entering Process Stream Data:



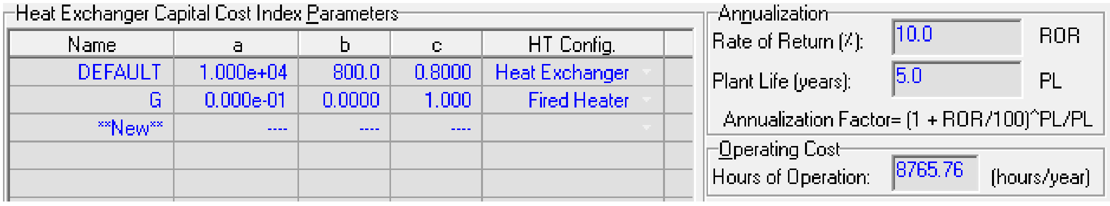
Name		Inlet T [C]	Outlet T [C]	MCp [kJ/C-h]	Enthalpy [kJ/h]	Segm.	HTC [kJ/h-m2-C]
h1	↙	136.0	30.0	19.51	2068		720.00
h2	↙	255.0	176.1	9.887	780.1		720.00
h3	↙	353.0	198.9	43.16	6650		720.00
h4	↙	198.9	171.1	13.48	374.7		720.00
h5	↙	171.1	75.0	19.28	1853		720.00
c1	↗	158.3	160.0	221.5	376.5		720.00
c2	↗	327.8	457.8	54.69	7109		720.00
c3	↗	126.7	176.7	15.60	779.9		720.00
c4	↗	126.7	176.7	133.3	6666		720.00
c5	↗	126.7	146.7	21.40	428.0		720.00

2-Entering Utility Stream Data:



Name		Inlet T [C]	Outlet T [C]	Cost Index [Cost/kJ]	Segm.	HTC [kJ/h-m2-C]
Cooling Water	↗	20.00	25.00	2.125e-007		13500.00
Fired Heat (1000)	↙	1000	400.0	4.249e-006		399.60

3-Click the Economics tab:



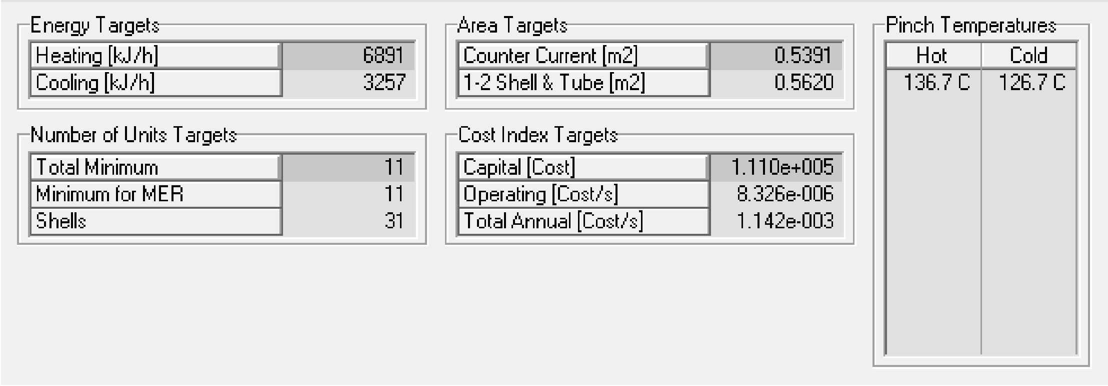
Heat Exchanger Capital Cost Index Parameters

Name	a	b	c	HT Config.
DEFAULT	1.000e+04	800.0	0.8000	Heat Exchanger
G	0.000e-01	0.0000	1.000	Fired Heater
New	----	----	----	

Annualization
Rate of Return (%): 10.0 ROR
Plant Life (years): 5.0 PL
Annualization Factor= (1 + ROR/100)^PL/PL

Operating Cost
Hours of Operation: 8765.76 (hours/year)

4-Examining the Targets:



Energy Targets

Heating [kJ/h]	6891
Cooling [kJ/h]	3257

Area Targets

Counter Current [m2]	0.5391
1-2 Shell & Tube [m2]	0.5620

Pinch Temperatures

Hot	Cold
136.7 C	126.7 C

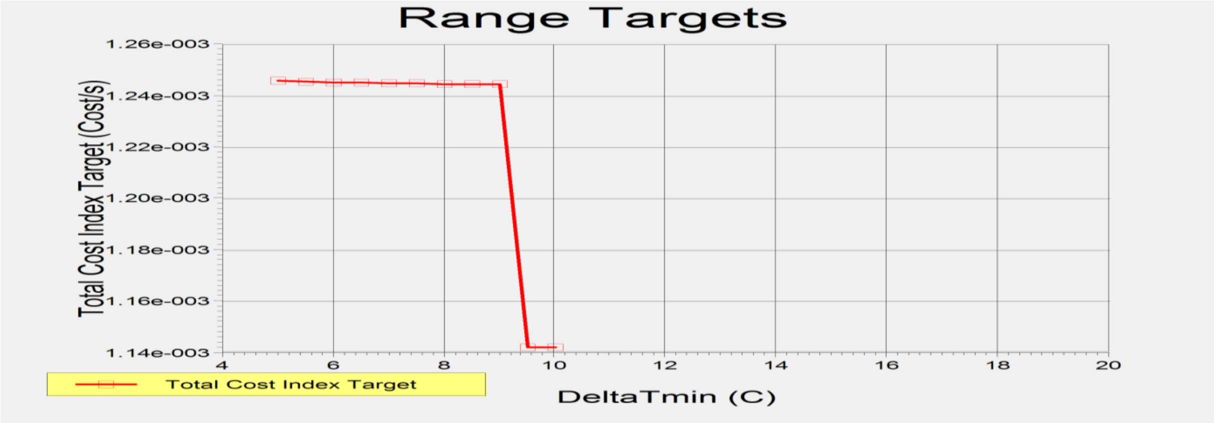
Number of Units Targets

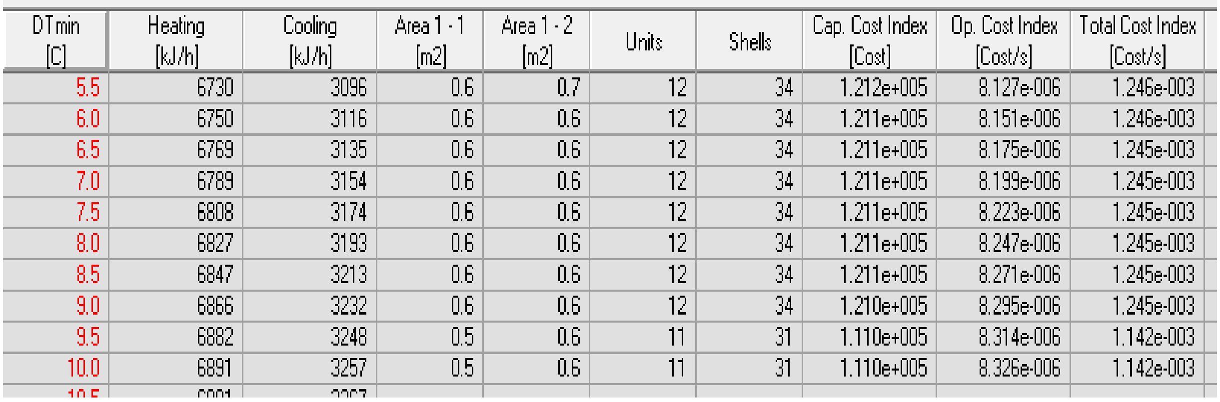
Total Minimum	11
Minimum for MER	11
Shells	31

Cost Index Targets

Capital [Cost]	1.110e+005
Operating [Cost/s]	8.326e-006
Total Annual [Cost/s]	1.142e-003

5-Range Targeting:





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]
5.5	6730	3096	0.6	0.7	12	34	1.212e+005	8.127e-006	1.246e-003
6.0	6750	3116	0.6	0.6	12	34	1.211e+005	8.151e-006	1.246e-003
6.5	6769	3135	0.6	0.6	12	34	1.211e+005	8.175e-006	1.245e-003
7.0	6789	3154	0.6	0.6	12	34	1.211e+005	8.199e-006	1.245e-003
7.5	6808	3174	0.6	0.6	12	34	1.211e+005	8.223e-006	1.245e-003
8.0	6827	3193	0.6	0.6	12	34	1.211e+005	8.247e-006	1.245e-003
8.5	6847	3213	0.6	0.6	12	34	1.211e+005	8.271e-006	1.245e-003
9.0	6866	3232	0.6	0.6	12	34	1.210e+005	8.295e-006	1.245e-003
9.5	6882	3248	0.5	0.6	11	31	1.110e+005	8.314e-006	1.142e-003
10.0	6891	3257	0.5	0.6	11	31	1.110e+005	8.326e-006	1.142e-003

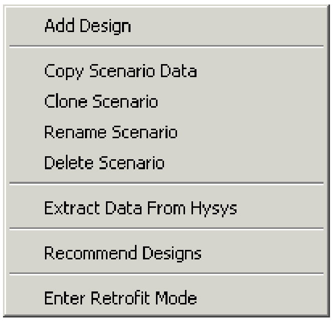
Click the Calculate button. Aspen Energy Analyzer automatically closes the Range Target view and performs the new calculation. The results indicate that the optimal DTmin value is 10°C.

6-Generating HEN Designs:

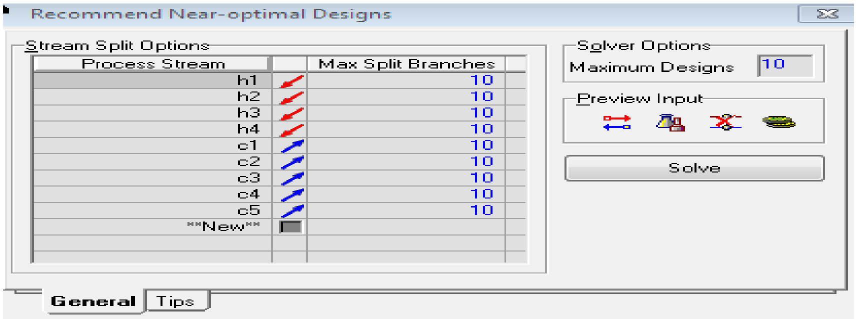
In this section, you'll learn how to create HEN designs automatically using Aspen Energy Analyzer's Recommend Designs tool. You have control over how many designs are generated using Aspen Energy Analyzer. The designs can then be compared, and changes can be made as needed.

1 In the Viewer group, click on the Scenario level.

2 Right-click the mouse button on the selected Scenario. The following menu appears



3 From this menu, select Recommend Designs. The Recommend Designs view appears as shown in the figure below. You can use this view to control certain aspects of the automatic design function.

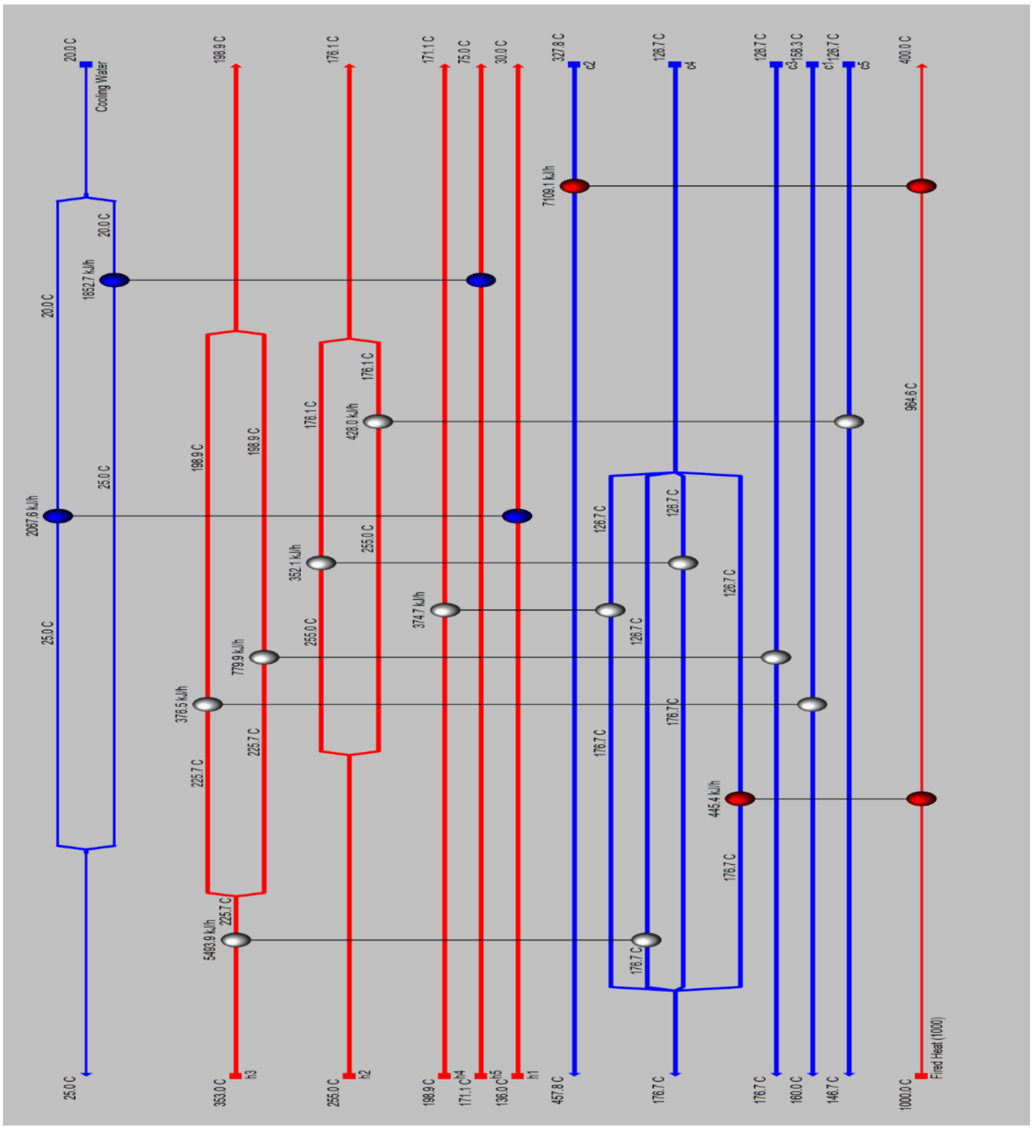


Process Stream		Max Split Branches
h1		10
h2		10
h3		10
h4		10
c1		10
c2		10
c3		10
c4		10
c5		10
New		

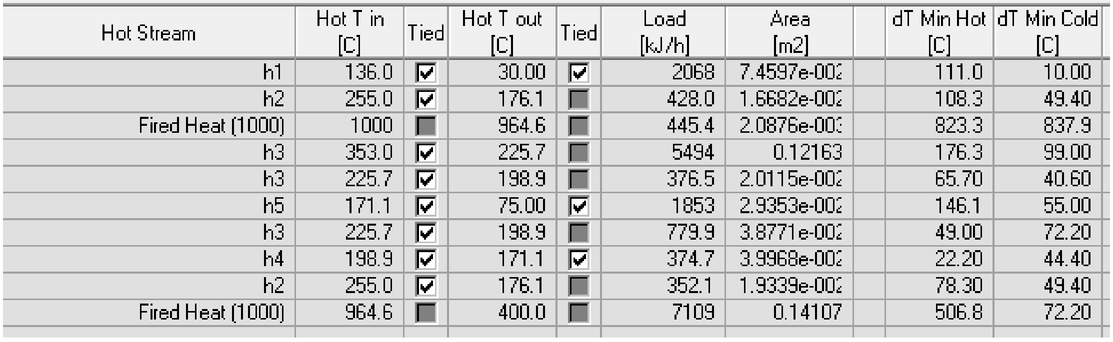
Maximum Designs 10

7-Building the Heat Exchanger Network:

Verify your heat exchanger using the worksheet and finished HEN diagram as shown in the pictures below.

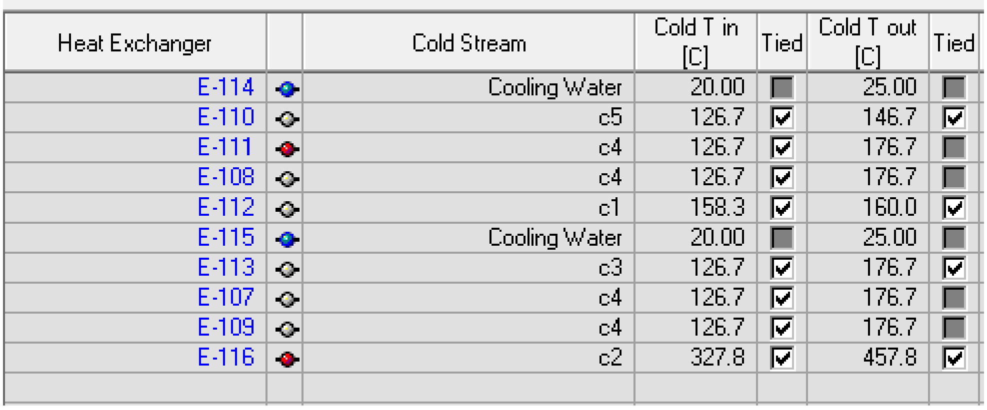


8-Targets:

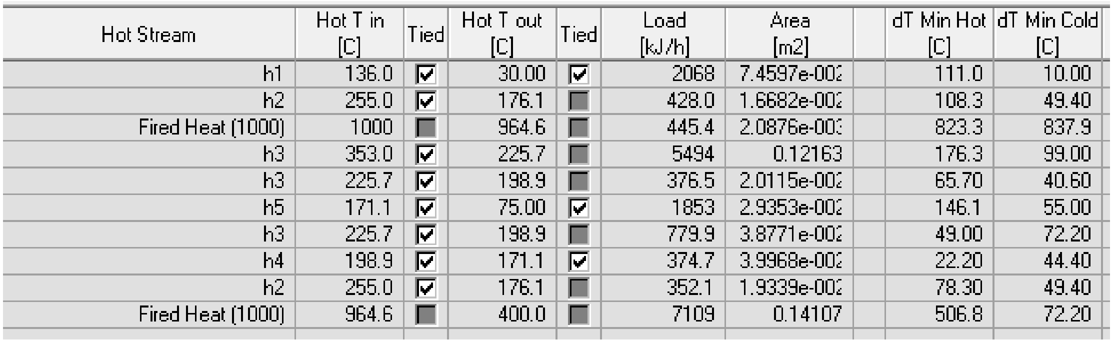


Hot Stream	Hot T in [C]	Tied	Hot T out [C]	Tied	Load [kJ/h]	Area [m2]		dT Min Hot [C]	dT Min Cold [C]
h1	136.0	☑	30.00	☑	2068	7.4597e-00		111.0	10.00
h2	255.0	☑	176.1	☐	428.0	1.6682e-00		108.3	49.40
Fired Heat (1000)	1000	☐	964.6	☐	445.4	2.0876e-00		823.3	837.9
h3	353.0	☑	225.7	☐	5494	0.12163		176.3	99.00
h3	225.7	☑	198.9	☐	376.5	2.0115e-00		65.70	40.60
h5	171.1	☑	75.00	☑	1853	2.9353e-00		146.1	55.00
h3	225.7	☑	198.9	☐	779.9	3.8771e-00		49.00	72.20
h4	198.9	☑	171.1	☑	374.7	3.9968e-00		22.20	44.40
h2	255.0	☑	176.1	☐	352.1	1.9339e-00		78.30	49.40
Fired Heat (1000)	964.6	☐	400.0	☐	7109	0.14107		506.8	72.20

9-worksheet:

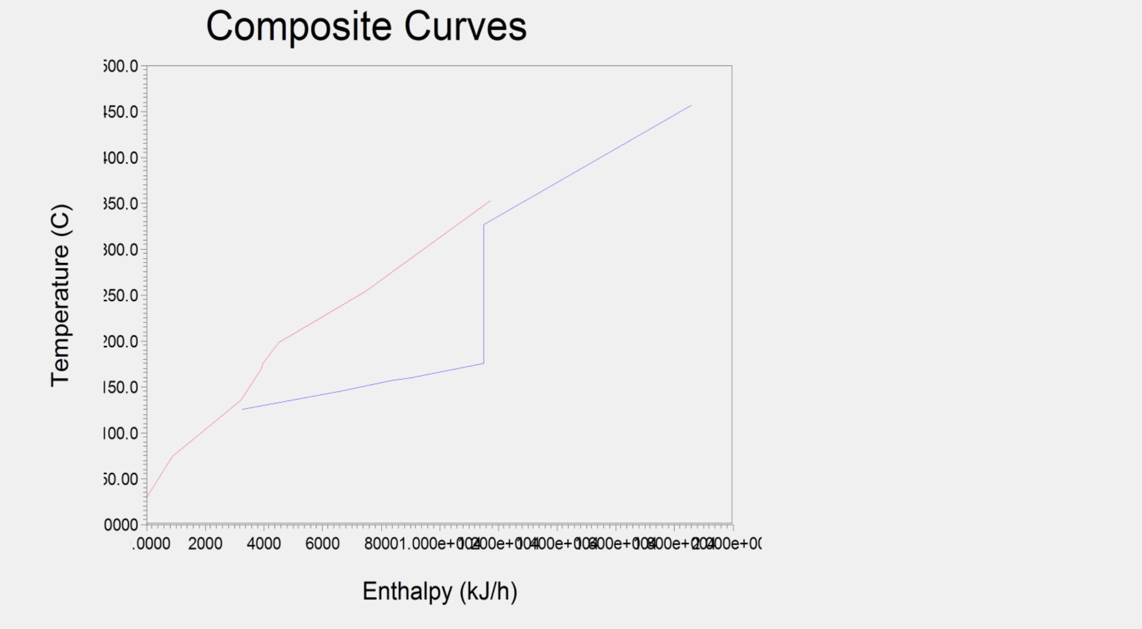


Heat Exchanger		Cold Stream	Cold T in [C]	Tied	Cold T out [C]	Tied
E-114	●	Cooling Water	20.00	☐	25.00	☐
E-110	○	c5	126.7	☑	146.7	☑
E-111	●	c4	126.7	☑	176.7	☐
E-108	○	c4	126.7	☑	176.7	☐
E-112	○	c1	158.3	☑	160.0	☑
E-115	●	Cooling Water	20.00	☐	25.00	☐
E-113	○	c3	126.7	☑	176.7	☑
E-107	○	c4	126.7	☑	176.7	☐
E-109	○	c4	126.7	☑	176.7	☐
E-116	●	c2	327.8	☑	457.8	☑



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]
h1	136.0	☑	30.00	☑	2068	7.4597e-002		111.0	10.00
h2	255.0	☑	176.1	☐	428.0	1.6682e-002		108.3	49.40
Fired Heat (1000)	1000	☐	964.6	☐	445.4	2.0876e-003		823.3	837.9
h3	353.0	☑	225.7	☐	5494	0.12163		176.3	99.00
h3	225.7	☑	198.9	☐	376.5	2.0115e-002		65.70	40.60
h5	171.1	☑	75.00	☑	1853	2.9353e-002		146.1	55.00
h3	225.7	☑	198.9	☐	779.9	3.8771e-002		49.00	72.20
h4	198.9	☑	171.1	☑	374.7	3.9968e-002		22.20	44.40
h2	255.0	☑	176.1	☐	352.1	1.9339e-002		78.30	49.40
Fired Heat (1000)	964.6	☐	400.0	☐	7109	0.14107		506.8	72.20

10-Composite curves:



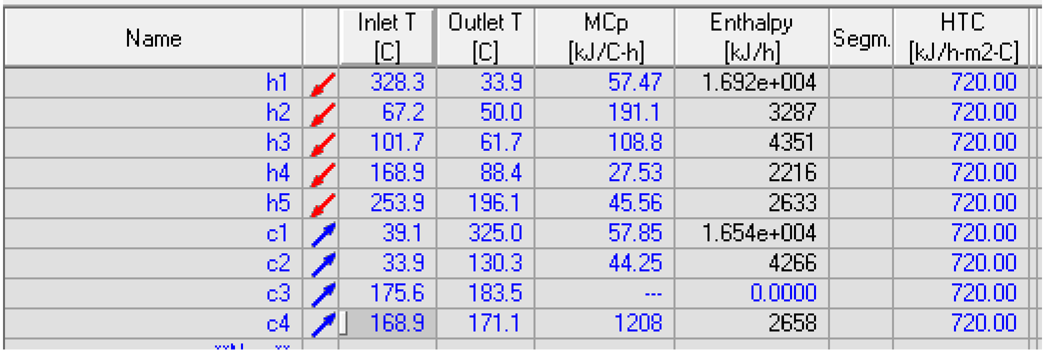
4-Naphtha Hydrotreating Unit

Our case study unit has the following data:

Stream	**Supply temp (°C)**	**Target temp (°C)**	**MCP (Kw/°C)**
H1	328.3	33.9	57.471
H2	67.2	50	191.086
H3	101.7	61.7	108.78
H4	168.9	88.3	27.527
H5	253.9	146.1	45.556
C1	39.1	325	57.85
C2	33.9	130.3	44.252
C3	175.6	183.5	589.627
C4	168.9	171.1	1208.129

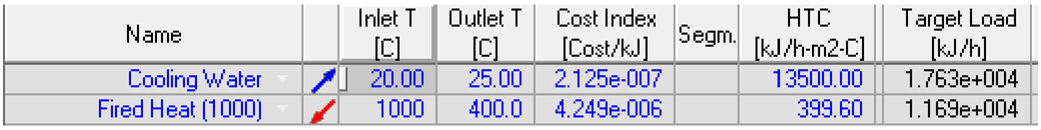
- **Heating cost = 55000 $/MW.year**
- **Cooling water cost = 10000 $/MW.year**
- **Heat transfer coefficient = 0.5 KW/m2. °C**
- **Installed unit cost = 700 A$^{0.83}$** (Aspen Energy Analyzer, 2022)

1-Entering Process Stream Data:



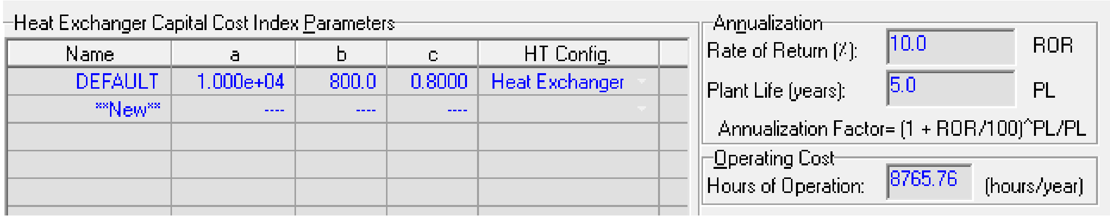
Name		Inlet T [C]	Outlet T [C]	MCp [kJ/C-h]	Enthalpy [kJ/h]	Segm.	HTC [kJ/h-m2-C]
h1	↙	328.3	33.9	57.47	1.692e+004		720.00
h2	↙	67.2	50.0	191.1	3287		720.00
h3	↙	101.7	61.7	108.8	4351		720.00
h4	↙	168.9	88.4	27.53	2216		720.00
h5	↙	253.9	196.1	45.56	2633		720.00
c1	↗	39.1	325.0	57.85	1.654e+004		720.00
c2	↗	33.9	130.3	44.25	4266		720.00
c3	↗	175.6	183.5	---	0.0000		720.00
c4	↗	168.9	171.1	1208	2658		720.00

2-Entering Utility Stream Data:



Name		Inlet T [C]	Outlet T [C]	Cost Index [Cost/kJ]	Segm.	HTC [kJ/h-m2-C]	Target Load [kJ/h]
Cooling Water	↗	20.00	25.00	2.125e-007		13500.00	1.763e+004
Fired Heat (1000)	↙	1000	400.0	4.249e-006		399.60	1.169e+004

3-Click the Economics tab:



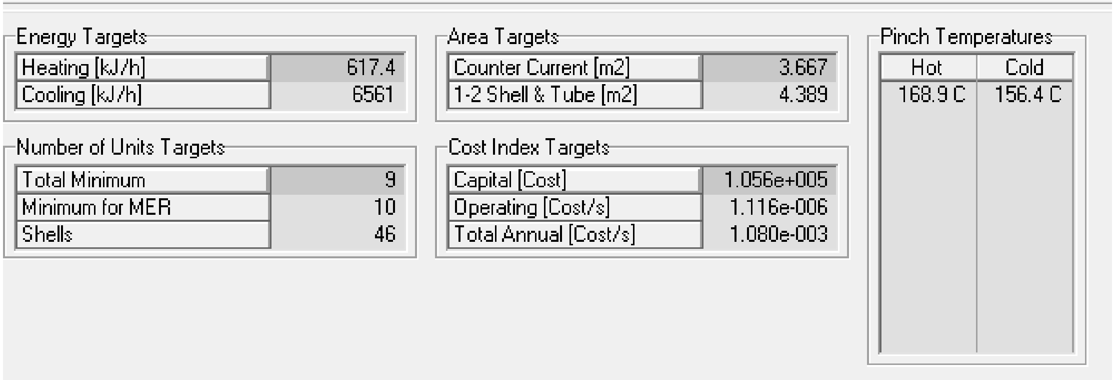
Heat Exchanger Capital Cost Index Parameters

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

Annualization
Rate of Return (%): 10.0 ROR
Plant Life (years): 5.0 PL
Annualization Factor= (1 + ROR/100)^PL/PL

Operating Cost
Hours of Operation: 8765.76 (hours/year)

4-Examining the Targets:



Energy Targets

Heating [kJ/h]	617.4
Cooling [kJ/h]	6561

Area Targets

Counter Current [m2]	3.667
1-2 Shell & Tube [m2]	4.389

Pinch Temperatures

Hot	Cold
168.9 C	156.4 C

Number of Units Targets

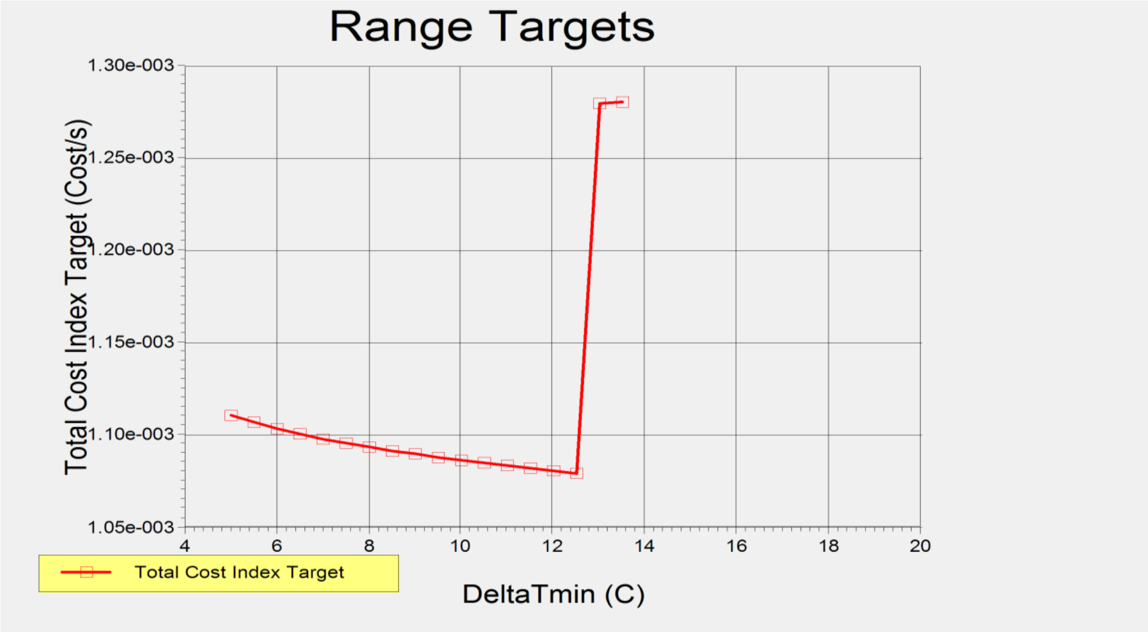
Total Minimum	9
Minimum for MER	10
Shells	46

Cost Index Targets

Capital [Cost]	1.056e+005
Operating [Cost/s]	1.116e-006
Total Annual [Cost/s]	1.080e-003

5-Range Targeting:

Click the Calculate button. Aspen Energy Analyzer automatically closes the Range Target view and performs the new calculation. The results indicate that the optimal DTmin value is 12.5°C.

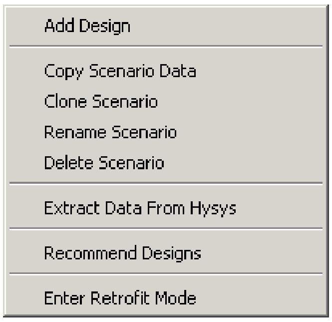


6-Generating HEN Designs

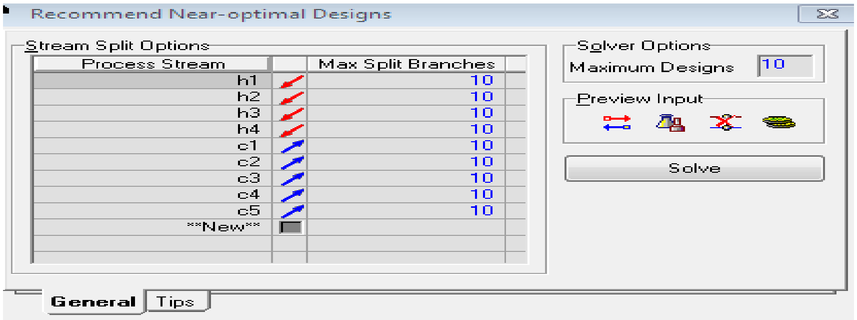
This section explains how to use the Recommend Designs tool in Aspen Energy Analyzer to automatically create HEN designs. You have control over the number of designs generated with the Aspen Energy Analyzer. You can then compare the design and make changes as needed.

1 In the Viewer group, click on the Scenario level.

2 Right-click the mouse button on the selected Scenario. The following menu appears.



3 From this menu, select Recommend Designs. The Recommend Designs view appears as shown below. This view can be used to control specific automatic design features.

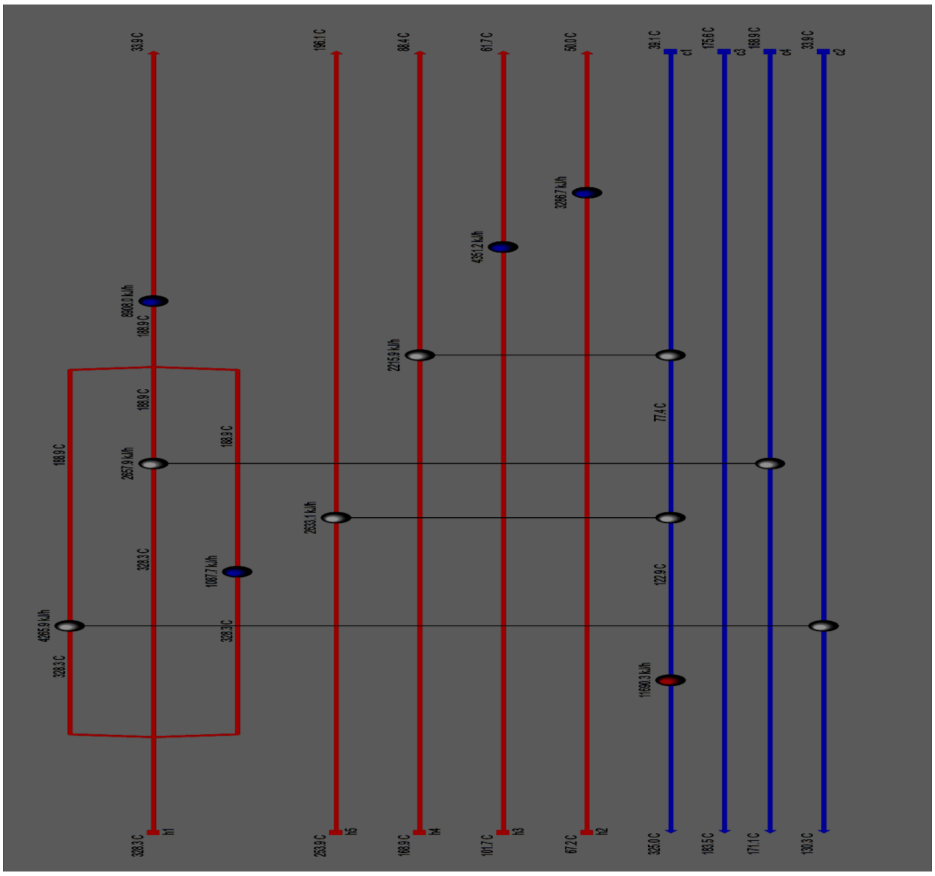


Process Stream	Max Split Branches
h1	10
h2	10
h3	10
h4	10
c1	10
c2	10
c3	10
c4	10
c5	10
New	

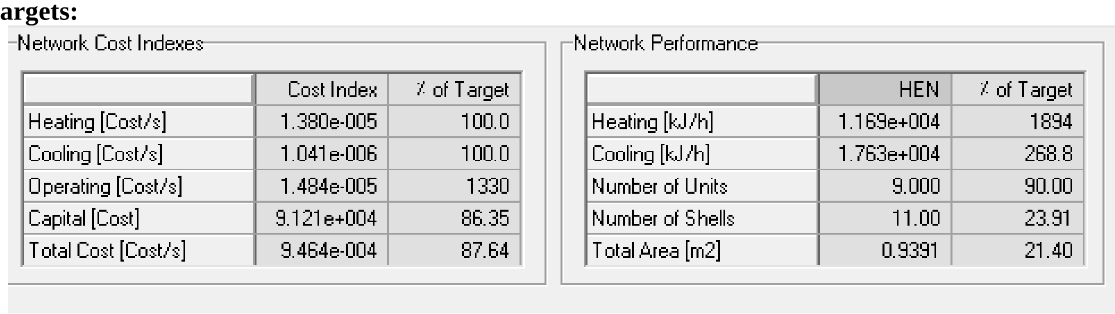
Maximum Designs 10

7-Building the Heat Exchanger Network

Use the completed HEN diagram and worksheet to confirm the heat exchanger, as shown in the figure below.



8-Targets:



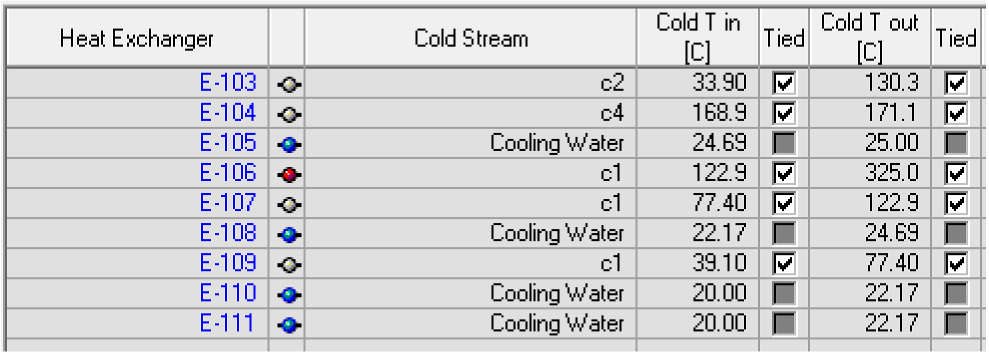
Network Cost Indexes

	Cost Index	% of Target
Heating [Cost/s]	1.380e-005	100.0
Cooling [Cost/s]	1.041e-006	100.0
Operating [Cost/s]	1.484e-005	1330
Capital [Cost]	9.121e+004	86.35
Total Cost [Cost/s]	9.464e-004	87.64

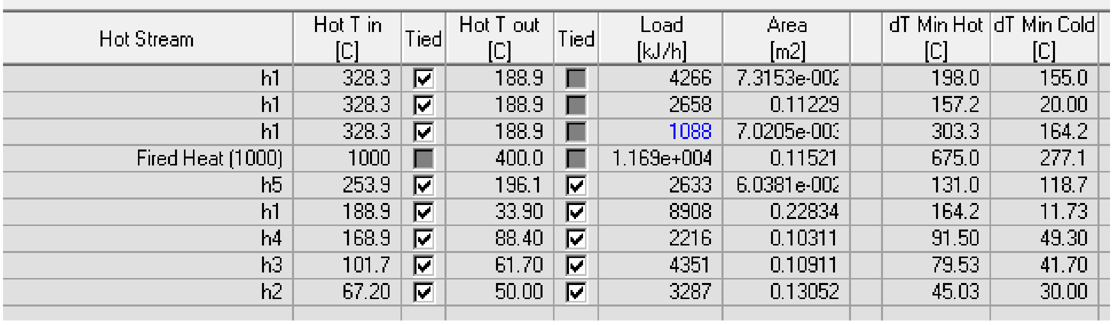
Network Performance

	HEN	% of Target
Heating [kJ/h]	1.169e+004	1894
Cooling [kJ/h]	1.763e+004	268.8
Number of Units	9.000	90.00
Number of Shells	11.00	23.91
Total Area [m2]	0.9391	21.40

9-worksheet:

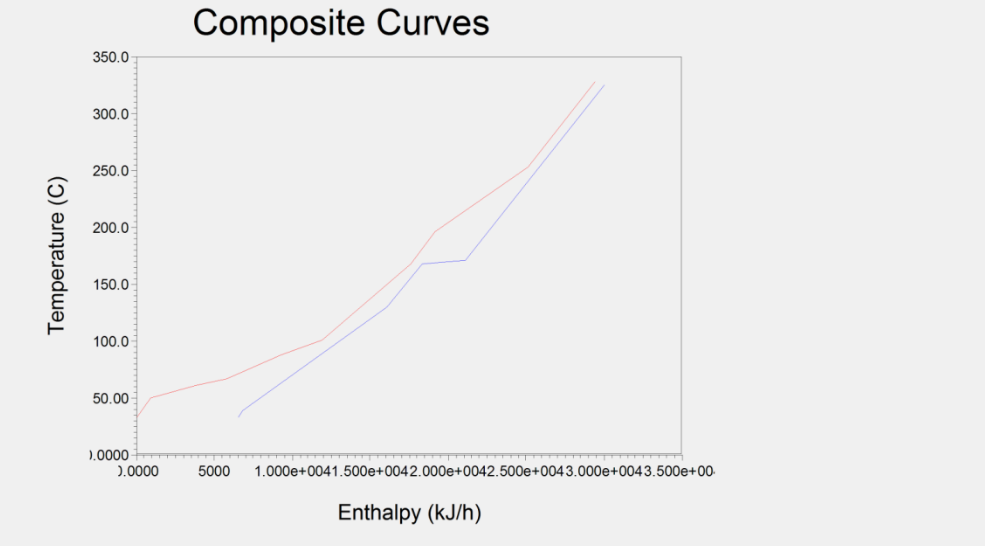


Heat Exchanger		Cold Stream	Cold T in [C]	Tied	Cold T out [C]	Tied
E-103	○	c2	33.90	☑	130.3	☑
E-104	○	c4	168.9	☑	171.1	☑
E-105	🔵	Cooling Water	24.69	■	25.00	■
E-106	🔴	c1	122.9	☑	325.0	☑
E-107	○	c1	77.40	☑	122.9	☑
E-108	🔵	Cooling Water	22.17	■	24.69	■
E-109	○	c1	39.10	☑	77.40	☑
E-110	🔵	Cooling Water	20.00	■	22.17	■
E-111	🔵	Cooling Water	20.00	■	22.17	■



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]
h1	328.3	☑	188.9	■	4266	7.3153e-002		198.0	155.0
h1	328.3	☑	188.9	■	2658	0.11229		157.2	20.00
h1	328.3	☑	188.9	■	1088	7.0205e-003		303.3	164.2
Fired Heat (1000)	1000	■	400.0	■	1.169e+004	0.11521		675.0	277.1
h5	253.9	☑	196.1	☑	2633	6.0381e-002		131.0	118.7
h1	188.9	☑	33.90	☑	8908	0.22834		164.2	11.73
h4	168.9	☑	88.40	☑	2216	0.10311		91.50	49.30
h3	101.7	☑	61.70	☑	4351	0.10911		79.53	41.70
h2	67.20	☑	50.00	☑	3287	0.13052		45.03	30.00

10-Composite curves:

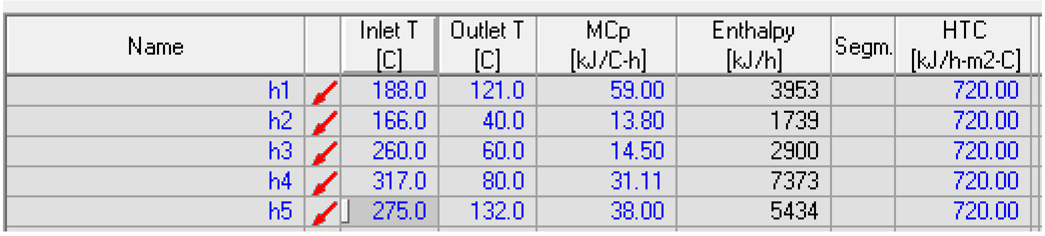


5-Crude Oil Distillation

We have a crude oil distillation unit that has one cold stream and five hot steams. The full data of the unit is given as follows: (Aspen Energy Analyzer, 2022)

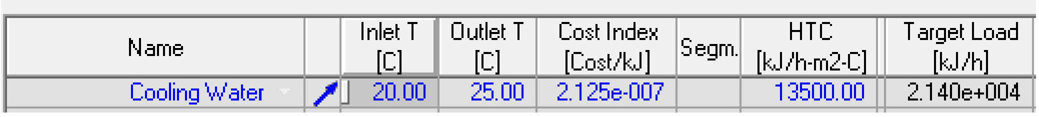
Stream	Type	T(Supply◦C)	T(Target◦C)	MCP(kW/◦c)
H1	T.P.A	188	121	59
H2	Kerosene	166	40	13.8
H3	Gas Oil	260	60	14.5
H4	Fuel oil	317	80	31.11
H5	B.P.A	275	132	38

1-Entering Process Stream Data:

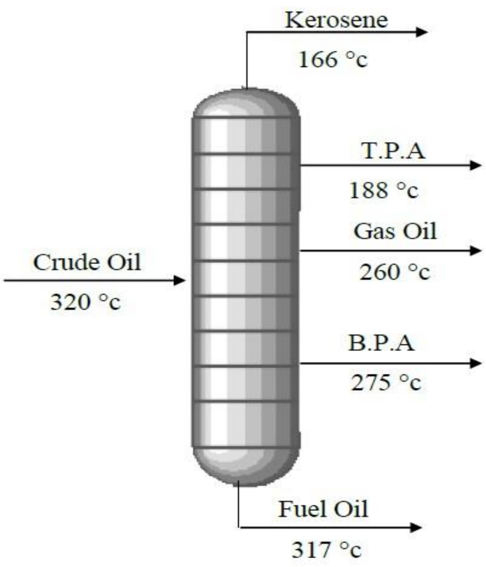


Name		Inlet T [C]	Outlet T [C]	MCp [kJ/C-h]	Enthalpy [kJ/h]	Segm.	HTC [kJ/h-m2-C]
h1	↙	188.0	121.0	59.00	3953		720.00
h2	↙	166.0	40.0	13.80	1739		720.00
h3	↙	260.0	60.0	14.50	2900		720.00
h4	↙	317.0	80.0	31.11	7373		720.00
h5	↙	275.0	132.0	38.00	5434		720.00

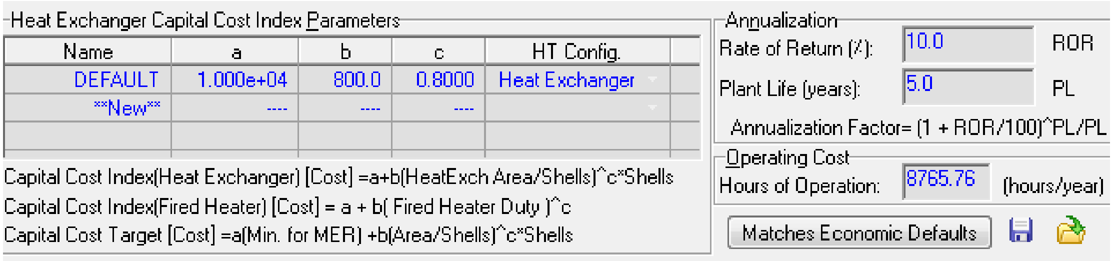
2-Entering Utility Stream Data:



Name		Inlet T [C]	Outlet T [C]	Cost Index [Cost/kJ]	Segm.	HTC [kJ/h-m2-C]	Target Load [kJ/h]
Cooling Water	↗	20.00	25.00	2.125e-007		13500.00	2.140e+004



3-Click the Economics tab:



Heat Exchanger Capital Cost Index Parameters

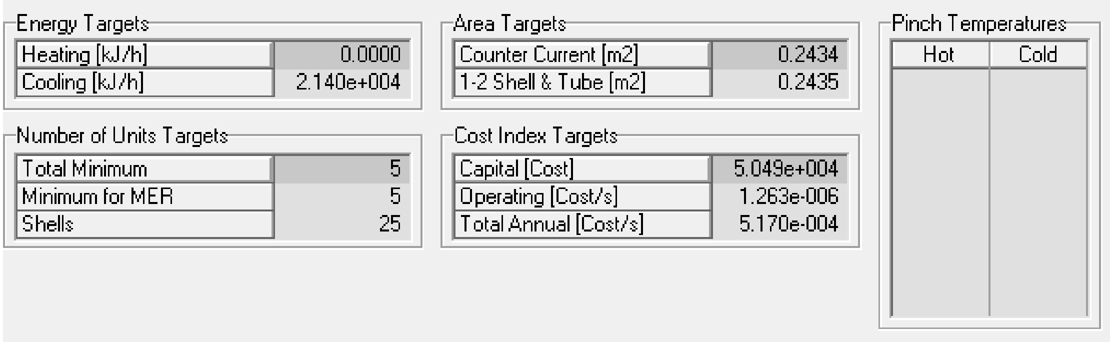
Name	a	b	c	HT Config.
DEFAULT	1.000e+04	800.0	0.8000	Heat Exchanger
New	----	----	----	

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
Capital Cost Target [Cost] =a(Min. for MER) +b(Area/Shells)^c*Shells

Annualization
Rate of Return (%): 10.0 ROR
Plant Life (years): 5.0 PL
Annualization Factor= (1 + ROR/100)^PL/PL

Operating Cost
Hours of Operation: 8765.76 (hours/year)

4-Examining the Targets:



Energy Targets

Heating [kJ/h]	0.0000
Cooling [kJ/h]	2.140e+004

Area Targets

Counter Current [m2]	0.2434
1-2 Shell & Tube [m2]	0.2435

Number of Units Targets

Total Minimum	5
Minimum for MER	5
Shells	25

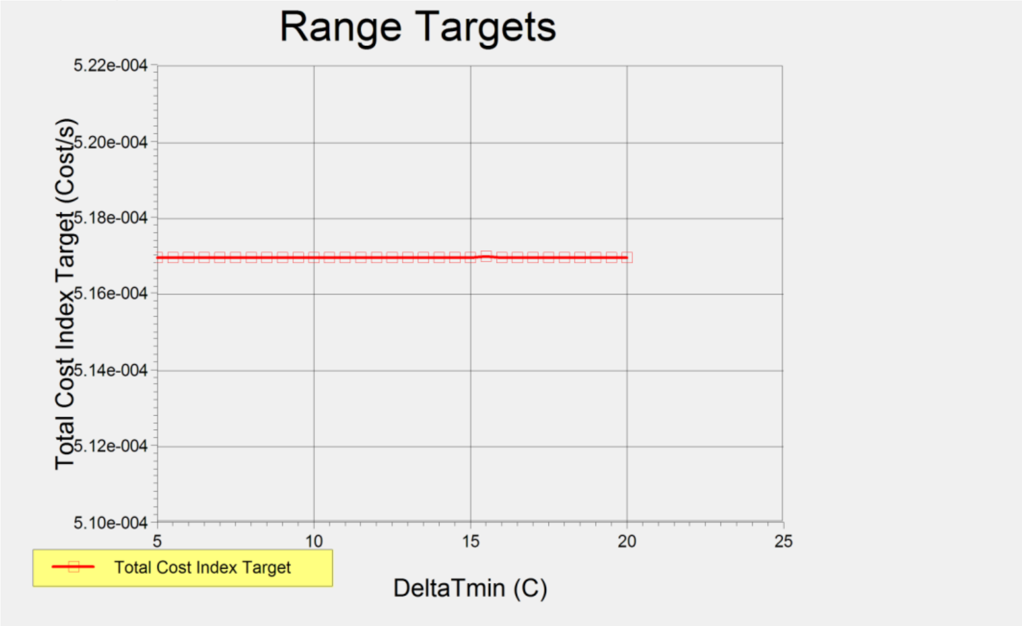
Cost Index Targets

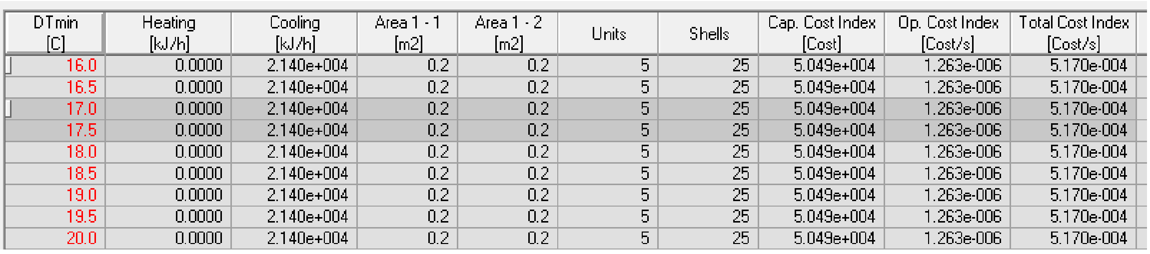
Capital [Cost]	5.049e+004
Operating [Cost/s]	1.263e-006
Total Annual [Cost/s]	5.170e-004

Pinch Temperatures

Hot	Cold

5-Range Targeting:





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]
16.0	0.0000	2.140e+004	0.2	0.2	5	25	5.049e+004	1.263e-006	5.170e-004
16.5	0.0000	2.140e+004	0.2	0.2	5	25	5.049e+004	1.263e-006	5.170e-004
17.0	0.0000	2.140e+004	0.2	0.2	5	25	5.049e+004	1.263e-006	5.170e-004
17.5	0.0000	2.140e+004	0.2	0.2	5	25	5.049e+004	1.263e-006	5.170e-004
18.0	0.0000	2.140e+004	0.2	0.2	5	25	5.049e+004	1.263e-006	5.170e-004
18.5	0.0000	2.140e+004	0.2	0.2	5	25	5.049e+004	1.263e-006	5.170e-004
19.0	0.0000	2.140e+004	0.2	0.2	5	25	5.049e+004	1.263e-006	5.170e-004
19.5	0.0000	2.140e+004	0.2	0.2	5	25	5.049e+004	1.263e-006	5.170e-004
20.0	0.0000	2.140e+004	0.2	0.2	5	25	5.049e+004	1.263e-006	5.170e-004

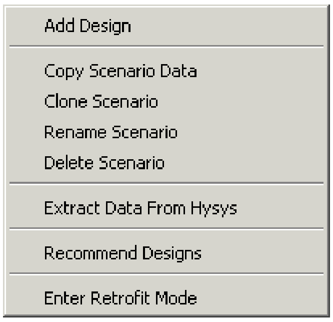
Click the Calculate button. Aspen Energy Analyzer automatically closes the Range Target view and performs the new calculation. The results indicate that the optimal DTmin value is 20°C.

6-Generating HEN Designs:

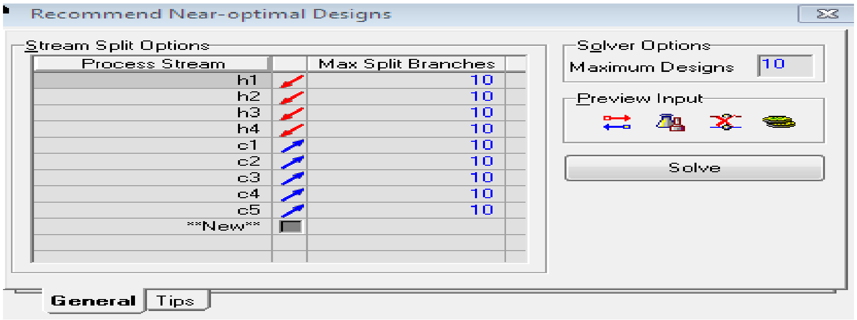
In this section, you will create HEN designs automatically using the Aspen Energy Analyzer's Recommend Designs feature. You have control over the number of designs that Aspen Energy Analyzer generates. You can then compare the designs and make all the necessary changes.

1. In the Viewer group, click on the Scenario level.

2 Right-click the mouse button on the selected Scenario. The following menu appears.



3 From this menu, select Recommend Designs. The Recommend Designs view appears as shown in the figure below. You can use this view to control certain aspects of the automatic design function.

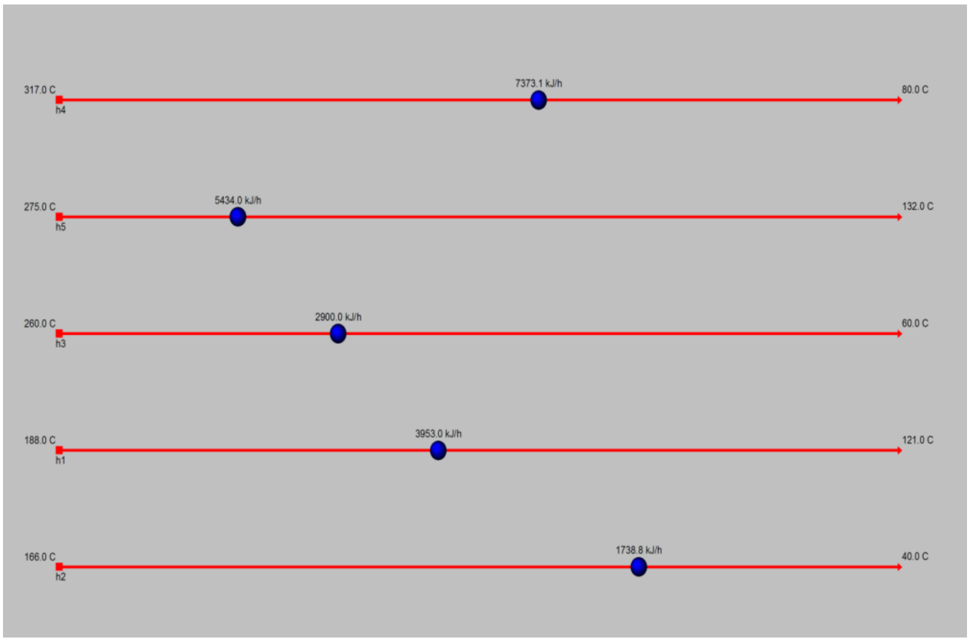


Process Stream		Max Split Branches
h1		10
h2		10
h3		10
h4		10
c1		10
c2		10
c3		10
c4		10
c5		10
New		

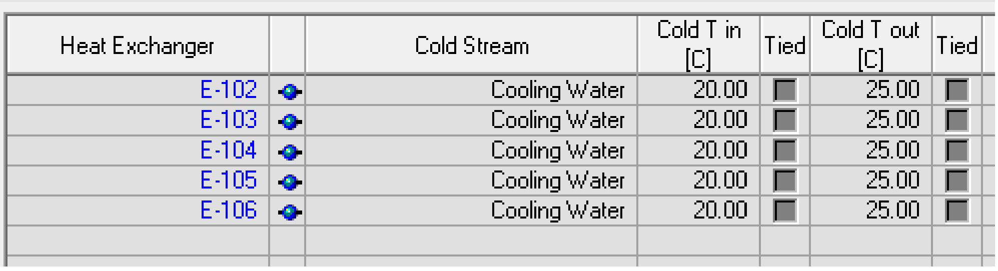
Maximum Designs 10

7-Building the Heat Exchanger Network:

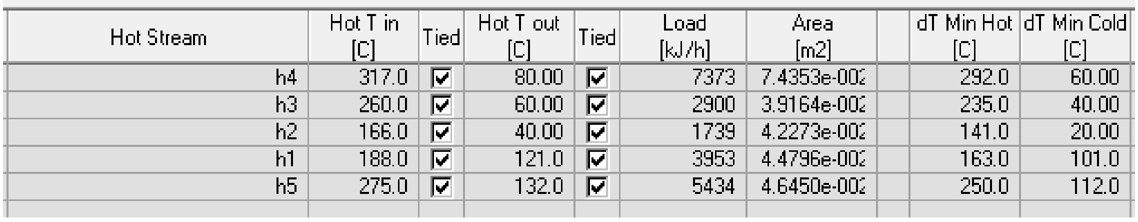
Confirm your heat exchanger with the completed HEN diagram and worksheet as shown in the figures below.



8-worksheet:

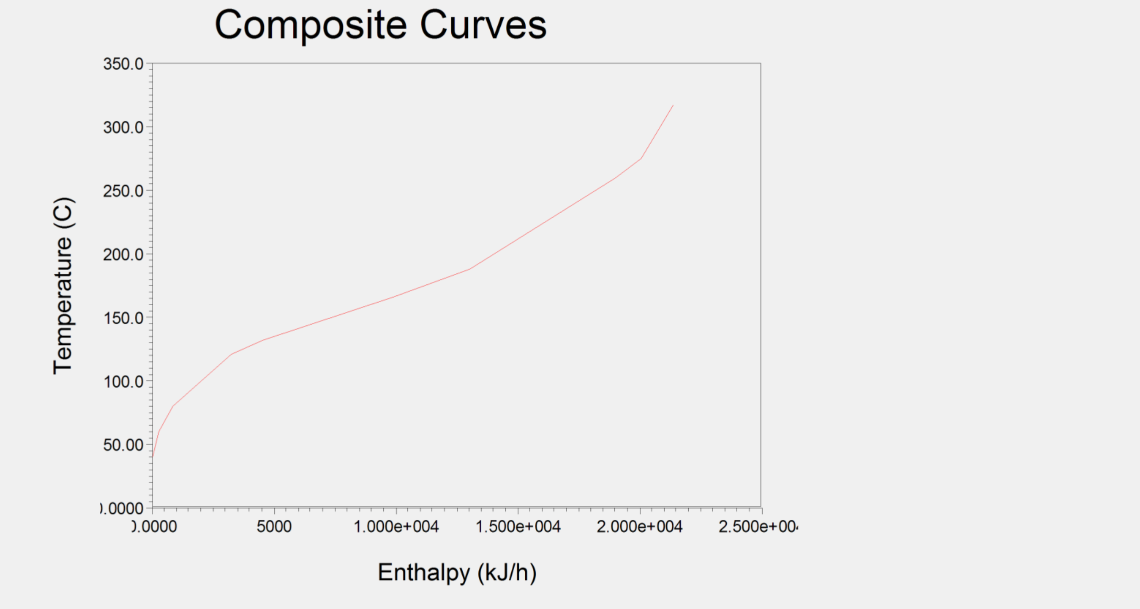


Heat Exchanger		Cold Stream	Cold T in [C]	Tied	Cold T out [C]	Tied
E-102	●	Cooling Water	20.00	☐	25.00	☐
E-103	●	Cooling Water	20.00	☐	25.00	☐
E-104	●	Cooling Water	20.00	☐	25.00	☐
E-105	●	Cooling Water	20.00	☐	25.00	☐
E-106	●	Cooling Water	20.00	☐	25.00	☐

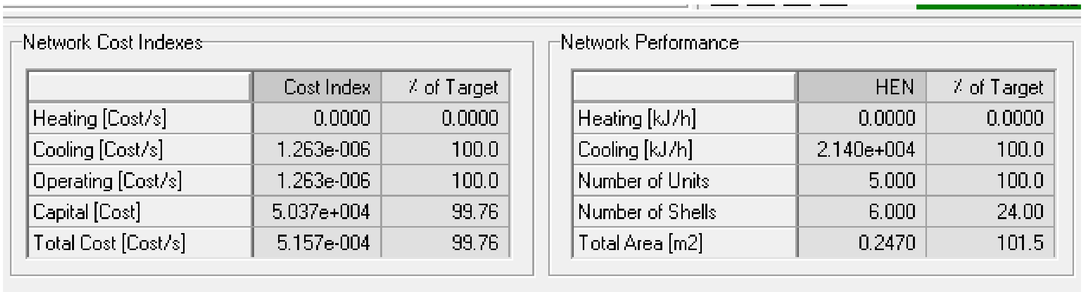


Hot Stream	Hot T in [C]	Tied	Hot T out [C]	Tied	Load [kJ/h]	Area [m2]		dT Min Hot [C]	dT Min Cold [C]
h4	317.0	☑	80.00	☑	7373	7.4353e-002		292.0	60.00
h3	260.0	☑	60.00	☑	2900	3.9164e-002		235.0	40.00
h2	166.0	☑	40.00	☑	1739	4.2273e-002		141.0	20.00
h1	188.0	☑	121.0	☑	3953	4.4796e-002		163.0	101.0
h5	275.0	☑	132.0	☑	5434	4.6450e-002		250.0	112.0

9-Composite curves:



10-Targets:



Network Cost Indexes

	Cost Index	% of Target
Heating [Cost/s]	0.0000	0.0000
Cooling [Cost/s]	1.263e-006	100.0
Operating [Cost/s]	1.263e-006	100.0
Capital [Cost]	5.037e+004	99.76
Total Cost [Cost/s]	5.157e-004	99.76

Network Performance

	HEN	% of Target
Heating [kJ/h]	0.0000	0.0000
Cooling [kJ/h]	2.140e+004	100.0
Number of Units	5.000	100.0
Number of Shells	6.000	24.00
Total Area [m2]	0.2470	101.5

References

[1]. Ahmed F. Zobaa, R. C. (2011). Handbook of Renewable Energy Technology.
[2]. Al-Sammarraie, A. T., & Vafai, K. (2017). Heat transfer augmentation through convergence angles in a pipe.
[3]. Aspen Energy Analyzer, 2 (2022).
[4]. Aspen Energy Analyzer, 3 (2022).
[5]. Aspen Energy Analyzer, 4 (2022).
[6]. Aspen Energy Analyzer, 5 (2022).
[7]. Aspen Energy Analyzer, 1 (2022). Retrieved from https://www.aspentech.com/en/products/pages/aspen-energy-analyzer
[8]. aspentech. (2022). Maximize energy efficiency and reduce emissions using insights and energy-saving suggestions provided by pinch technology. Retrieved from Aspen Energy Analyzer: https://www.aspentech.com/en/products/engineering/aspen-energy-analyzer
[9]. E. M. Greitzer, Z. S. (2022). heat exchanger. Retrieved from Thermodynamics and Propulsion: http://web.mit.edu/16.unified/www/FALL/thermodynamics/notes/node131.html
[10]. Forsberg, C. H. (2020). Heat Transfer Principles and Application.
[11]. Geankoplis, C. J. (2003). Transport Processes and Separation Principles.
[12]. Lavine, I. D. (2007). Introduction to Heat Transfer.
[13]. Lienhard, J. H., & Lienhard, J. H. (2019). A Heat Transfer Textbook.
[14]. Liu, S. K. (2004). Heat Exchangers: Selection, Rating, and Thermal Design.
[15]. Rennie, T. J. (2004). Numerical And Experimental Studies of a Double pipe Helical Heat Exchanger.
[16]. Richardson, J. M. (1999). Coulson & Richarson's Chemical Engineering Volume 1.