

# Process Simulation Using Aspen HYSYS V8

## Experience the New Aspen HYSYS\*.

The best process simulation software is now easier to use and faster to learn than ever!

Aspen HYSYS is a comprehensive process modeling system used by the world's leading oil & gas producers, refineries, and engineering companies to optimize process design and operations.

#### Why Aspen HYSYS?

## **Eng. Ahmed Deyab Fares Process Simulation Consultant**



Aspen HYSYS is a market-leading process modeling tool for conceptual design, optimization, business planning, asset management, and performance monitoring for oil & gas production, gas processing, petroleum refining, and air separation industries. Aspen HYSYS is a core element of AspenTech's aspenONE<sup>TM</sup> Process Engineering applications.

#### Objectives

• Learn to build, navigate and optimize process simulations using Aspen HYSYS

• Learn the efficient use of different HYSYS functions to build steady state process simulations

#### Who Should Attend

- New engineering graduates/technologists who will be using Aspen HYSYS in their daily work
- Process engineers doing process design and optimization projects and studies
- Plant engineers checking plant performance under different operating conditions
- R&D engineers and researchers using Aspen HYSYS for process synthesis

#### Prerequisites

• A background in chemical engineering or industrial chemistry



#### Content:

- ✓ Getting Started
- ✓ Propane Refrigeration Loop
- ✓ Refrigerated Gas Plant
- ✓ Oil Characterization
- ✓ Pre-Heat Train
- ✓ Atmospheric Towers & Side operations
- ✓ Gas Gathering
- ✓ Optimization
- ✓ NGL Fractionation Train
- ✓ Oil Stabilization Optimization



# **Getting Started**

### Experience the New Aspen HYSYS\*.



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Aspen HYSYS is a comprehensive process modeling system used by the world's leading oil & gas producers, refineries, and engineering companies to optimize process design and operations.







## Workshop

The Getting Started module introduces you to some of the basic concepts necessary for creating simulations in HYSYS. You will use HYSYS to define three gas streams to be used as feeds to a gas plant. In addition, you will learn how to determine properties of these streams by using the Phase Envelope and the Property Table utilities.

## Learning Objectives

- Define a fluid package (property package, components, hypotheticals).
- Add streams.
- Understand flash calculations.
- Attach stream utilities.
- Customize the Workbook.

Example:



We have a stream containing 15% ethane, 20% propane, 60% i-butane and 5% n-butane at 50°F and atmospheric pressure, and a flow rate of 100lbmole/hr. This stream is to be compressed to 50 psia and then cooled to 32°F. The resulting vapor and liquid are to be separated as the two product streams. Neglect the pressure drop inside the condenser.

• Fluid pkg: Peng Robinson

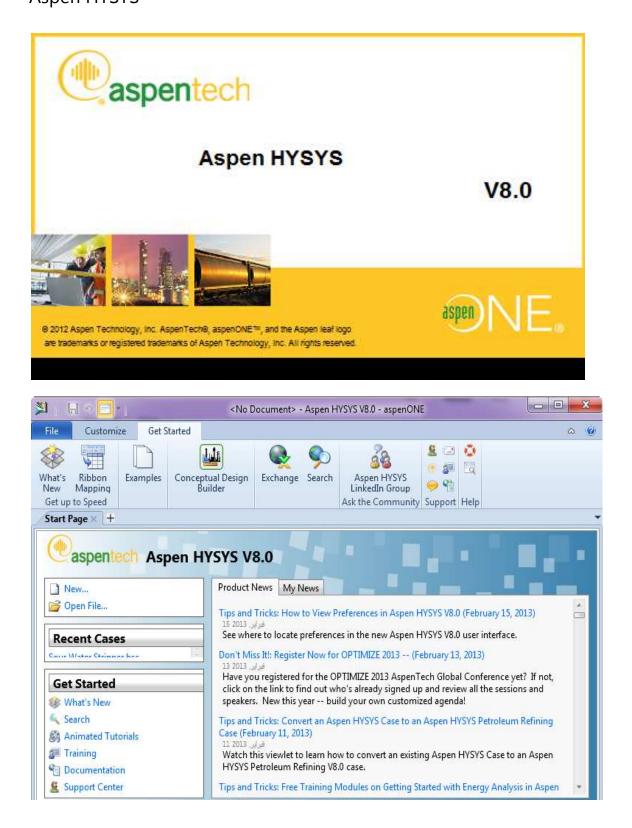
\* What are the flow rates and molar compositions of two product streams?

Component	Vapor	Liquid
Ethane		
Propane		
I-Butane		
N-Butane		
Total Flow rate		

\* Create a case study to see the effect of changing temperature of the cooler out stream on the molar flow of the liquid product stream, and write your comment.



To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.x >>>> Aspen HYSYS >> Aspen HYSYS





1- First, Start a new case

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2- Add the Components

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#### 3- Choose the system components from the databank:

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	Replace			
	Remove			

Now, select the suitable fluid package

When you have established a component list, you combine the component list with a property package. The property package is a collection of methods for calculating the properties of the selected components. The



combination of the component list and the property package, along with other simulation settings, is called the fluid package.

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The built-in property packages in HYSYS provide accurate thermodynamic, physical and transport property predictions for hydrocarbon, non-hydrocarbon, petrochemical and chemical fluids.

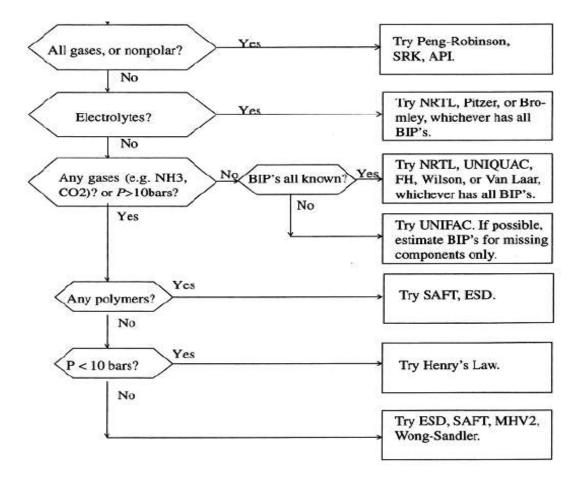
The database consists of an excess of 1500 components and over 16000 fitted binary coefficients. If a library component cannot be found within the database, a comprehensive selection of estimation methods is available for creating fully defined hypothetical components.

There are about 33 property packages inside HYSYS database; the question now is **HOW TO SELECT THE SUITABLE FLUID PACKAGE?** 

We can select the suitable one by specifying:

- 1- Process / Application type
- 2- Temperature and Pressure Range







Type of System	Recommended Property Method
TEG Dehydration	PR
Sour Water	PR, Sour PR
Cryogenic Gas Processing	PR, PRSV
Air Separation	PR, PRSV
Atm. Crude Towers	PR, PR Options, GS
Vacuum Towers	PR, PR Options, GS (<10 mmHg), Braun K10, Esso K
Ethylene Towers	Lee Kesler Plocker
High H <sub>2</sub> Systems	PR, ZJ or GS
Reservoir Systems	Steam Package, CS or GS
Hydrate Inhibition	PR
Chemical Systems	Activity Models, PRSV
HF Alkylation	PRSV, NRTL
TEG Dehydration with Aromatics	PR
Hydrocarbon systems where H <sub>2</sub> O solubility in HC is important	Kabadi Danner
Systems with select gases and light HC	MBWR

ASPEN HYSYS contains an assistant tool to help you in the selection f the suitable FP, called Methods Assistant:



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In this case, select Peng-Robinson

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Now you can start drawing the flow sheet for the process by clicking the Simulation button:

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Now add a material stream to define the composition and the conditions of the feed stream



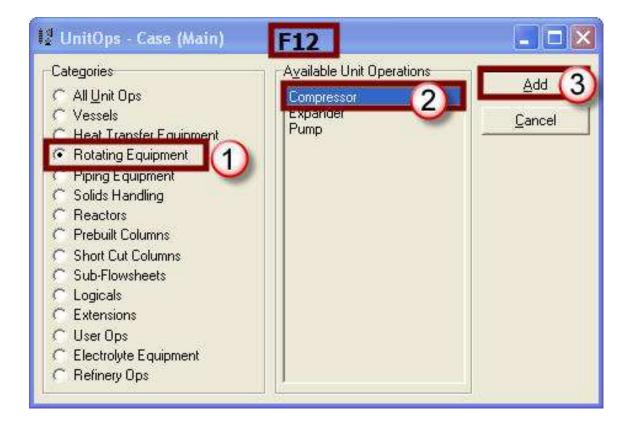
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Oil & Gas Feed	Molar Flow [kgmole/h]	45.36
Petroleum Assay K Value	Mass Flow [kg/h]	2318
User Variables	Std Ideal Liq Vol Flow [m3/h]	4.406
Notes	Molar Enthalpy [kJ/kgmole]	-1.220e+005
Cost Parameters	Molar Entropy [kJ/kgmole-C]	168.8
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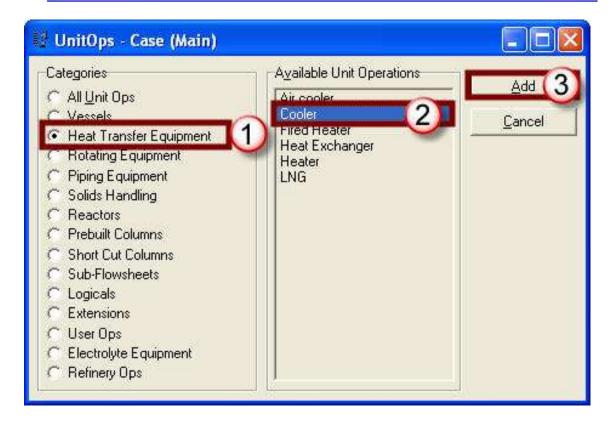


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	Molar Entropy [kJ/kgmole-C]	168.8	<empty></empty>	mmHg(0C inHg(32F)
	Heat Flow [kJ/h]	-5.533e+006	<empty></empty>	inHg(60F)
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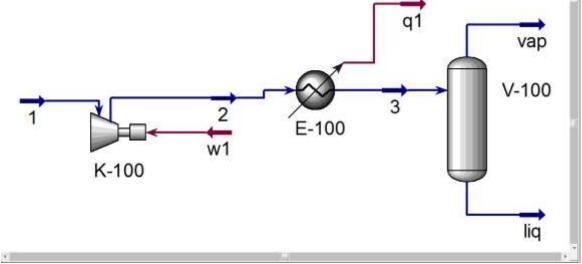


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<ul> <li>Solids Handling</li> <li>Reactors</li> <li>Prebuilt Columns</li> <li>Short Cut Columns</li> <li>Sub-Flowsheets</li> <li>Logicals</li> <li>Extensions</li> <li>User Ops</li> <li>Electrolyte Equipment</li> <li>Refinery Ops</li> </ul>	Tank	



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Now you can view the results by double clicking on the separator, in the worksheet tab:





Worksheet				
	1	3	liq	vap
Conditions	Ethane	0.1500	0.0731	0.4026
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/F Specs		0.6000	0.6823	0.3299
	n-Butane	0.0500	0.0593	0.0196

## **Save Your Case!**

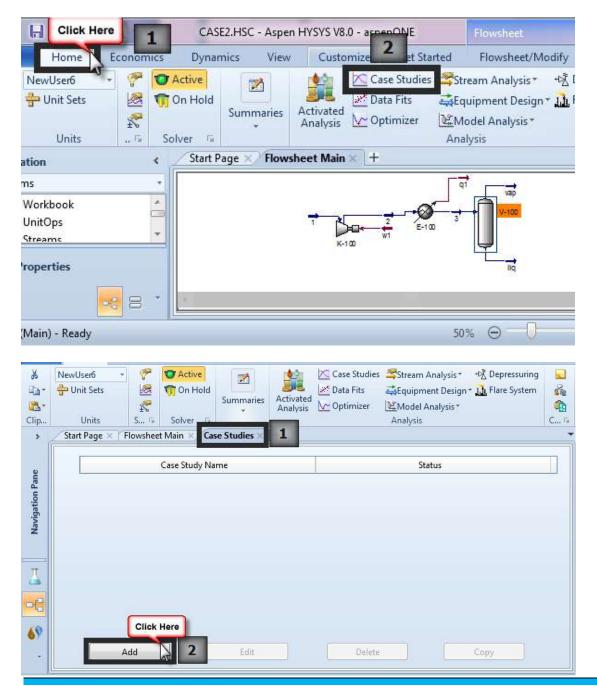


## Case Study

We need to study the effect of changing the Temperature of the cooler out stream (stream no 3) on the flow rate of the liquid product stream.

Use range: from -30 to 30 °C with step size =5 °C

To create a case study in HYSYS you can simply click on Case Studies button on the Home menu:



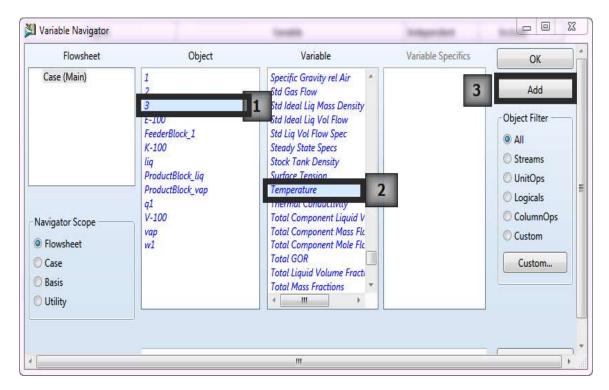
By: Eng. Ahmed Deyab Fares- http://www.adeyab.comMobile: 002-01227549943- Email: eng.a.deab@gmail.com



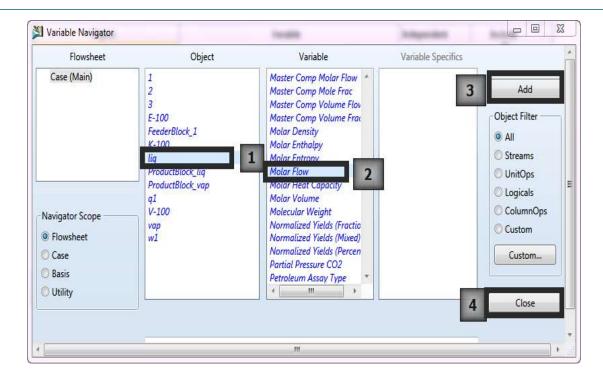


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#### Add the two variables:







#### Specify the range of the study:

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Click run, and then you can view results from the Results tab

By: Eng. Ahmed Deyab Fares<br/>Mobile: 002-01227549943- http://www.adeyab.com<br/>- Email: eng.a.deab@gmail.com



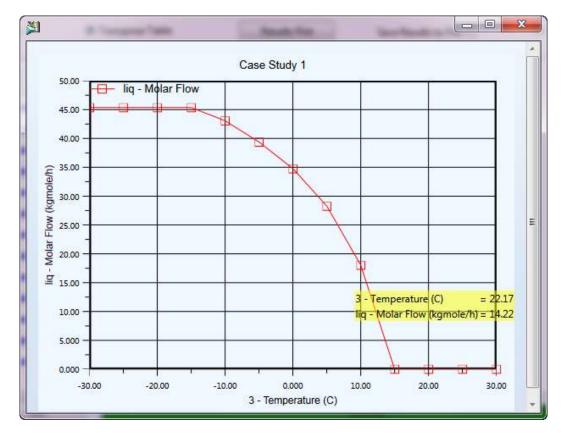
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		State 1	-30	45.36			
		State 2	-25	45.36			
	1	State 3	-20	45.36			
		State 4	-15	45.36			
		State 5	-10	43.07			
	+	State 6	-5	39.39			
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		State 11	20	0			
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By: Eng. Ahmed Deyab Fares - http://www.adeyab.com Mobile: 002-01227549943 - Email: eng.a.deab@gmail.com



Click Results Plot to view graph



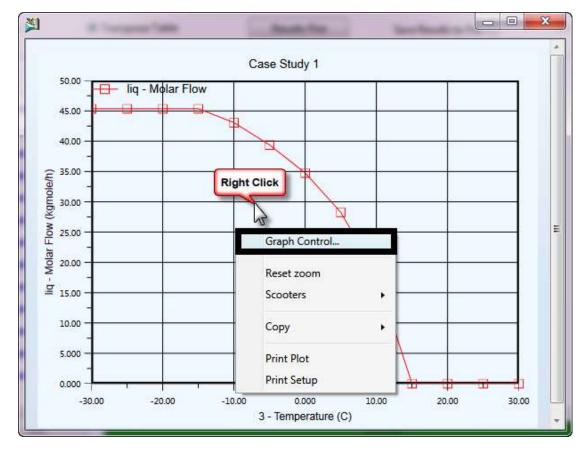
#### Comment:

As we see, when the temperature increases the liquid flow rate decrease, the liquid start to decrease @ -15 °C, and @ 15 °C there will be no liquid product and all the product will be vapor.

This is a simple case; you can create your own case study with the same steps.



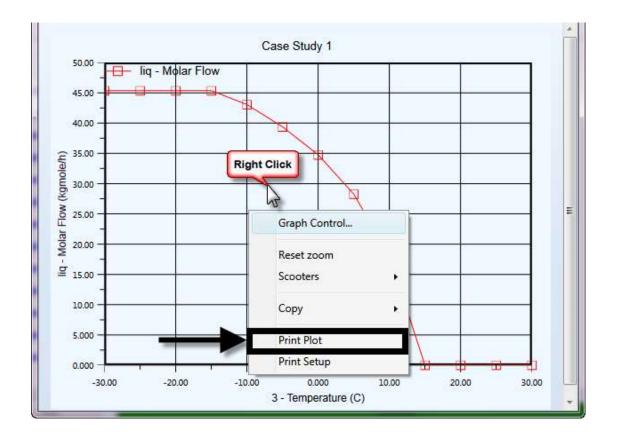
You can change the scale of axis & the curve color by right click on the plot area and click graph control:



Data Axes Title	Legend Plot Area			-
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You can also print this plot from the same menu:



## **Save Your Case!**



# Refrigerated Gas Plant

#### Experience the New Aspen HYSYS\*.



The best process simulation software is now easier to use and faster to learn than ever!

Aspen HYSYS is a comprehensive process modeling system used by the world's leading oil & gas producers, refineries, and engineering companies to optimize process design and operations.







## Workshop

In this simulation, a simplified version of a refrigerated gas plant is going to be modeled. The purpose is to find the LTS (Low Temperature Separator) temperature at which the hydrocarbon dew point target is met. The Sales Gas hydrocarbon dew point should not exceed -15°C at 6000 kPa. The incoming gas is cooled in two stages—first by exchange with product Sales Gas in a gas-gas exchanger (Gas-Gas) and then in a propane chiller (Chiller), represented here by a Cooler operation. A Balance operation will be used to evaluate the hydrocarbon dew point of the product stream at 6000 kPa.

## Learning Objectives

- Add a hypothetical component
- Install and converge heat exchangers.
- Understand logical operations (Balances and Adjusts).
- Use the Case Study tool to perform case studies on your simulation.



#### Example:

The feed stream enters an **inlet separator**, which removes the free liquids. Overhead gas from the Separator is fed to the Chiller where it is cooled to -20°C, which will be modeled simply as a Cooler (Pressure Drop=35 kPa). The cold stream is then separated in a low-temperature separator (LTS). Overhead gas from the LTS is fed to the heater (Pressure drop=5kPa) where it is heated to 10°C to meet Sales Gas Specifications.

Feed Stream:

Temperature	Pressure	Molar Flow Rate
15°C	6200 kPa	1440 kgmole/h

Component	Mole	Component	Mole
N <sub>2</sub>	0.0066	n-Butane	0.0101
$H_2S$	0.0003	i-Pentane	0.0028
CO <sub>2</sub>	0.0003	n-Pentane	0.0027
Methane	0.7575	n-Hexane	0.0006
Ethane	0.1709	H <sub>2</sub> O	0.0000
Propane	0.0413	C7+ (NBP=110°C)	0.0001
i-Butane	0.0068		

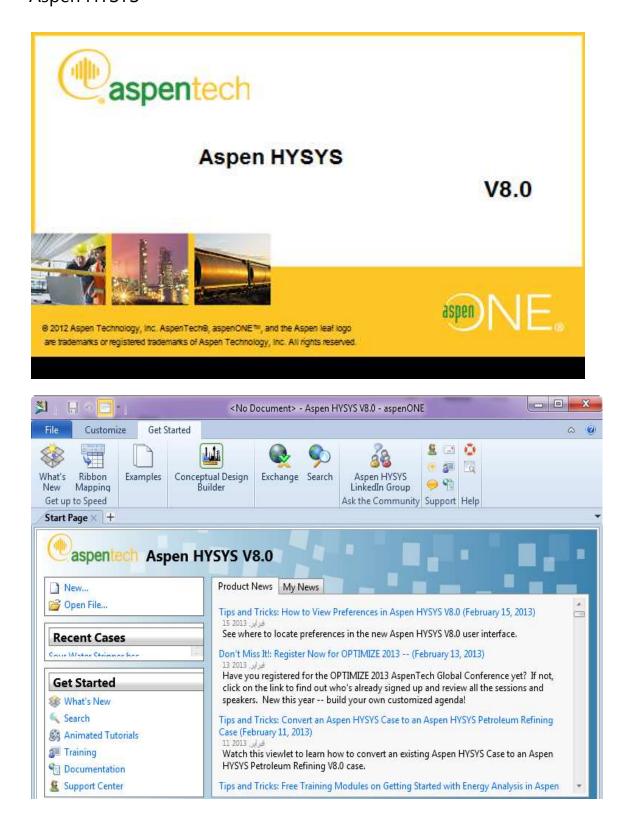
#### **Composition:**

FP: Peng Robinson

- Calculate the duty rejected from the chiller
- Calculate the duty Absorbed inside the Heater



To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.0 >>>> Aspen HYSYS >> Aspen HYSYS





4- First, Start a new case

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5- Add the Components

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#### 6- Choose the system components from the databank:

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					Propane		G	G (4)
			Replace		i-Butane n-Butane		i-C4 n-C4	C4
			A ANTONY IF		i-Pentane		+C5	(3)
					n-Pentane		n-C5	GI
			lanove		n-Hexane		C6	C6H
					n-Heptane		07	CTI
					n-Octane		C8	CBI
					n-Nonane		9	C91
					n-Decane		C10	C10
					n-C11		C11	cii
					n-C12		C12	C12H

Search for:	56	Group	Туре	Component
	_		Pure Component	Methane
Simulation N	2		Pure Component	Propane
1			Pure Component	Ethane
	< Add			
	Replace			
	Remove			

After adding the pure components (N<sub>2</sub>, H<sub>2</sub>S, CO<sub>2</sub>, C1, C2, C3, n-C4, i-C4, n-C5, i-C5, n-C6, H<sub>2</sub>O) we have to add the last component (C7<sup>+</sup>) which is not a pure component as it represents all components above C7 including C7 in the feed.

To define C7+ we have to create it as a hypothetical component as the following:



#### From the drop menu select Hypothetical instead of pure components

atabank: HYSYS	A Eng	ed Deyab Fai	es	Select:	Pure Compone	
mponent	Туре	Group		Search for:	Hypothetical	
Methane	Pure Component				Hypothetical S	olid
Ethane	Pure Component			Simulation	n Name	Full Name / Syr
Propane	Pure Component				n-Heptane	
i-Butane	Pure Component		< Add	K T	n-Octane	
n-Butane	Pure Component				n-Nonane	
i-Pentane	Pure Component				n-Decane	
n-Pentane	Pure Component		Replace		n-C11	
n-Hevane	Pure Component				(12)	

#### Select create and edit hypos

nitial Boiling Point:	30.00 C	Interv	val 🔹	10.00 C
Final Boiling Point:	900.0 C			
New Hypo Group	Generate H	łypos		
Name	Added ?	Normal Boiling Point	Molecular Weight	Liquid Density

Click on New Hypo





Select:	Hypothetical	- Met	Create and	Edit Hypos 🔻
Hypo Group:	HypoGroup1	т Тур	e: Base Prope	rties 🔻
New Hypo Grou		lick Here		=
Name	Added ?	Normal Boiling Poir	nt Molecular Weight	Liquid Density

After adding a hypo component you can edit the name, add the properties you have, and estimate the unknown properties as follows:

		Select:	Hypothetical	<ul> <li>Method:</li> </ul>	Create and E	dit Hypos 🔹
Group		Hypo Group:	HypoGroup1	▼ Type:	Base Proper	ties 🔹
nt						
nt						
nt						
nt	<< Add All					
nt		New Hypo Grou	p New Hypo			
nt			Newsel Delling Delet		Linuid Density	Tc
nt	4 < Add	Name	Normal Boiling Point	Molecular Weight	Liquid Density [kg/m3]	[C]
nt			C7+* <b>7</b> 110.0	0 <empty></empty>	-	<empty:< td=""></empty:<>
nt						
nt	Remove					
nt						
nt	_					
						,
	3	Estimate Unknov	vn Delete Hypo			

Finally add the hypo component to the component list



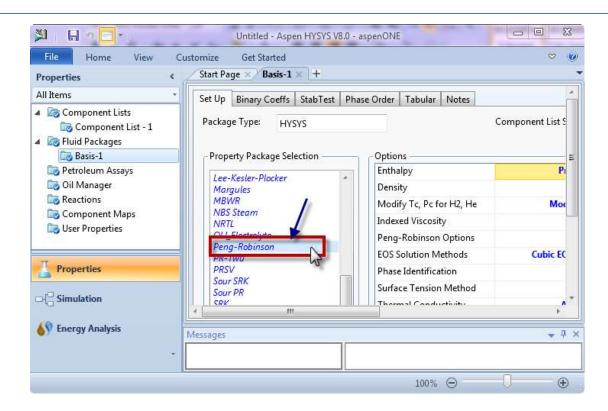
Properties <	Start Page × Component	List - 1 × +		
All Items 🔹				
🔺 📷 Component Lists	Source Databank: HYSYS			
📷 Component List - 1	Source Butabania Prioro			
🔁 Fluid Packages		-	-	1
📷 Petroleum Assays	Component	Туре	Group	
📷 Oil Manager	Methane	Pure Component		
Contractions	Ethane	Pure Component		
📷 Component Maps	Propane	Pure Component		
🔯 User Properties	i-Butane	Pure Component		<< Add All
	n-Butane	Pure Component		
	i-Pentane	Pure Component		
	n-Pentane	Pure Component		< Add
	n-Hexane	Pure Component		
	CO2	Pure Component		
	H2S	Pure Component		Remove
	Nitrogen	Pure Component		
	H2O	Pure Component		
	C7+* Us	er Defined Hypothetica	HypoGroup1	

Now, select the suitable fluid package

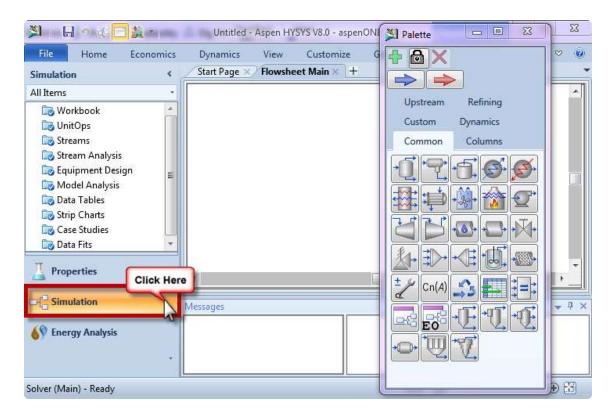
劉 品 ^ 🖸 -		Untitled - Aspen HYSYS V8	.0 - aspenONE		
File Home View	Customize	Get Started			∞ ⊘
Properties	C Start Pa	ge 🗙 Fluid Packages 🗙 🕴	ŧ		-
All Items Component Lists Component List - 1 Fluid Packages Petroleum Assays Oil Manager Reactions Component Maps		Fluid Package	Componer	nt List	Property Packag
Component waps Compo		Add	Edit		opy
69 Energy Analysis	Messages	nfo : Fluid Packages Sele III ++++++++++++++++++++++++++++++++++			+ # ×
			10	0% Θ 👘	

In this case, select Peng-Robinson





Now you can start drawing the flow sheet for the process by clicking the Simulation button:

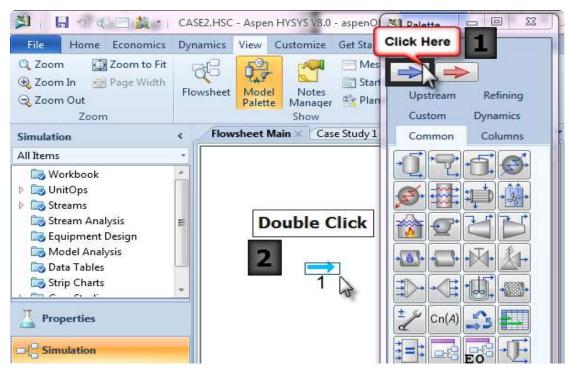


Now add a material stream to define the composition and the conditions

of the feed stream



#### From the palette:

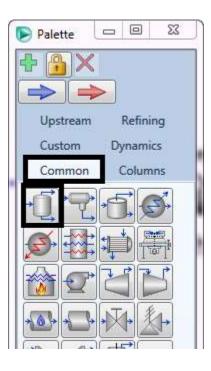


Vorksheet	Attachmer	nts	Dynamics				_^
Works	heet				Mole F	ractions	
Conditio		Nit	rogen			0.0066	
Propertie		H2	-			0.0003	
Composition		CO	2			0.0003	
Petroleu		Me	thane			0.7575	
K Value	m Assay	Eth	ane			0.1709	
User Var	iables	Pro	pane			0.0413	
Notes		i-Bi	utane			0.0068	
Cost Par	ameters	n-B	utane			0.0101	
Normaliz	ed Yields	i-Pe	entane			0.0028	
		n-P	entane			0.0027	
			lexane			0.0006	
		C7-	+*			0.0001	
					*	m	
				Total	1.00000		-L
			Edit	View Pro	operties	Basis	



Worksheet Attachme	ents Dynamics	
Worksheet	Stream Name	To Refrig
Conditions	Vapour / Phase Fraction	1.0000
Properties	Temperature [C]	15.00
Composition	Pressure [kPa]	6200
Oil & Gas Feed	Molar Flow [kgmole/h]	1440
Petroleum Assay K Value	Mass Flow [kg/h]	2.990e+004
User Variables	Std Ideal Liq Vol Flow [m3/h]	88.31
Notes	Molar Enthalpy [kJ/kgmole]	-8.127e+004
Cost Parameters	Molar Entropy [kJ/kgmole-C]	149.4
Normalized Yields	Heat Flow [kJ/h]	-1.170e+008
	Liq Vol Flow @Std Cond [m3/h]	3.391e+004
	Fluid Package	Basis 1
	Utility Type	
		4
	OK	
	- OK	

From the palette select the separator:







🕟 Separator: Inet	Set Gas				_ 0 X
Design Reacti	ons Rating Worksheet D	ynamics			*
Desian	<u>N</u> ame	Inet Set Gas			
Connections Parameters User Variables Notes	Inlets To Refrig << Stream >>		<u>V</u> apour Outlet	1	7
	Energy (Optional)			<b>→</b>	
	Vessel Fluid Package Basis 1	•	3	Liquid O <u>u</u> tlet Inlet Sep Liq	-
Delete		OK			Ignor
•		Ш			•

### Add a cooler:

esign	Rating	Worksheet	Performance	Dynamics		
Desig			Name	Chiller		
onnect aramet		4				
Jser Var Votes	ables	Inlet			Energy	1
	1	Inlet	Sep Vap	*	Chiller Q	2
				$\frown$	>	
			>	$( \mathbf{\overline{\zeta}} )$	>	
		_		$\sim$	Outlet	
		Fluid F	ackage		Gas to LTS	•
		Basis	13%	*		
			2		<b>m</b>	



Design	Rating	Worksheet	Performance	Dynamics			 1
Desi	gn	Delta I	<b>b</b>				
Connect		35.00	kPa	2			
Parame User Va					-		
Notes		Delta 1	r.		Duty		
				$\sim$		->	
				$\bigcirc$		~	
			>			<b>*</b>	
			>			<b>*</b>	

Worksheet	Name	Inlet Sep Vap	Gas to LTS	Chiller Q
Conditions	Vapour	1.0000	0.8735	<empty></empty>
Properties Composition	Temperature [C]		2 -20.00	<empty></empty>
	Pressure [kPa]	6200	6165	<empty></empty>
PF Specs	Molar Flow [kgmole/h]	1440	1440	<empty></empty>
	Mass Flow [kg/h]	2.990e+004	2.990e+004	<empty></empty>
	Std Ideal Liq Vol Flow [m3/h]	88.31	88.31	<empty></empty>
	Molar Enthalpy [kJ/kgmole]	-8.127e+004	-8.417e+004	<empty></empty>
	Molar Entropy [kJ/kgmole-C]	149.4	138.6	<empty></empty>
	Heat Flow [kJ/h]	-1.170e+008	-1.212e+008	4.186e+006

Add the LTS Separator:

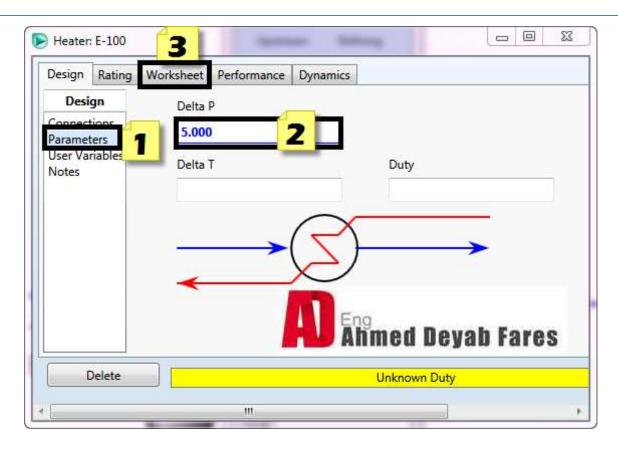


Design Reacti	ons Rating Worksheet Dynamics			
Design	Name LTS			
Connections Parameters	Inlets			
Parameters User Variables	Gas to LTS	Vapour Ou	tlet LTS Vap	-
Notes	<< Stream >>			
		*****		
	>			
	<b></b>			
	Energy (Optional)	2		
		$\checkmark$		
	Vessel Fluid Package		Liquid Outlet	
	Basis 1		LTS Liq	
Delete		OK		📃 📃 Ig

### Add a heater:

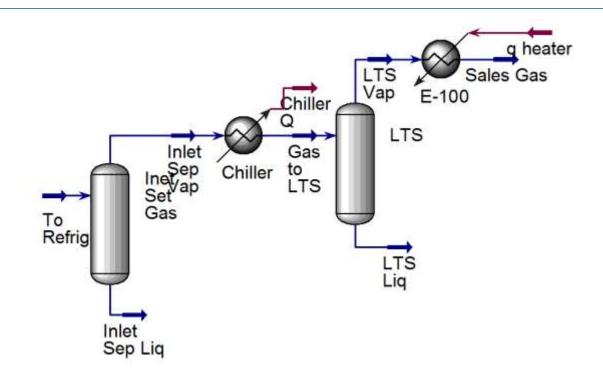
Design	Rating	Worksheet	Performance	Dynamics		
Desi	gn		Name	E-100		
Connect Paramet User Va Notes	ters		Ahmed De Vap	yab Fare	S Energy q heater	•
			<b>&gt;</b>	$\bigcirc$	Outlet Sales Gas	*
		Basis	Package	•		





sign Ratin	g Worksheet	Performance	Dynamics			
orksheet	Nar <b>1</b>	_		LTS Vap	Sales Gas	
nditions	Vapou			1.0000	1.0000	
perties	Temperature	[C]		-20.00	2 10.00	
mposition	Pressure [kPa]			6165	6160	
Specs	Molar Flow [k	gmole/h]		1258	1258	
	Mass Flow [kg	/h]		2.444e+004	2.444e+004	
	Std Ideal Liq \	ol Flow [m3/h]		74.84	74.84	
	Molar Enthalp	y [kJ/kgmole]		-8.149e+004	-7.967e+004	1
	Molar Entropy	[kJ/kgmole-C]		141.9	148.7	
	Heat Flow [kJ/	'h]		-1.025e+008	-1.002e+008	
						_
Delete				OK		





- The duty rejected from the chiller = **4.186 e6** (4.186  $*10^6$ ) kJ/hr
- The duty Absorbed inside the Heater =  $2.287 \text{ e6} (2.287 * 10^6) \text{ kJ/hr}$

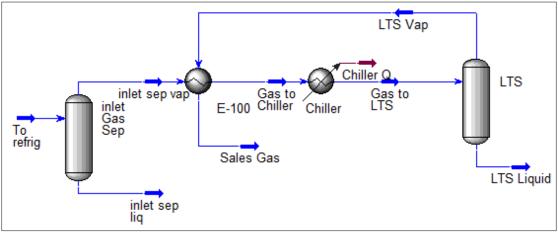


# Heat Exchanger

The design is modified to reduce the operating cost represented in Chiller & Heater duties, by adding a Heat Exchanger before the Chiller where the overhead from the inlet separator is pre-cooled by already refrigerated gas from LTS.

### Heat Exchanger Design Specifications:

- Sales Gas Temperature= 10°C
- Tube side Pressure drop=35kPa
- Shell side Pressure drop= 5kPa
- No heat losses inside the heat exchanger.
- Choose Weighted Exchanger as Model



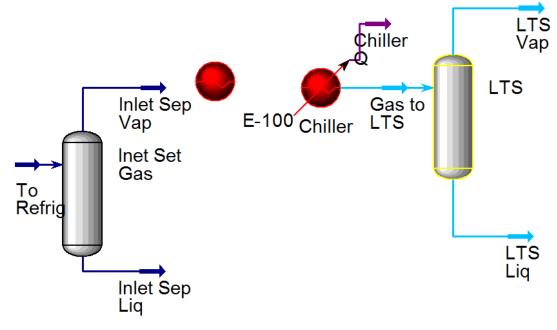
Calculate the duty rejected from the chiller after this modification

Calculate the Overall Heat Transfer Coefficient (UA) for the HX



### Solution:

- 1- Remove the heater, outlet stream and heater energy stream.
- 2- Disconnect the chiller inlet from the chiller (cooler).
- 3- Add a heat exchanger from the palette:



4- Open the heat exchanger and complete the required data:

esign	Rating	Worksheet Perform	ance Dynamics	Rigorous	Shell&Tube	
Desi	Contaction and	Tube Side Inlet		Name	E-100	Shell Side Inlet
aramet pecs		Inlet Sep Vap	_ <u>]]</u> }	A	Ahmed Deyab Fares	
		Tube	side Flowsheet Case (Mi	ain)	Shellside Flowshee Cas	t e (Main)
		Tube Side Outlet		_	100	Shell Side Outlet
		to chiller	2		Switch streams	Sales Gas 4
		Tube <mark>Sid</mark> e Fluid Pk	9			Shell Side Fluid Pkg
		GasPlant	•			GasPlant





B Heat Exchanger:	E-1 <b>4</b>						X
Design Rating	Worksheet Performan	ce Dynami	cs Rigorous Shell&T	ube			*
Design	Heat Exchanger Model						
Connections Parameters	Simple Weighted		-				
Specs User Variables Notes	Rigorous Shell&Tub V Simple End Point Simple Steady State	_	2	<empty></empty>			_
	Simple Weighted Dynamic Rating			SHELL-SIDE	TUBE-SIDE		
	Specified Pressure Dro	op [kPa]		5.000	35.00		
	Pass Name	Intervals	Dew/Bubble Pt	Step Type	Pressure Profile		
	Inlet Sep Vap-to chill	5		Equal Enthalpy	Const dPdH		
	LTS Vap-Sales Gas	5	▼	Equal Enthalpy	Const dPdH		
	Rigorous Model		-	Size R	igorous Shell&Tube	•	
	click Rigorous Sh	ell&Tube bu	itton here	🔲 Use De	sign Template File		
							+
	-						

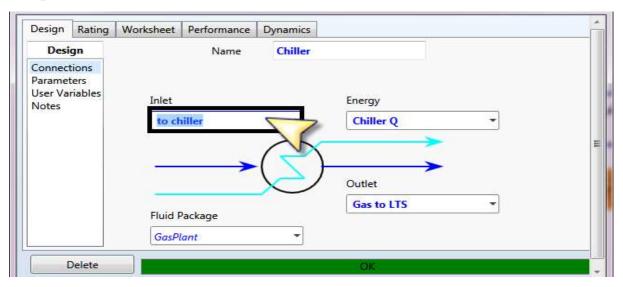
- Weighted. The heating curves are broken into intervals, which then exchange energy individually. An LMTD and UA are calculated for each interval in the heat curve and summed to calculate the overall exchanger UA. The Weighted method is available only for Counter-Current exchangers.
- **Endpoint**. A single LMTD and UA are calculated from the inlet and outlet conditions. For simple problems where there is no phase change and Cp is relatively constant, this option may be sufficient.

Sales Gas <empty></empty>
<empty></empty>
10.00
<empty></empty>

By: Eng. Ahmed Deyab Fares- http://www.adeyab.comMobile: 002-01227549943- Email: eng.a.deab@gmail.com



5- Open the chiller and re-connect the tube side outlet to the chiller inlet



The duty rejected from the chiller after this modification =  $1.878 \ e6 \ kJ/hr$ The Overall Heat Transfer Coefficient (UA) for the HX=  $2.786 \ e5 \ kJ/C-h$ 

	<b>Before Modification</b>	After Modification
Chiller Duty	<b>4.186</b> *10 <sup>6</sup>	1.878 *10 <sup>6</sup>
Heater Duty	2.287 *10 <sup>6</sup>	0

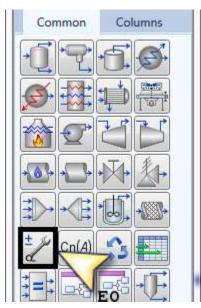


# Adjust

Adjust the LTS feed temperature to ensure the LTS vapor rate of 1200 kgmole/hr using Adjust operation.

Calculate the temperature of LTS feed .....

1- Select an adjust operation from the palette:



2- Open the adjust operation and select the adjusted variable (LTS

feed Temperature) and the Target variable (LTS Vapor molar flow).

Connections	Parameters	Monitor	User Variables		
Connections		Ad	just Name	ADJ-1	
Connections Notes	Adjust Objec Variab	-	e		Click Here Select Var
	Objec				Select Var
	Variab Target	t Value —			

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Flowsheet		Object	Variable	Variable Specifics	ок 3
Case (Main)	Product	Black 1 TS Gas p Liq Block_Inlet Sep I Block_LTS Liq Block_sales gas	Std Liq Vol Flow Spec		Ok 3 Object Filter All Streams UnitOps Logicals Utilities ColumnOps Custom Custom
	arameters Mor	nitor User Va Adjust Nan	ariables ne ADJ-1	-	
onnections					
onnections onnections lotes	Adjusted Va	Gas to LTS		Sele	ct Var
onnections	Object: Variable:	Gas to LTS Temperature	e	Sele	ct Var
onnections	Object:	Gas to LTS Temperature	e		ct Var

Flowsheet	Object	Variable	Variable Specifics	OK
Case (Main)	1	Master Comp Volume Flow 🔹		OK
	2	Master Comp Volume Frac		
	Chiller	Molar Density		Object Filter -
	Chiller Q	Molar Enthalpy		All
	E-100	Malan Futuryyy		
	FeederBlock_1	Molar Flow		© Streams
	Gas to LTS	Molar Heat Capacity		🔘 UnitOps
	Inet Set Gas	Molar Volume		O Logicals
	Inlet Sep Liq	Molecular Weight		
	LTS	Normalized Yields (Fraction		O Utilities
	ITSLin	Normalized Yields (Mixed)		ColumnOps
	LTS Vap	Normalized Yields (Percent)		Custom



Connections		Adjust Name	ADJ-1		
Connections Notes	Adjusted V	ariable			
	Object:	Gas to LTS			Select Var
	Variable:	Temperature			
	Target Vari	iable			
	Object:	LTS Vap			Select Var
	Variable:	Molar Flow			
	- Target Valu	Je			
	Source -	Supplied	Specified	Target Value	
	Anot	her Object	1200.000	0	2
	© Sprea	adSheetCell Object			- <u>-</u>
			Jnknown Maximum		

You can see the total number of iterations from the monitor tab:

Monitor –	Iteration Histo	orv —		
Tables Plots	Total Iterati		7	
	Iter	Adjusted Value [C]	Target Value [kgmole/h]	Residual [kgmole/h]
	1	-20.000	1259.243	59.24
	2	-21.000	1247.547	47.55
	3	-21.445	1242.197	42.20
	4	-31.178	1099.027	-101.0
	5	-23.008	1222.687	22.69
	6	-24.507	1202.861	2.861
	7	-24.723	1199.905	-9.471e-002

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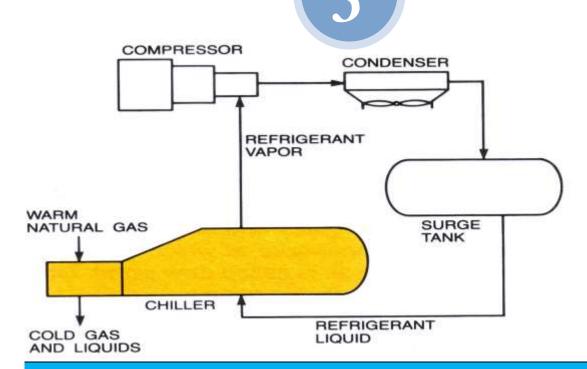
# Propane Refrigeration Loop

## Experience the New Aspen HYSYS\*.

V8

The best process simulation software is now easier to use and faster to learn than ever!

Aspen HYSYS is a comprehensive process modeling system used by the world's leading oil & gas producers, refineries, and engineering companies to optimize process design and operations.



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# Workshop

Refrigeration systems are commonly found in the natural gas processing industry and in processes related to the petroleum refining, petrochemical, and chemical industries. Refrigeration is used to cool gas to meet a hydrocarbon dewpoint specification and to produce a marketable liquid.

In this module you will construct, run, analyze and manipulate a propane refrigeration loop simulation. You will convert the completed simulation to a template, making it available to connect to other simulations.

# Learning Objectives

Once you have completed this module, you will be able to:

- Add and connect operations to build a flowsheet.
- Understand how to simulate the vapor compression loop.
- Understand forward-backward information propagation in HYSYS.

• Using the spread sheet to calculate the COP (Coefficient Of Performance) for the loop.



Example:

A Refrigeration cycle utilizes propane as the working fluid is used in the liquefaction of the NG. Propane is fed to an evaporator (Heater) the pressure drop=5 kPa, where it absorbed 1.50e+6 kJ/hr from the NG and leaves at the dew point (Vapor Fraction=1.0) at T= -15°C. The output of the evaporator is then compressed adiabatically with efficiency of 75%, and then it's condensed to reject heat. Inside the Condenser there is a pressure drop of 30 kPa, and leaves as saturated liquid at 45°C. Finally, the propane passes through a valve to return the pressure of the Evaporator.

Fluid Pkg: Peng Robinson

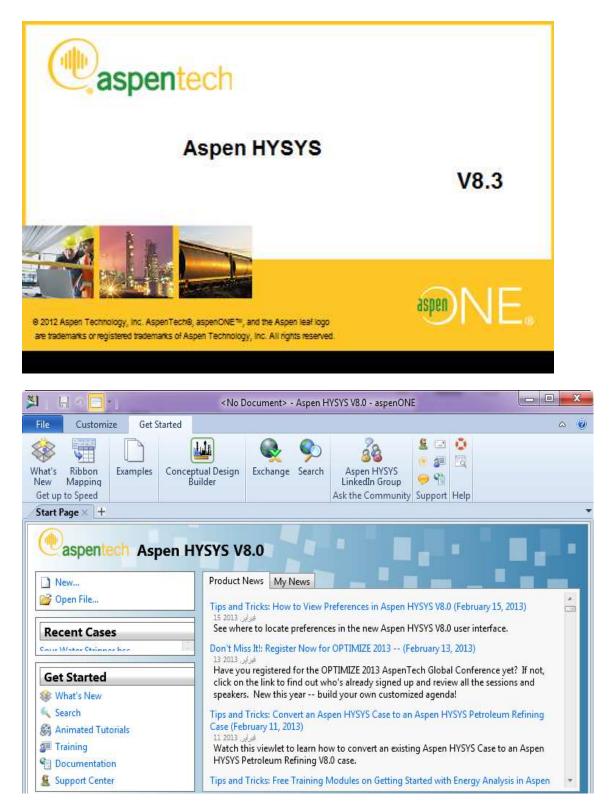
Calculate:

Pressure of the evaporator fed in kPa.	
Flow rate of propane in kmol/hr.	
Valve pressure drop in kPa.	
Temperature of the valve outlet in °C.	
Compressor duty in hp.	
Condenser duty in kJ/hr.	

\* Calculate the COP (Coefficient of Performance) for the cycle

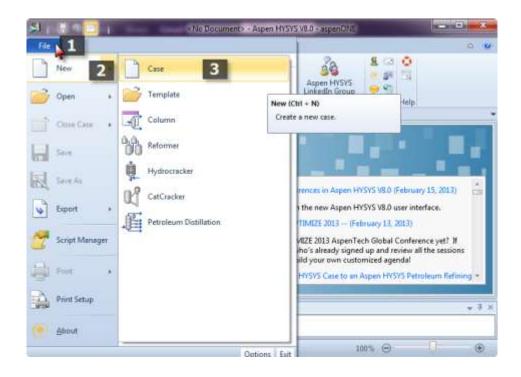


To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.3 >>>> Aspen HYSYS >> Aspen HYSYS





1- First, Start a new case



2- Add the Components

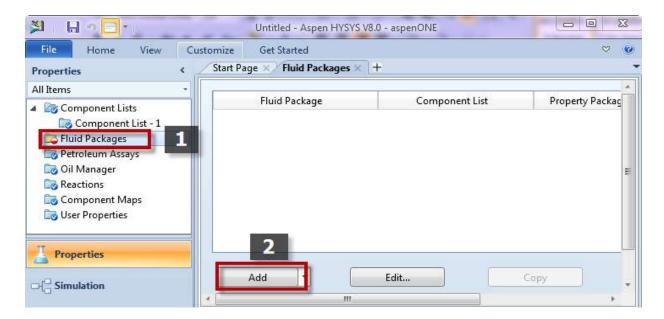
M		Untitled - /	Aspen HYSYS V8.0	) - aspe	nONE	-	
File Home View C	lustomize	Get Starte	d				a 🕐
Lipboard Composition	roperties	Petroleum Assays Refining Ta	Hypotheticals	Oil	Aspen Properties Options	PVT Laboratory Measurements PVT Data	
Properties <	Start Pag	e × Com	ponent Lists $ imes$	+			•
All Items	1	2	Name			Source	E
Properties [-] Simulation Simulation Energy Analysis	Im  Messages		Co Expc III ackages S			Delete	• ‡ ×
	R.4.				100	% Θ	•



### 3- Choose the system components from the databank:

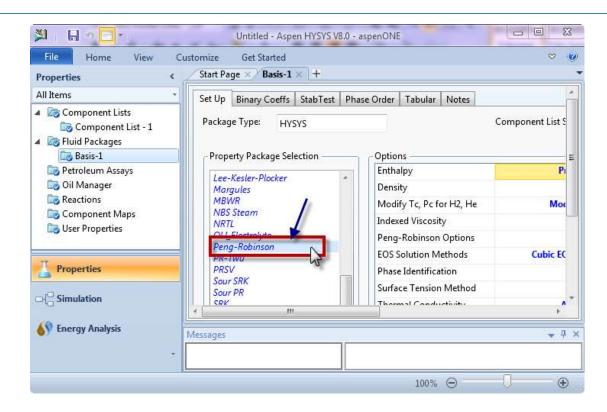
Page × aspenONE Exchange × Con	nponent List - 1 × +				-
e Databank: HYSYS			Select:	Pure Components	
Component Type Propane Pure Comp	Group		Search for:		
			Simulat	ion Name	
		< Add		Methane	=
		< Add		Ethane	
		15		i-Butane	
				n-Butane	
		Replace		i-Pentane	
				n-Dentane	

Now, select the suitable fluid package

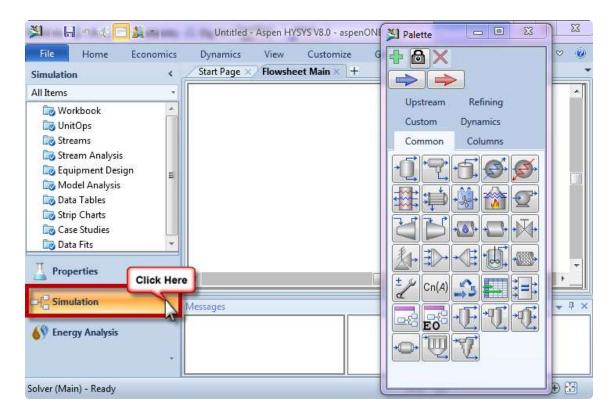


In this case, select Peng-Robinson





Now you can start drawing the flow sheet for the process by clicking the Simulation button:



Now add a material stream to define the composition and the conditions

of the feed stream



### From the palette:

	CASE2.HSC	- Aspen I	HYSYS V8.0	- aspenO	Ralette	
File Home Economics	Dynamics	View (	Customize	Get Sta	Click Here	1
C Zoom In Dependent Communication Fit Communication Communication Fit Fit Communication Fit	Flowsheet	Model Palette	Notes Manager Show	E Mes		Refining Dynamics
Simulation	< Flow	sheet Ma	ain × Cas	e Study 1	Common	Columns
All Items  Workbook  UnitOps  Grams  Streams  Stream Analysis  Contemport Design  Model Analysis  Data Tables  Strip Charts  Properties  Strip Charts  Strip		<b>D</b> o	ouble C	Click		

Add the mole fraction for the inlet stream (Propane =1)

Worksheet Attach	ments	Dynamics			
Worksheet				Mole Fra	actions
Conditions Properties Composition Oil & Gas Feed Petroleum Assay K Value User Variables Notes Cost Parameters Normalized Yield		opane			1
			Total	0.00000	
			Total	0.00000	





	MoleFraction	Composition Basis
Propane	1.0000	Mole Fractions
	)	Mass Fractions
		C Liq Volume Fractions
		C Mole Flows
		Mass Flows
		C Liq Volume Flows
		Composition Controls
		Erase
		Equalize Composition
		Cancel

Then leave the stream not solved till the loop is closed

Add the evaporator (heater)

♣ <mark>}</mark> ×	
Upstream	Refining
Custom	Dynamics
Common	Columns
-0	£.
Ø.	
	<u>a</u> r



Complete the connections and then go to parameters page to add the pressure drop and the duty rejected

esign Rating	Worksheet	Performance	Dynamics		
Design		Name	E-100		
onnections arameters		-			
ser Variables	Inlet	C.		Energy	~
lotes	1)1		-	q 1	37-
					- and
	_	~	$( \overline{\ } )$		
				Outlet	
		10 MA	(2	2	-
	6	ackage	<u>u</u>		
	Basis-	1	•		

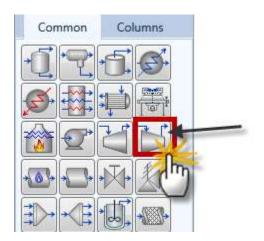
Design	Rating	Worksheet	Performance	Dynamics	
Desi	gn	Delta I	p		
Connect Paramet		5.000	kPa		
User Va Notes	riables	Delta	г		Duty
		-0.494	41 C		1.50000e+006 kJ/h
		+	>	$\bigcirc$	>

Go to stream 2 and complete the vapor fraction & temperature



Worksheet Attachme	ents Dynamics			
Worksheet	Stream Name	2		
Conditions	Vapour / Phase Fraction	1.0000		
Properties	Temperature [C]	-15.00		
Composition	Pressure [kPa]	291.1		
Oil & Gas Feed Petroleum Assay	Molar Flow [kgmole/h]	<empty></empty>		
K Value	Mass Flow [kg/h]	<empty> <empty></empty></empty>		
User Variables	Std Ideal Liq Vol Flow [m3/h]			
Notes	Molar Enthalpy [kJ/kgmole]	-1.072e+005		
Cost Parameters	Molar Entropy [kJ/kgmole-C]	141.9		
Cost Parameters Normalized Yields	Heat Flow [kJ/h]	<empty></empty>		
	Liq Vol Flow @Std Cond [m3/h]	<empty></empty>		
	Fluid Package			
	Utility Type			
		4 [ III ]		
	Unknown Flow Rate			

Then add a compressor to raise the pressure of the vapor out from the heater



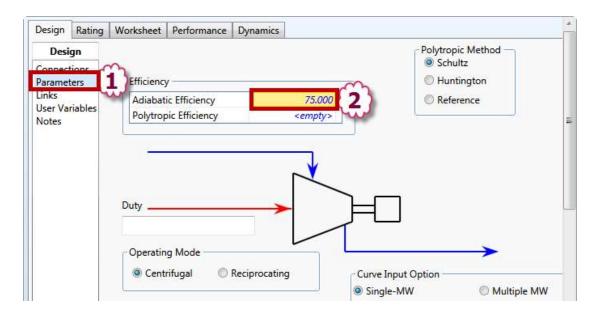






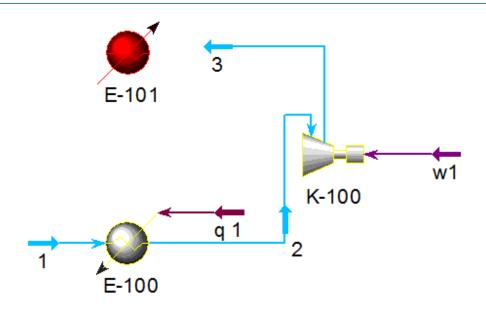
Design	Rating	Worksheet	Performance	Dynamics	
Desi	gn		Name	K-100	
Connec Parame Links User Va User Va Notes	ters	Inlet 2 Energy w1		] 	Fluid Package Basis-1

Then go to parameters to make sure that the adiabatic efficiency is 75%



Leave the compressor not solved till the loop is closed then add a cooler







Design	Rating	Worksheet	Performance	Dynamics		
Desi Connoci	ione	2	Name	E-101		
Paramet User Va Notes	riables	Inlet	<u>(</u> 1		Energy q2	{2} ·
		Fluid	Package -1		Outlet	3.
[	Delete				Unknown Delta P	

Complete the connections and then go to parameters page to add the

pressure drop =30 kPa





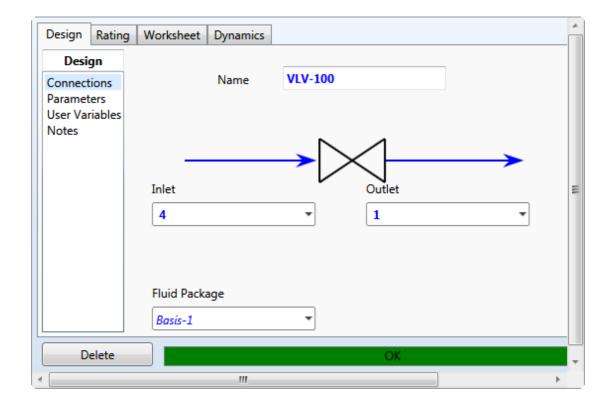
Design Delta P Connections Parameters 30.00 kPa	
20.00 kPa	
User Variables Notes Delta T Duty	
	>
$\longrightarrow$ ( $\Sigma$ )	→
Delete Unknown Duty	

Go to stream 4 and complete the vapor fraction (Saturated liquid=0.0) & temperature ( $45^{\circ}C$ )

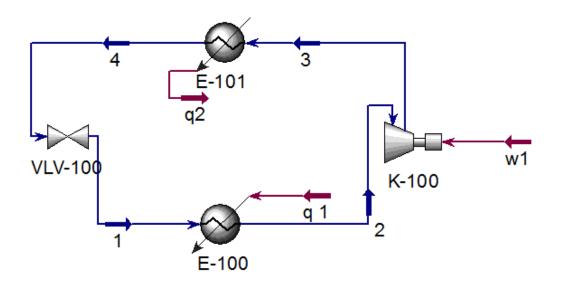
Worksheet Attachm	ents Dynamics		1
Worksheet	Stream Name	4	
Conditions	Vapour / Phase Fraction	0.0000	
Properties	Temperature [C]	45.00	
Composition	Pressure [kPa]	1539	
Oil & Gas Feed Petroleum Assay K Value	Molar Flow [kgmole/h]	<empty></empty>	
	Mass Flow [kg/h]	<empty></empty>	
User Variables	Std Ideal Liq Vol Flow [m3/h]	<empty></empty>	>
Notes	Molar Enthalpy [kJ/kgmole]	-1.174e+005	
Notes Cost Parameters Normalized Yields	Molar Entropy [kJ/kgmole-C]	98.88	
	Heat Flow [kJ/h]	<empty></empty>	
	Liq Vol Flow @Std Cond [m3/h]	<empty></empty>	
	Fluid Package	Basis-1	
	Utility Type		
		*	-
	Unknown Flow R	ate	1

Then add a valve to close the loop





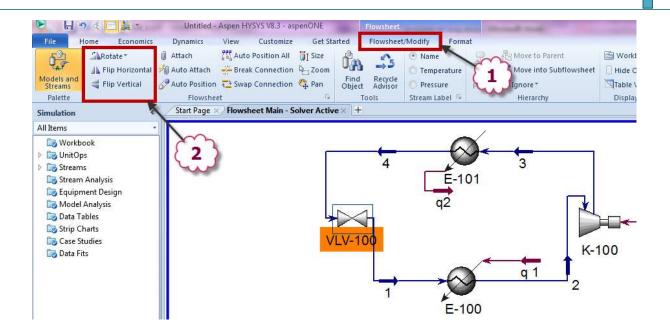




You can adjust the Flowsheet and rotate the streams and equipment from the above menu (Flowsheet/Modify)







**Results:** 

Pressure of the evaporator fed in kPa.	296.1
Flow rate of propane in kmol/hr.	146.4
Valve pressure drop in kPa.	1243.34
Temperature of the valve outlet in °C.	-14.51
Compressor duty in hp.	252.8
Condenser duty in kJ/hr.	2.179 e+6





# Coefficient of Performance (COP)

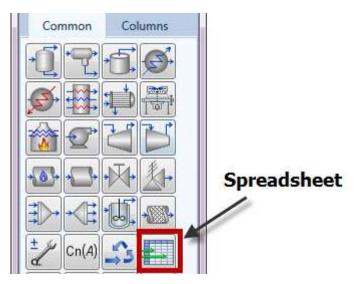
Is a measure of the efficiency of a refrigeration cycle is the *coefficient of performance*, COP

It is the ratio of desired output divided by the required input.

In the vapor-compression system, the net power input is equal to the compressor power, since the expansion valve involves no power input or output.

### **COP= Evaporator Duty/ Compressor Power**

We can use the spreadsheet operation in HYSYS to calculate the COP of the cycle:







Connections	Parameters	Formulas	Spreadsheet	Calculation Order	User Variables	Notes
Current Ce	II Variable:	[		2	Exportable 🛄 Angles in:	•
1	A		В	c		D
2						

Now we can calculate the COP by importing the two variables; Evaporator duty & Compressor power



	B1 Variable:			Exportable	
	A	В	с		D
1	A Evaporator duty	В	с		D
1		В	с		D



	B1 Variable:	Expor	table 🛄 es in: 🔤 🔻
	A Right Click B	c	D
1	Evaporator duty	Select All	
2	Compressor power	Сору	Ctrl+C
3	СОР	Paste	Ctrl+V
4		Fasic	Curty
5		Send To	•
6		View Associated Object	
7		Import Variable	
	Delete Function He		

Right click on the cell B1 and select import variable to import the duty of the evaporator

Flowsheet	Object	Variable	Variable Specifics	ОК
Case (Main)	1 2 3 4 E-100 E-101 K-100 q 1	Heat Flow 2 Heat Flow2 Mass Flow Overall UA Power Power2 Properties Temperature Approach		Object Filter All  Streams  UnitOps
avigator Scope	92 VLV-100 w1	User Variables Utility flow rate Utility Fluid Cp Utility Fluid Holdup Utility Heat Flow		ColumnOps ColumnOps

Right click on the cell B2 and select import variable to import the power of the Compressor



	A	В	с		D	
1	Evaporator d Righ	nt Click <mark>0e+006</mark>	i kJ/h			
2	Compressor power					
3	СОР	45	Select All			=
4			Сору		Ctrl+C	
5			Paste		Ctrl+V	
6			Send To		•	
7			View Associated Ob	ject		
	Delete	Function H	Import Variable			-
4			Evport Formula Res	ult		

Note that the 2 variables must be in the same units (kJ/hr or KW)

Flowsheet	Object	Variable	Variable Specifics	OK
Case (Main)	1	Heat Flow		
25 1 32	2	Heat Flow2		
	3	Mass Flow		
	4	Overall UA		Object Filter
	E-100	Power		
	E-101	Power2		
	K-100	Properties		Streams
	q 1	Temperature Approach		O UnitOps
	q2	User Variables		
	VIV-100	→ Utility flow rate		C Logicals
vigator Scope	w1	Utility Fluid Cp		ColumnOps
igator scope		Utility Fluid Holdup		00.

Now, divide the two variables in the cells b1 & b2 to calculate the COP in b3

2 Compressor power 6.787e+005 kJ/h		Variable Type:		•	Exportable		
A         B         C         D           1         Evaporator duty         1.500e+006 kJ/h             2         Compressor power         6.787e+005 kJ/h		B3 Variable:			Angles in:	Rad	•
1     Evaporator duty     1.500e+006 kJ/h       2     Compressor power     6.787e+005 kJ/h	=						
2 Compressor power 6.787e+005 kJ/h			-				
		0.55		с		D	
3 COP =b1/b2		0.55		С		D	
		Evaporator duty	1.500e+006 kJ/h	С		D	

The result will be 2.2





	B4 Variable:		Export Angles	able
	A	В	с	D
1	Evaporator duty	1.500e+006 kJ/h		
2	Compressor power	6.787e+005 kJ/h		
3	СОР	2.210		E
4				
5				

### **Challenge:**

Now change the duty of the evaporator to 3 e6 kJ/hr (in the evaporator not in the spreadsheet), then open the spreadsheet to calculate the COP & explain the results.

•	•	•	•••	•	•••	•	•••	• •	••	•••	•	•••	••	•	•••	•	•••	•	•••	•	• •	•	•••	••	•	•••	• •	••	••	•	•••	•	•••	• •	•••	•••	•	•••	•••	• •	•	•••	•••	••	• •	••	• •	•	•••	• •	••	••	•••	•
•	•	•	••	•	•••	•	••	• •	••	•••	•	•••	••	•	••	•	•••	•	•••	•	• •	•	••	••	•	•••	••	••	•••	•	••	•	•••	• •	•••	•••	•	•••	•••	••	•	•••	•••	••	• •	•	• •	•	•••	• •	••	••	•••	•
•	•	•	•••	•	••	•	••	•••	••	•••	•	•••	••	•	••	•	••	•	•••	•	• •	•	•••	••	•	••	••	••	••	•	••	•	••	• •	••	•••	•	••	•••	••	•	•••	•••	••	• •	••	•••	•	••	• •	••	••	• •	•
•	• •	•	••	•	••	•	••	• •	•••	•••	•	•••	••	•	••	•	•••	•	•••	•	• •	•	• •	••	•	••	• •	••	•••	•	••	•	••	• •	••	•••	•	••	•••	• •	•		••	••	• •	••	•••	•	••	• •	••	••	• •	•
•		•		•		•			••		•									•		•								•		•	••																					





4

Distillation Column

# Experience the New Aspen HYSYS\*.

The best process simulation software is now easier to use and faster to learn than ever!

Aspen HYSYS is a comprehensive process modeling system used by the world's leading oil & gas producers, refineries, and engineering companies to optimize process design and operations.







# Workshop

Separation of light products is present in any Hydrocarbons operations. In this module, a column will be modeled to separate Light and heavy components from each other using a distillation column with 12 trays.

# Learning Objectives

Once you have completed this section, you will be able to:

- Add columns using the Input Experts.
- Add extra specifications to columns.



Example:

We need to separate a mixture of five paraffins into light and heavy fraction by using a distillation column with 12 trays, a full reflux condenser, and a Kettle reboiler.

The feed stream (1000 lbmol/hr) consists of 3% (mole %) ethane, 20% propane, 37% n-butane, 35% n-pentane and 5% n-hexane at 225 °F and 250 psia, which enters the column on the sixth tray, counting from the top. The condenser and reboiler pressures are 248 and 252 psia, respectively. The preliminary design specifications require a **reflux ratio of 6.06** and **a vapor overhead product of 226 lbmol/hr**. Subsequently, the design is modified to ensure propane overhead flow of 191  $lb_{mol}/hr$  and n-butane bottom flow of 365  $lb_{mol}/hr$ .

### Use <u>SRK</u> Fluid Pkg

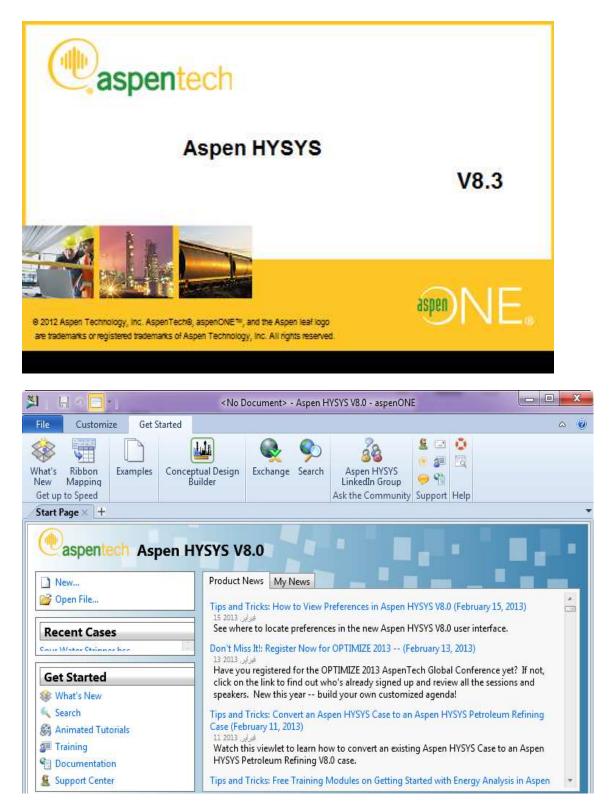
### Calculate:

The Condenser, the Reboiler Temperatures & the Reflux Ratio **after modification** 

Condenser Temp	ºC
Reboiler Temp	°C
Reflux Ratio	

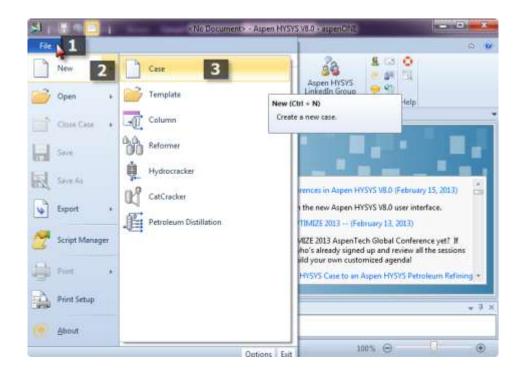


To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.3 >>>> Aspen HYSYS >> Aspen HYSYS





7- First, Start a new case



8- Add the Components

M	L L	Untitled - A	Aspen HYSYS V8.0	) - aspe	nONE	-	
File Home View C	ustomize	Get Starte	d				۵ 🔞
K Cut Copy Paste Clipboard K Map Con ↓ Update P ↓ Update P Comport Comport	roperties Pe	troleum Assays fining Ta	Mypotheticals	Oil	Aspen Properties Options	PVT Laboratory Measurements PVT Data	
Properties <	Start Page	×⁄ Com	ponent Lists $ imes$	+			•
All Items	1	List 1	Vame			Source	1
Fluid Packages Petroleum Assays Oil Manager Reactions Component Maps Component Maps	Ade	2	Co	py		Delete	
Properties	Impo	0	Expo	rt			, ,
6 Energy Analysis	Messages		121				▲ ù ×
*	Required Info	: Fluid P	ackages S				
	R. 1				100	% Θ	•



### 9- Choose the system components from the databank:

e Databank: HYSYS				Select:	Pure Compone
Component	Туре	Group		Search for:	
Ethane	Pure Component				
Propane	Pure Component			Simulat	tion Name
n-Butane	Pure Component				Methane
n-Pentane	Pure Component		< Add		i-Butane
n-Hexane	Pure Component				i-Pentane

Now, select the suitable fluid package

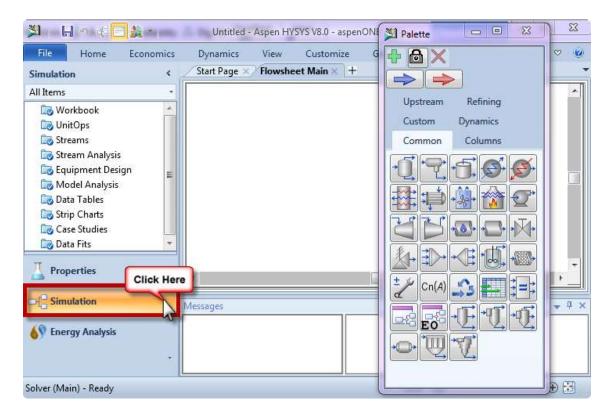
M 🔒 🕆 🗖 •	Untitled - Aspen HYSYS V	8.0 - aspenONE	
File Home View Custo	omize Get Started		~ @
Properties <	Start Page × Fluid Packages ×	+	
All Items  Component Lists Component List - 1 Fluid Packages Petroleum Assays Co Oil Manager	Fluid Package	Component List	Property Packag
Reactions Component Maps User Properties	2		
	Add	Edit	Сору

In this case, select SRK



All Items 🔹		
Component Lists	Property Package Selection	Options
🖌 📷 Fluid Packages 🛛 🚹	Lee-Kesler-Plocker  Margules	Enthalpy
🗔 Basis-1	MBWR	Density
Petroleum Assays	NBS Steam	Modify Tc, Pc for H2, He
🗔 Oil Manager	OLI_Electrolyte	Indexed Viscosity
Reactions	Peng-Robinson	EOS Solution Methods
Component Maps	PR-Twu PRSV	Phase Identification
	Sour SRK	Surface Tension Method
Properties	Sour PR	Thermal Conductivity
□-{□ Simulation		

Now you can start drawing the flow sheet for the process by clicking the Simulation button:



Now add a material stream to define the composition and the conditions of the feed stream



### From the palette:

🎽   🖯 🕫 🖂 🖊 🖊	CASE2.HSC - Aspen HYSYS V8.0 - aspen O State Dalatte D
File Home Economics	Dynamics View Customize Get Sta Click Here
Q Zoom In	Flowsheet Model Palette Show Custom Dynamics
Simulation	Flowsheet Main × Case Study 1     Common Columns
All Items  Workbook  UnitOps  Government Design  Model Analysis  Data Tables  Strip Charts  Properties  Simulation	$ \begin{array}{c}         Double Click \\         2 \\         1 \\         \lambda         \\         Cn(A) \\         From +From +Fro$

Add the mole fraction for the inlet stream

	MoleFraction	Composition Basis
thane Propane n-Butane n-Pentane n-Hexane	0.0300 0.2000 0.3700 0.3500 0.0500	<ul> <li>Mole Fractions</li> <li>Mass Fractions</li> <li>Liq Volume Fractions</li> <li>Mole Flows</li> <li>Mass Flows</li> <li>Liq Volume Flows</li> </ul>
		Composition Controls Erase Equalize Composition

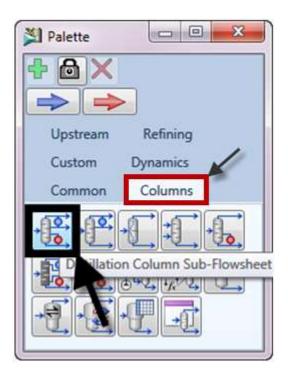
By: Eng. Ahmed Deyab Fares<br/>Mobile: 002-01227549943- http://www.adeyab.com<br/>- Email: eng.a.deab@gmail.com



Then go to the conditions page to complete the feed stream conditions:

Vorksheet Attachme	ents Dynamics	
Worksheet	Stream Name	1
Conditions	Vapour / Phase Fraction	0.2340
Properties	Temperature [C] 225 °F	107.2
Composition	Pressure [kPa] 250 psia	1724
Oil & Gas Feed	Molar Flow [kgmole/h] 1000 lbmole/hr	453.6
Petroleum Assay K Value	Mass Flow [kg/h]	2.757e+004
User Variables	Std Ideal Liq Vol Flow [m3/h]	46.91
Notes	Molar Enthalpy [kJ/kgmole]	-1.353e+005
Cost Parameters	Molar Entropy [kJ/kgmole-C]	128.5
Normalized Yields	Heat Flow [kW]	-1.705e+004
	Liq Vol Flow @Std Cond [m3/d]	1112
	Fluid Package	
	Utility Type Eng	Deyab Fares
	4	[. III ]

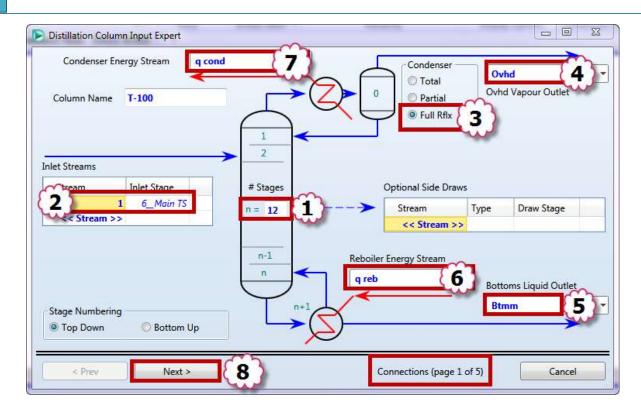
Add a distillation tower (with condenser & Reboiler):



Now, start building the column:

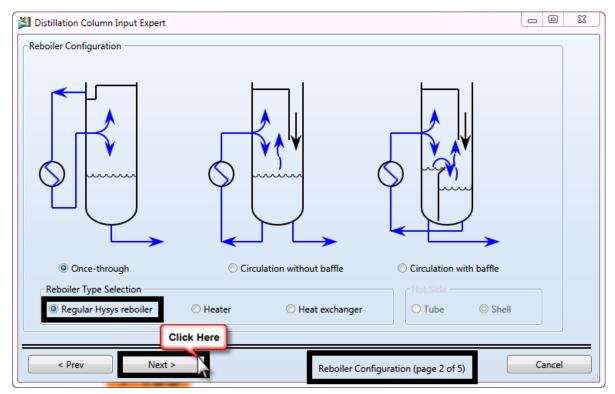






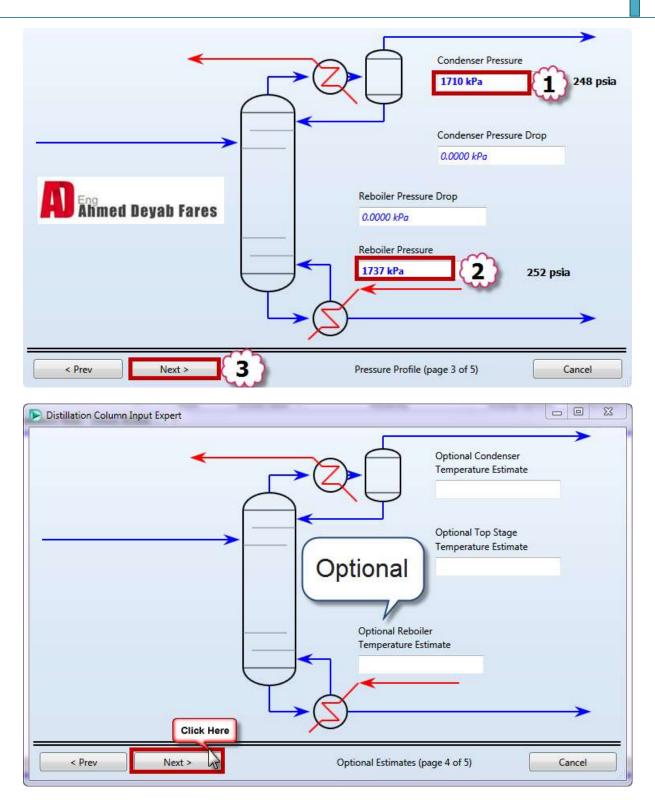
Select Regular Hysys Reboiler in the reboiler configuration page for Kettle

### Reboiler as follows:







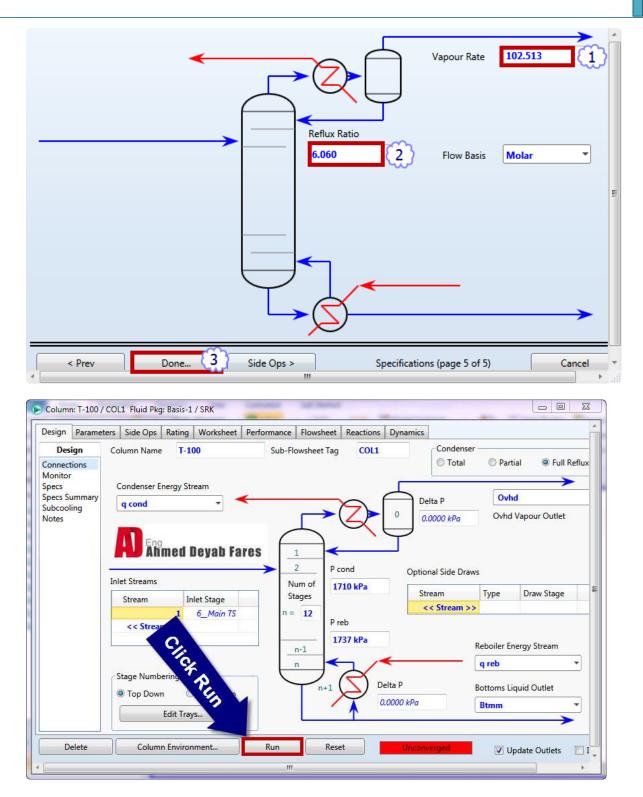


The target is to run the column with 2 specifications:

- 1- Reflux Ratio = 6.06
- 2- Overhead vapor rate (Vent rate) =226  $lb_{mole}/hr$







The column statues bar (Red bar) is now unconverged till clicking the RUN button to converge the column.





Subcooling Notes	q cond		0         Delta P         Ovhd Vapour Outlet           0         0.0000 kPa         Ovhd Vapour Outlet
	Inlet Streams Stream Inlet Stage	1 2 P cond 1710 kPa Stages	Optional Side Draws           Stream         Type         Draw Stage           << Stream >>         Type         Type         Type
	1 6_Main TS << Stream >>	n = 12 P reb 1737 kPa	Reboiler Energy Stream
	Stage Numbering Top Down Bottom Up Edit Trays	n+1	Delta P Bottoms Liquid Outlet     0.0000 kPa   bttm
Delete	Column Environment	Run Reset	Converged Vpdate Outlets I

Let's go to the monitor page and see the current specifications:

Monitor Specs Specs Summary Subcooling Notes	Iter Step Equilib	rium Heat / Spec	<ul> <li>Temp</li> <li>Press</li> <li>Flows</li> </ul>	120.0 100.0 80.00 40.00 0 2	Temper	ature	10 1	2 14	
	Specifications					•			
		Specified Value	Current Value	Wt. Error	Active	Estimate			
	Reflux Ratio	6.060	6.061	0.0002	ব		$\checkmark$		
	Reflux Rate	<empty></empty>	621.5	<empty></empty>					
	Btms Prod Rate	<empty></empty>	351.1	<empty></empty>					
	Vent Rate	102.5 kgmole/h	102.5	0.0001	<ul><li>Image: A set of the set o</li></ul>		~		
	Degree of Freedom=# of unkown variables - # of equations         2 active specifications to acheive the DOF =0         View       Add Spec         Group Active       Update Inactive         Degrees of Freedom       0								
Delete	Column Environment.	. Run	Reset	Converged		✓ Updat			

We must make 2 specifications active to make the DOF=0.0 and to converge the column.

The two specifications are the target that you want to achieve from the column.

Although the column is converged, it is not always practical to have vapor rate & reflux ratio specifications. These specifications can result in columns which cannot be converged or that produce product streams with undesirable properties if the column feed conditions change.

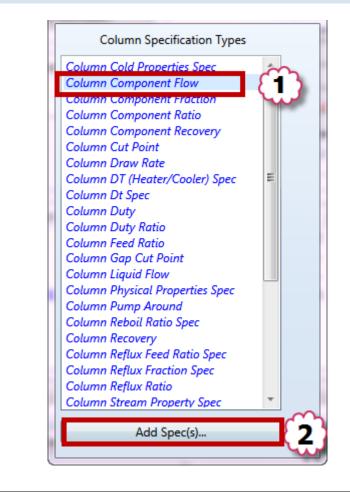


An alternative approach is to specify either component fractions or component flow rates for the column product streams.

Now we have to give the column another 2 new specifications to run with (more practical)

- 1- Propane overhead flow of 191 lb<sub>mol</sub>/hr
- 2- Butane bottom flow of 365  $lb_{mol}/hr$ .

	Specified Value	Current Value	Wt. Error	Active	Estimate	Current	
Reflux Ratio	6.060	6.061	0.0002	V	V		
Reflux Rate	<empty></empty>	621.7	<empty></empty>		$\checkmark$		
Btms Prod Rate	<empty></empty>	351.0	<empty></empty>		$\checkmark$		
Vent Rate	102.5 kgmole/h	102.6	0.0006				
View	Click Here	Active	Indate Inactive				0
View		Active	Jpdate Inactive	De	egrees of Fr	reedom	0





Parameters	Summary	Spec Typ	e	
Name		m	Comp Flow	
Draw			ovhd @COL1	Overhead stream
Flow Basis	Ja	-	Molar	
Spec Value	1	21	86.64 kgmole/h	191 lb <sub>mol</sub> /hr
Components:		3	Propane Component >>	3
	0	Stream	Stage	

Add the other specification:

Column Specification Types	;		
Column Cold Properties Spec	â	~	
Column Component Flow	-3	2	
Column Component Fraction			
Column Component Ratio			
Column Component Recovery			1
Column Cut Point			
Column Draw Rate			
Column DT (Heater/Cooler) Spec	=		
Column Dt Spec			
Column Duty			
Column Duty Ratio			
Column Feed Ratio			
Column Gap Cut Point			
Column Liquid Flow			
Column Physical Properties Spec			
Column Pump Around			
Column Reboil Ratio Spec			
Column Recovery			
Column Reflux Feed Ratio Spec			
Column Reflux Fraction Spec			
Column Reflux Ratio			
Column Stream Property Spec	Ŧ	~	
Add Spec(s)		2	1
		~~	



Parameters	Summary	Spec Type			-
Name	-		Comp Flow - 2		
Draw	{ <b>1</b> }		bttm @COL1	Bottom stream	
Flow Basis	m		Molar *		
Spec Value	{21		165.6 kgmole/h	365 lb <sub>mol</sub> /hr	
Components:	3	<< Co	n-Butane omponent >>		

You can change the specifications by marking the Active check box on the 2 new specifications

A	Ahmed Deyab Fares	Current Value	Wt. Error	Active	Estimate	Current	
Reflux Ratio	6.060	8.546	0.4102				
Reflux Rate	<empty></empty>	875.8	<empty></empty>		$\checkmark$		
Btms Prod Rate	<empty></empty>	351.1	<empty></empty>				
Vent Rate	102.5 kgmole/h	102.5	-0.0004		$\checkmark$		
Comp Flow	86.64 kgmole/h	86.60	-0.0004		<b>V</b>		
Comp Flow - 2	165.6 kgmole/h	165.6	0.0000				
View	Add Spec Group		Active	De	grees of Fr	eedom	0
Column Environmer	it Run f	Reset	Converged		V Updat		

The Results is always inside the performance page:

Design Parameters	Side Ops Rating	Worksheet	Performance	Flowsheet	Reactions	Dynamics	-
Performance	Feeds					* 10	
Summary			1				
	2 Flow Rate (kgmole,	/h)	453.5970				
Peeds / Products Plots							
Cond./Reboiler	Ethane		0.0300				
	Propane		0.2000				
	n-Pentane		0.3500				
n-Hexane		n-Hexane 0.0500					
	n-Butane		0.3700				
				A Eng			
				Ahi	med Dey	yab Fares	



Go to column profile to see the temperature & Pressure profile across the tower.

Design	Parameters	Side Ops	Rating	Worksheet	Performance F	lowsheet	Reactions	Dynamics
Perform Summary		Reflux Ratio Boilup Ratio		8.546 2.121	Flows	Energy		Basis 💿 Molar
Column P	rofiles							🔘 Liq Vol
Feeds / Pr	oducts				_			
Plots				Temperature	Pressure	Net Li		Net Vapour
Cond./Rel	ooiler			[C]	[kPa]	[kgmo	ole/h]	[kgmole/h]
		Condenser		46.06	171	.0	875.775	
		1_Main TS		51.63	171	.0	854.449	978.252
		2_Main TS		57.72	171	2	816.478	956.925
		3_Main TS		65.82	171	.5	772.861	918.954
		4_Main TS		75.93	171	.7	733.714	875.337
		5_Main TS		87.10	172	20	698.895	836.190
		6_Main TS		98.81	172	22	1044.86	801.372
		7_Main TS		103.5	172	25	1064.36	693.744
		8_Main TS		107.6	172	27	1081.04	713.240
		9_Main TS		111.1	173	30	1094.06	729.924
		10_Main TS		114.4	173	32	1102.07	742.942
		11_Main TS		117.8	173	35	1103.22	750.946
		12_Main TS		122.3	173	37	1095.84	752.095
		Reboiler		128.8	173	37		744.719

Condenser Temp	46 °C
Reboiler Temp	128.8 °C
Reflux Ratio	8.54



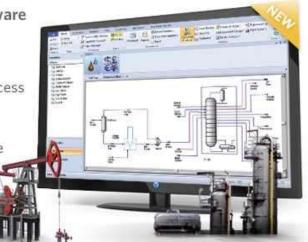
# **Oil Characterization**

# Experience the New Aspen HYSYS\*.



The best process simulation software is now easier to use and faster to learn than ever!

Aspen HYSYS is a comprehensive process modeling system used by the world's leading oil & gas producers, refineries, and engineering companies to optimize process design and operations.







# Workshop

The petroleum characterization method in HYSYS will convert laboratory analyses of condensates, crude oils, petroleum cuts and coaltar liquids into a series of discrete hypothetical components. These petroleum hypo components provide the basis for the property package to predict the remaining thermodynamic and transport properties necessary for fluid modeling.

HYSYS will produce a complete set of physical and critical properties for the petroleum hypo components with a minimal amount of information. However, the more information you can supply about the fluid, the more accurate these properties will be, and the better HYSYS will predict the fluid's actual behavior.

In this example, the Oil Characterization option in HYSYS is used to model a crude oil. The crude is the feed stock to a Pre-heat Train, followed by the Atmospheric Crude Column, which will be modelled in a subsequent module.

# Learning Objectives

Once you have completed, you will be able to use the Oil Characterization option in HYSYS.

# **Oil Characterization**



The petroleum characterization method in HYSYS will convert laboratory analyses of condensates, crude oils, petroleum cuts and coal-tar liquids into a series of discrete hypothetical components. These petroleum hypocomponents provide the basis for the property package to predict the remaining thermodynamic and transport properties necessary for fluid modeling.

In this example, the Oil Characterization option in HYSYS is used to model a crude oil. The crude is the feed stock to oil refining process. (FPkg=PR)

#### **Bulk Properties of the crude:**

API Gravity of 29 for the crude

#### Light Ends (Liquid Volume):

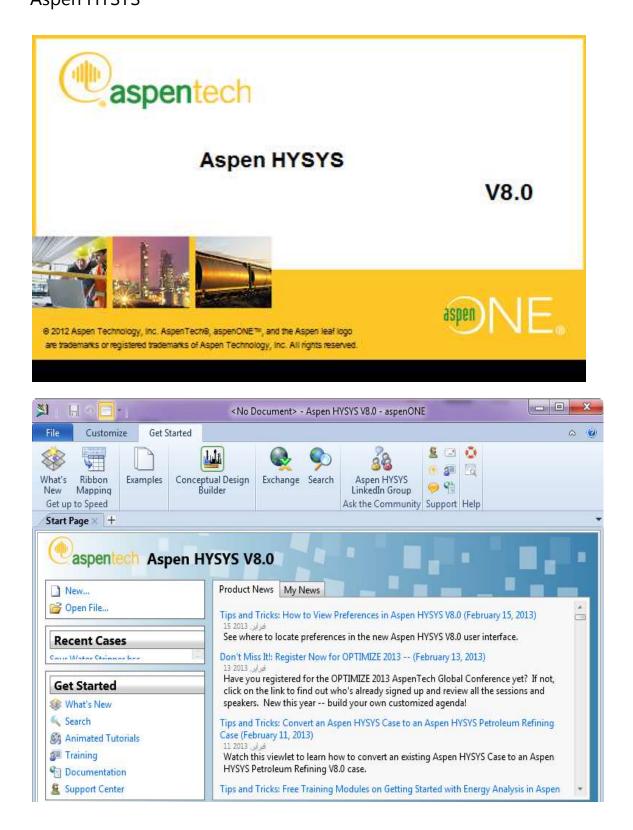
Light Ends	Liquid Vol %
Methane	0.0065
Ethane	0.0225
Propane	0.3200
i-butane	0.2400
n-butane	1.7500
i-pentane	1.6500
n-pentane	2.2500

### TBP distillation data (Liquid Volume %):

Assay Percent	Temperature (°C)
0	-12
4	32
9	74
14	116
20	154
30	224
40	273
50	327
60	393
70	450
76	490
80	516



To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.0 >>>> Aspen HYSYS >> Aspen HYSYS





1- First, Start a new case

SI	«No Document»	- Aspen HY5Y5 V8.0 - aspenDNE	
File 1			a 🔮
File New 2 New 2 Open • Cose Case • Save 5 Save 5 Save 6 Save 7 Save 6 Save 6 Sa	Case 3 Template Column Reformer Hydrocracker CatCracker Petroleum Distillation	Aspen HYSYS LinkedIn Group New (Ctrl + N) Create a new case. rences in Aspen HYSYS V8.0 (Februar the new Aspen HYSYS V8.0 user int TIMIZE 2013 (February 13, 2013) VIZE 2013 AspenTech Global Confer	ary 15, 2013)
Port + Print Setup  About		tho's already signed up and review a aild your own customized agendal HYSVS Case to an Aspen HYSVS Pet	

### 2- Add the Components

M		Untitled - As	pen HYSYS V8.	) - aspe	nONE	Country I	
File Home View	Customize	Get Started					۵ 🔞
Copy* Paste	ap Components odate Properties omponents	Petroleum Assays Refining Ta	Mypotheticals	Oil •	Aspen Properties Options	PVT Laboratory Measurements PVT Data	
Properties	< Start F	age × Comp	onent Lists $ imes$	+			-
All Items	1	List Na	ame			Source	-
Fluid Packages Fluid		Add n	Co	ру		Delete	E
Properties		Import 💽	Expo	nt			•
6 Energy Analysis	Message	Info: Fluid Pao	kages S				<b>→</b> Å ×
			, tuyes - s				
					100	%Θ	•



- 3- Choose the system components from the databank:
- 4- First we should add the pure components first (Light Ends)

Light Ends are defined as pure components with low boiling points. Components in the boiling range of C1 to n-C5 are most commonly of interest.

ce Databank: HYSYS				Select	Pure Compone	nts •	Filteri	All families
Component	Туре	Group		Search for	i i i i i i i i i i i i i i i i i i i	1	Search by:	Full Name/Synonym
				Simulatio		Full Name /	Contract Manager	Formula
			< Add		Methane		a	(
					Ethane Propane		2	
					i-Butane		C3 1-04	CI CI
			Replace		n-Butane		n-C4	CA
					i-Pentane		+C5	G
					n-Pentane		n-C5	G
			lano-e		in-Hexane		C6	C6
					n-Heptane		C7	0
					n-Octane		C8	CB
					n-Nonane		C9	C9
					n-Decane		C10	C10
					n-C11		C11	cit
					n-C12		C12	0

Component	Туре	Group		Search for:
Methane	Pure Component			
Propane	Pure Component		2	Simulation Name
Ethane	Pure Component			1
			< Add	n-E
				i-Pe
				n-Pe
			Replace	n-H
				n-He
				n-C
			Remove	n-N
				n-D

Add the pure components (C1, C2, C3, n-C4, i-C4, n-C5, i-C5, H<sub>2</sub>O)



### Now, select the suitable fluid package

	Untitled - Aspen HYSYS V8	.0 - aspenONE	
File Home View C	Customize Get Started		♡ 0
Properties <	Start Page × Fluid Packages ×	+	-
All Items	Fluid Package	Component List	Property Packag
User Properties  Properties  Control  Simulation	Add	Edit	Сору
Energy Analysis	Messages Required Info : Fluid Packages Selei		<b>→</b> <sup>‡</sup> ×
	2	100% Θ 🗌	

### In this case, select Peng-Robinson

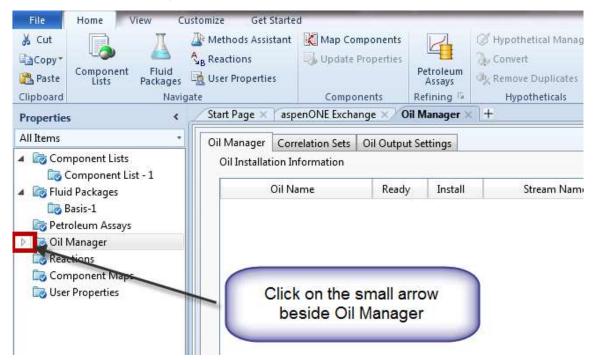
M H	Untitled - Aspen HYSYS V8.0 - a	spenONE	
File Home View C	ustomize Get Started		~ @
Properties <	Start Page × Basis-1 × +		-
All Items	Set Up Binary Coeffs StabTest Phas Package Type: HYSYS	e Order Tabular Notes	Component List 5
Fluid Packages     Basis-1	Property Package Selection	Options	E Pr
<ul> <li>Petroleum Assays</li> <li>Oil Manager</li> <li>Reactions</li> <li>Component Maps</li> <li>User Properties</li> </ul>	Lee-Kesler-Plocker Margules MBWR NBS Steam NRTL OUL Stoctrolute	Enthalpy Density Modify Tc, Pc for H2, He Indexed Viscosity Peng-Robinson Options	Moc
Properties	Peng-Robinson PK-1WU PRSV Sour SRK	EOS Solution Methods Phase Identification	Cubic EC
□ {□ Simulation	Sour PR SRK III	Surface Tension Method	, <b>*</b> *
🚯 Energy Analysis	Messages		
	<u>.                                    </u>	100% Θ	- <b>(</b>



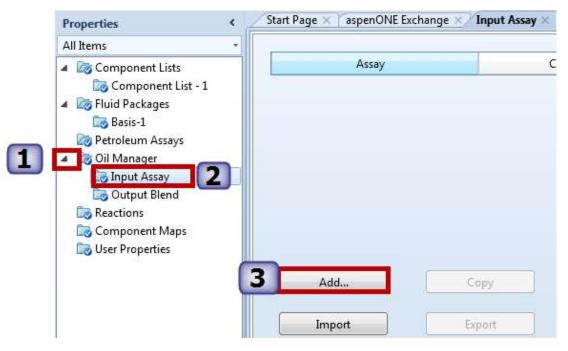
### Characterize the Assay

The assay contains all of the petroleum laboratory data, boiling point curves, light ends, property curves and bulk properties. HYSYS uses the supplied Assay data to generate internal TBP, molecular weight, density and viscosity curves, referred to as Working Curves. To characterize the assay follow the following steps:

1- Go to Oil Manager.

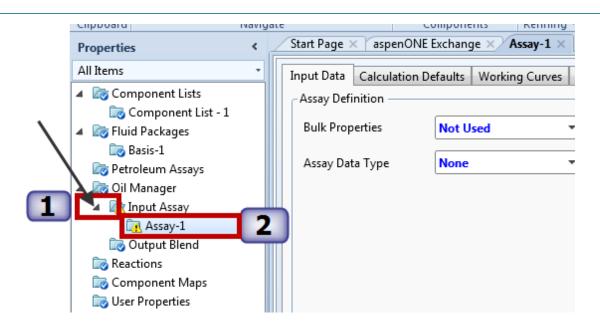


2- Click on Input Assay & then Click Add button:



By: Eng. Ahmed Deyab Fares- http://www.adeyab.comMobile: 002-01227549943- Email: eng.a.deab@gmail.com



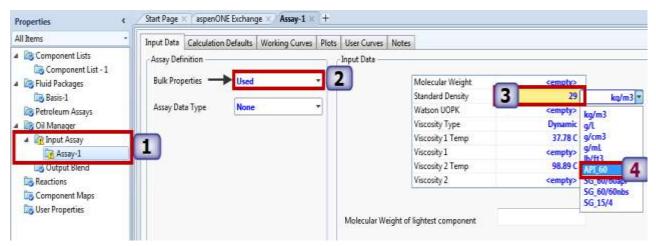


### **Bulk Properties**

Bulk Properties for the sample may also be supplied. The bulk properties are optional if a distillation curve or chromatograph have been supplied Change the bulk properties from **Not used** to **Used** and add the value for standard Density = 29 API\_60

Note:

$$API = \frac{141.5}{SG} - 131.5$$



Select the Assay Data Type >> TBP



Start Page ×   aspenUN	IE Exchange × Assay-1 ×	t		
Input Data Calculation	Defaults Working Curves P	lots User Curves	Notes	
Assay Definition		Input Data		
Bulk Properties	Used Click H	lere	Molecular Weight	<empty></empty>
			Standard Density	879.8 kg/m3
Assay Data Type	None	2	Watson UOPK	<empty></empty>
	TBP	<b>v</b>	Viscosity Type	Dynamic
	ASTM D86	STM D1160 STM D86-D1160	Viscosity 1 Temp	37.78 C
			Viscosity 1	<empty></empty>
	ASTM D80-D1100		Viscosity 2 Temp	98.89 C
	Chromatograph		Viscosity 2	<empty></empty>
	EFV None			
		Molecular Wei	ght of lightest component	

- Select the Distillation radio button in the Input Data group box.
- Select the Assay Basis as Liquid Volume (use the drop-down menu).
- Click the Edit Assay button; this will allow you to enter the assay information below.

Assay Definition ———			Input Data		
Bulk Properties	Used	•	Bulk Props	Assay Basis	Liquid Volume 3 -
Assay Data Type	твр 1	]-]-	Distillation	Assay Percent	Temperature [C]
Light Ends	Iqnore	•			
Molecular Wt. Curve	Not Used	•			
Density Curve	Not Used	•			
Viscosity Curves	Not Used	•			
TBP Distillation Conditi	ons	_			
Atmospheric	🔘 Vacuum				
			Edit Assay 4	At least 5	5 points are required

Add the assay data:



Assay Percent [%]	Temperature [C]
0.0000	-12.00
4.000	32.00
9.000	74.00
14.00	116.0
20.00	1 154.0
30.00	224.0
40.00	273.0
50.00	327.0
60.00	393.0
70.00	450.0
76.00	490.0
80.00	516.0
um of Points to Add	Add Data Poin

Use the drop-down lists to select Input Composition for Light Ends

Input Data Calculation D	efaults   Working Curv	es Plots	s User Curves Notes	;
Assay Definition			Input Data	
Bulk Properties	Used	-	Bulk Props	Assay
Assay Data Type	ТВР	-	Oistillation	Ass
Light Ends	Ignore			
Molecular Wt. Curve	Iqnore Input Composition			
Density Curve	Auto Calculate Not Used	-		
Viscosity Curves	Not Used	•		
TPD Distillation Conditi	0.05			

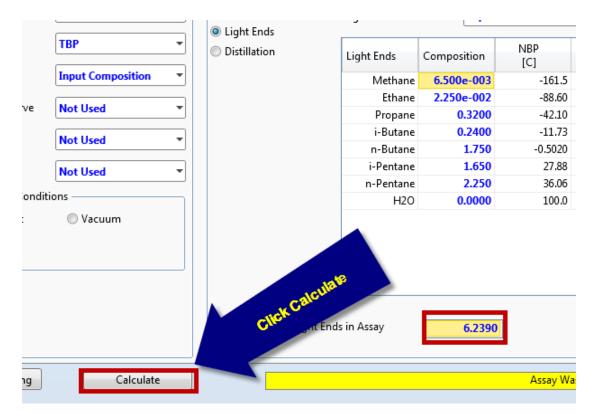
Select the Light Ends radio button and enter the data given from Input

### Data



put Data Calculation D	efaults   Working Curv	es Plo	ts User Curves Notes			
Assay Definition ———			_ Input Data			
Bulk Properties	Used	•	Bulk Props Light Ends	Light Ends Basis	Liquid	Volume %
Assay Data Type	ТВР	-	<ul> <li>Distillation</li> </ul>	Light Ends	Composition	NBP [C]
Light Ends	Input Composition	~		Methane	6.500e-003	-161.5
Molecular Wt. Curve	NetHead	-		Ethane	2.250e-002	-88.60
wolecular wt. Curve	Not Used	_		Propane	0.3200	-42.10
Density Curve	Not Used	•		i-Butane	0.2400	-11.73
bensity curre	norosca			n-Butane	1.750	-0.5020
Viscosity Curves	Not Used	•		i-Pentane	1.650	27.88
				n-Pentane	2.250	36.06
- TBP Distillation Conditi	ions			H2O	0.000	100.0

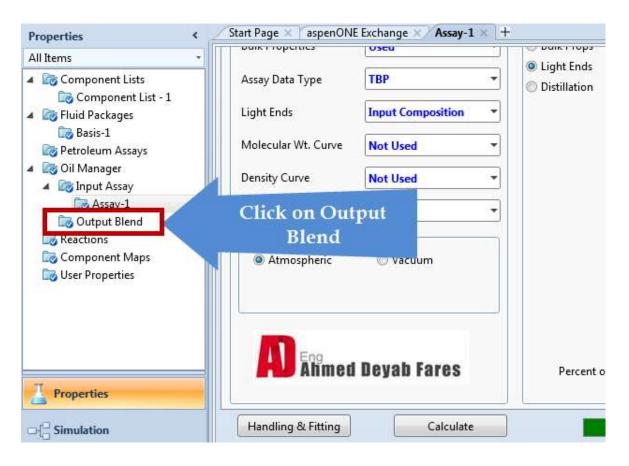
Once you have entered all of the data, click the Calculate button. The status message at the bottom of the Assay view will display Assay Was Calculated.



Once the Assay is calculated, the working curves are displayed on the **Plots** and **Working Curves** tabs. The working curves are regressed and extrapolated from the Assay input. From the user-supplied data, HYSYS generates curves for NBP, molecular weight, mass density, and viscosity. These working curves are used in determining the properties of the hypo components generated in the Blend step.

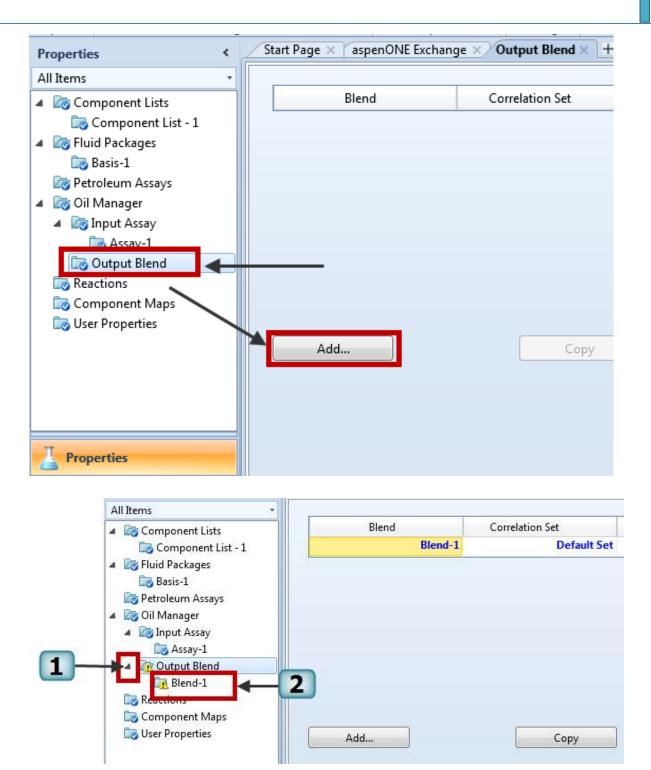


Point #	Moles	Cum. Moles	NBP [C]	Mole Wt	Mass Density [kg/m3]	Viscosity 1 [cP]	Viscosity 2 [cP]
0	0.00000	0.00000	47.57	71.49	724.7	0.407	0.21
1	0.02524	0.02524	55.42	74.83	730.6	0.404	0.21
2	0.02436	0.04960	63.01	78.13	736.2	0.311	0.18
3	0.02355	0.07315	70.44	81.43	741.6	0.326	0.19
4	0.02274	0.09589	78.20	84.93	747.1	0.345	0.20
5	0.02214	0.11803	84.34	87.77	751.5	0.362	0.21
6	0.02161	0.13964	89.76	90.35	755.2	0.377	0.22
7	0.02103	0.16067	95.80	93.37	759.4	0.396	0.23
8	0.02032	0.18099	103.4	97.27	764.5	0.421	0.24
9	0.01965	0.20064	111.1	101.3	769.8	0.450	0.26
10	0.01907	0.21971	118.3	105.0	774.5	0.479	0.27
11	0.04476	0.26446	134.1	113.3	784.8	0.550	0.30
12	0.04236	0.30682	148.3	121.1	793.8	0.623	0.34
13	0.03994	0.34676	163.7	130.0	803.3	0.714	0.38
14	0.03748	0.38424	180.5	140.3	813.5	0.842	0.44
15	0.03521	0.41945	197.2	151.2	823.4	1.024	0.50
16	0.03313	0.45258	213.7	162.5	832.9	1.252	0.58

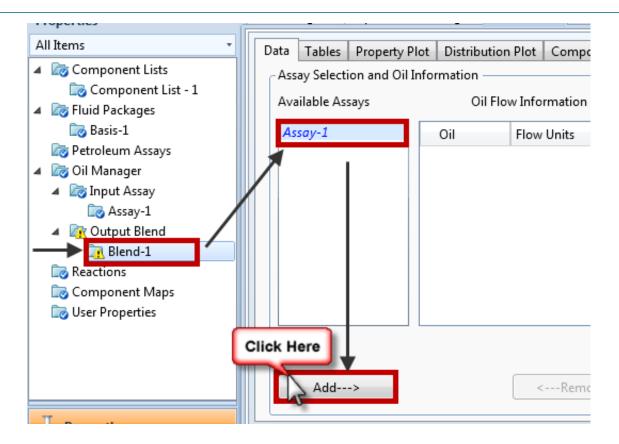


The Output Blend characterization in HYSYS splits the internal working curves for one or more assays into hypo components. The Blend tab of the Oil Characterization view provides two functions, cutting the Oil into Hypo components and Blending two or more Assays into one set of hypo components.









### The results of the calculation can be viewed on the Tables tab

Table Type	- Component P	hysical Propertie	25		
Component Properties	Comp Name	NBP [C]	Mole Wt.	Density [kg/m3]	Visco [cf
Table Control	NBP_5	NBP_57 56.5		728.7	7
Main Properties	NBP_6	i8 68.4	2 78.92	2 737.5	5
·	NBP_8	83.3	85.95	5 748.7	7
Other Properties	NBP_9	6 95.9	6 91.89	) 757.4	1
Oil:	NBP_11	1 111	1 99.31	767.2	2
Blend-1	NBP_12	25 124	.6 105.8	3 775.5	5
Dienu-1	NBP_14	0 139	9 112.3	3 783.5	5
	NBP_15	3 152	.7 119.6	5 792.1	L
	NBP_16	57 166	9 127.2	2 800.	5
	NBP_18	1 181	1 135.5	5 808.9	9
	NBP_19	195	1 144.3	8 817.3	3
	NBP_20	9 209	3 153.8	8 825.7	7
	NBP_22	223	5 164.3	834.4	1
	NBP_23	237	5 175.5	5 843.0	)
		001	4 100 1	050/	



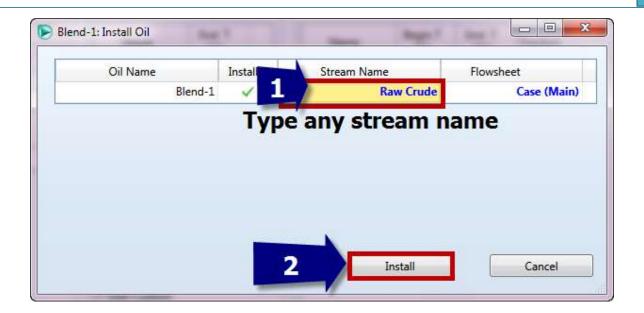
Data Tables Property Plot Distrik	oution Plot Compo	osite Plot	Plot Summan	y Correlations	Notes		
Table Type	Cut Input Informati	on	[ <sup>Ci</sup>	ıt Distributions —			
Oil Distributions	Name	End T [C]		Name	Begin T [C]	End T [C]	Fraction
Table	Off Gas	10.00		Off Gas	-19.54	10.00	0.021
	Lt St Run	70.00		Lt St Run	10.00	70.00	0.064
Basis: ne 🔻	Naphtha	180.0		Naphtha	70.00	180.0	0.153
	Kerosene	240.0		Kerosene	180.0	240.0	0.094
Oil:	Light Diesel	290.0		Light Diesel	240.0	0.00	0.102
Blend	Heavy Diesel	340.0		Heavy Diesel	200		0.087
	Atm Gas Oil	370.0		Atm Gas Oil		.0	0.045
	Residue	1200		Resi		825.2	0.434
	< <new>&gt;</new>	< <new>&gt;</new>					
	· · · · · ·						

The final step of the characterization is to transfer the hypo component information into the Flowsheet.

Add>		<remov< th=""><th>2</th><th>Default Method</th></remov<>	2	Default Method
	Click Install Oc.		nnicu ucyau	Hypocomponent Ideal Liqu
	Ä		ng hmed Deyab	
	ta l			Viscosity 2 temp Viscosity2
				Viscosity 1
		7		Viscosity 1 Temp
				Viscosity Type
	Assay-1	Liquid Vol	<empty></empty>	Watsonwopk
	Oil	Flow Units	Flow Rate	Mass Density
Available Assays	OII FIO	w Information	Molecular Weight	

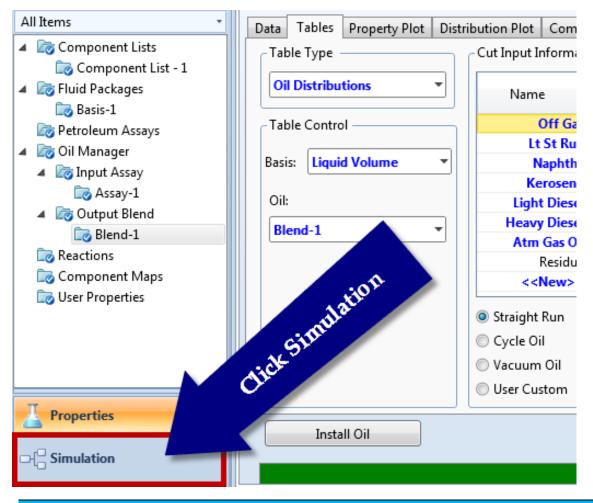
In the Stream Name column, enter the name **Raw Crude** to which the oil composition will be transferred.



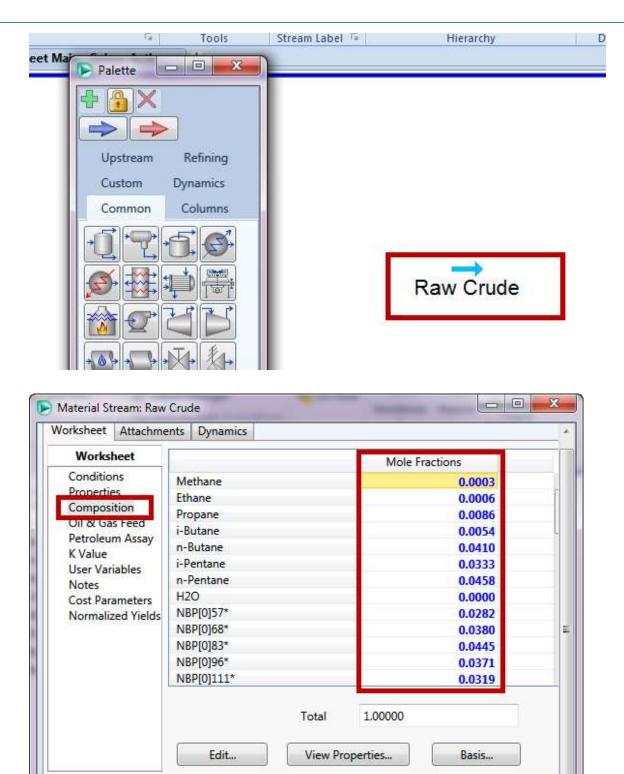


HYSYS will assign the composition of your calculated Oil and Light Ends into this stream, completing the characterization process.

Now you can return to the Simulation environment to see the stream (Raw Crude) with a full composition:







## Save Your Case!

Unknown Temperature

Define from Other Stream...

88

Delete

¢

⇒



# **Atmospheric Distillation**

## Experience the New Aspen HYSYS\*.



The best process simulation software is now easier to use and faster to learn than ever!

Aspen HYSYS is a comprehensive process modeling system used by the world's leading oil & gas producers, refineries, and engineering companies to optimize process design and operations.







## Workshop

Atmospheric Crude Columns are one of the most important pieces of equipment in the petroleum refining industry. Typically located after the Desalter and the Crude Furnace, the Atmospheric Tower serves to distil the crude oil into several different cuts. These include naphtha, kerosene, light diesel, heavy diesel and AGO.

In this module, you will construct, run, analyze and manipulate an Atmospheric Crude Column simulation. You will begin by building a simple column and continue by adding side operations to the column.

# Learning Objectives

- Build and converge an Atmospheric Crude Column.
- Use HYSYS to analyze and predict the behavior of a simulated column.
- Add side operations to a column to improve operation and efficiency.
- Add cut point specifications to increase side product quality and quantity.

## **Pre-Heat Train**



A crude stream at 15°C, 1000 kPa and flowrate of  $6\times10^5$  kg/hr is mixed with a stream of water at 15°C, 1000 kPa and flowrate of 21600 kg/hr using a Mixer, the outlet from the mixer is then heated to 65°C through a Heater ( $\Delta p$ =50 kPa), the heater outlet is fed to the tube side of a Shell & Tube Heat Exchanger, where it's heated using a Shell inlet stream having the same composition as the crude feed stream and enters the shell of the heat exchanger at 180°C, 200 kPa and flowrate of 175m<sup>3</sup>/hr. The pressure drops for the Tube and Shell sides, will be 35 kPa and 5 kPa, respectively. The tube outlet from the HX is then sent to a desalter which is simply modeled as Three Phase Separator where desalted water, oil and gas is separated. The oil stream (light liquid) from the desalter is then heated to 175°C through a Heater (Pressure drop=375 kPa) and then sent to a Preflash (Separator) to reduce the light components in the feed. The liquid product from the separator is then heated to 400°C inside a Heater (Pressure drop=250 kPa) before entering the Atmospheric Column.

Heat Exchanger Specification:

- Use Simple weighted model
- Min Approach = 30°C (54°F). This is the minimum temperature difference between the hot and the cold stream.

Calculate:

- The vapor fraction of the product stream before entering the Atmospheric column.
- The Shell side outlet Temperature.
- The vapor molar flow rate from the Preflash.

# **Atmospheric Distillation**



A feed stream from the pre-heat train is fed to the  $28^{th}$  tray of a *Refluxed Absorber* with 29 trays and a partial condenser to separate Off Gases, Naphtha and Bottom Residue. A steam stream (vapor fraction =1.0, pressure =1380 kPa and flowrate=3400 kg/hr) is fed to the bottom of the tower to provide the necessary heat. A water draw stream is required to remove the condensed steam from the overhead condenser. The tower is operated with the following conditions:

Condenser Pressure	140 kPa
Condenser Pressure Drop	60 kPa
Bottom Stage Pressure	230 kPa

Condenser Temperature	40 °C
Top Stage Temperature	120 °C
Bottom Stage Temperature	340 °C

Specifications:

Overhead vapor rate	0.0 kgmole/hr
Distillate rate (Naphtha rate)	

What is the flow rate of?

Naphtha \_\_\_\_\_ Residue \_\_\_\_\_

Wastewater \_\_\_\_\_



# **Side Strippers & Pump Arounds**

<u>Side Strippers</u> are added to the column in order to improve the quality of the three main products (Kerosene, Diesel, and AGO). There are two types of side strippers available in HYSYS: Reboiled and Steam Stripped. We will install one reboiled side stripper and two steam stripped.

	AGO SS	Diesel SS	Kerosene SS
Draw Stage	22	17	9
Return Stage	21	16	8
Configuration	Steam Stripped	Steam Stripped	Reboiled
Product flow			

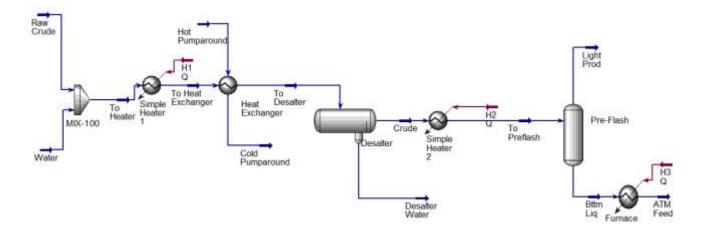
	Temperature	Pressure	Flowrate
AGO Steam	150 °C	350 kPa	1150 kg/hr
Diesel Steam	150 °C	350 kPa	1350 kg/hr

**Pump Arounds** help to improve the column's efficiency. They operate by drawing a liquid stream from one stage cooling it, and pumping it into a higher stage. In effect, this process adds to the reflux between these two stages.

	AGO PA	Diesel PA	Kerosene PA
Draw Stage	22	17	9
Return Stage	21	16	8
Flowrate	200 m <sup>3</sup> /h	200 m <sup>3</sup> /h	330 m <sup>3</sup> /h
Duty	-3.7e7 kJ/h	-3.7e7 kJ/h	-4.5e7 kJ/h



# Load your Pre-Heat Train case from the Pre-Heat Train module.



Add a steam stream to provide the heating effect to the bottom of the tower instead of using a reboiler:

Vapor fraction =1.0, pressure =1380 kPa and flowrate=3400 kg/hr

Composition (100% water)

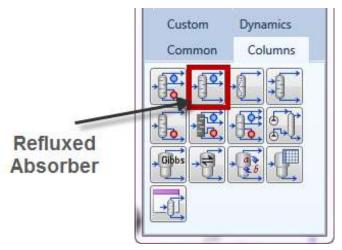
Worksheet	Stream Name	Bottom Steam
Conditions	Vapour / Phase Fraction	1.0000
Properties	Temperature [C]	194.6
Composition	Pressure [kPa]	1380
Oil & Gas Fee	Molar Flow [kgmole/h]	188.7
Petroleum Ass K Value	Mass Flow [kg/h]	3400
User Variables	Std Ideal Liq Vol Flow [m3/h]	3.407
Notes	Molar Enthalpy [kJ/kgmole]	-2.359e+005
Cost Paramete	wolar Entropy (b) kginole-c	166.3
Normalized Yi	elds Heat Flow [kJ/h]	-4.453e+007
	Liq Vol Flow @Std Cond [m3	/h] 3.350
	Fluid Package	Refinery
	Utility Type	
		۲ III
	OK	



## **ADDING THE ATMOSPHERIC COLUMN**

The atmospheric column is modeled as a refluxed absorber,

- Double-click on the **Refluxed Absorber** icon on the Object Palette.



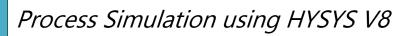
The tower (29 trays) is operated with the following conditions:

Condenser Pressure	140 kPa	Condenser Temperature	40 °C
Condenser Pressure Drop	60 kPa	Top Stage Temperature	120 °C
Bottom Stage Pressure	230 kPa	Bottom Stage Temperature	340 °C

Specifications:

Overhead vapor rate	0.0 kgmole/hr
Distillate rate (Naphtha rate)	$0.153 \times 681.9 \text{ m}^3/\text{hr} = 104.3 \text{ m}^3/\text{hr}$

ut Input Informati	on	ut Distributions —			
Name	End T [C]	Name	Begin T [C]	End T [C]	Fraction
Off Gas	10.00	Off Gas	-19.54	10.00	0.021
Lt St Run	70.00	Lt St Run	10.00	70.00	0.064
Naphtha	180.0	Naphtha	70.00	180.0	0.153
Kerosene	240.0	Kerosene	180.0	240.0	0.094
Light Diesel	290.0	Light Diesel	240.0	290.0	0.102
Heavy Diesel	340.0	Heavy Diesel	290.0	340.0	0.087
Atm Gas Oil	370.0	Atm Gas Oil	340.0	370.0	0.045
Residue	1200	Residue	370.0	825.2	0.434
	••				





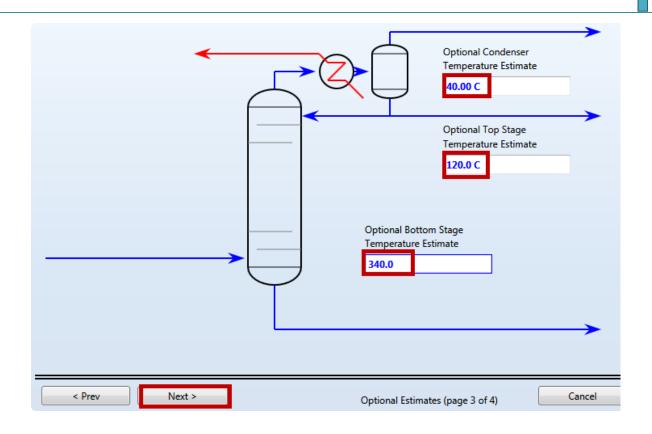
Condenser En	ergy Stream	nd 🔹		Off	gases 6 -
Column Name	T-100		4 Partial		Outlets
					htha 7 -
Optional Inlet Stream	Inlet Stage	2	Optional Side D		stewater 8
2 ATM Feed		# Stages	> Stream	Туре	Draw Stage
			< Stream	1>>	
Bottom Stage Inlet		> <u>n-1</u> n	Ahmed Deyab F	ares	
Bottom Steam	3	$\mathbf{\gamma}$		Botto	ms Liquid Outlet
Stage Numbering	9				
Top Down	O Bottom Up				
< Prev	Next >	10	Connections (pag	ge 1 of 4)	Cancel

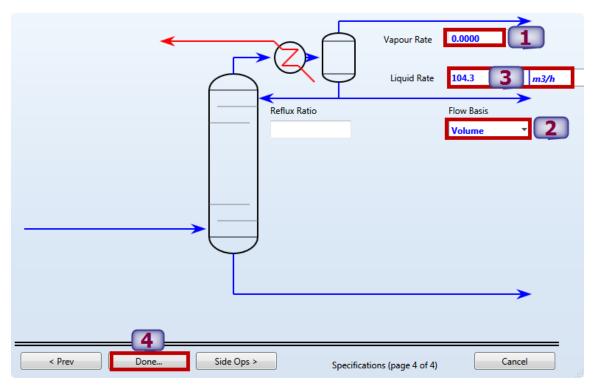
The Water Draw checkbox must be checked to prevent two liquid phases being formed in the column.

	Condenser Pressure 140.0 kPa Condenser Pressure Drop 60.00 kPa Bottom Stage Pressure 230.0
< Prev Next >	Pressure Profile (page 2 of 4)













Design Paramet	ters Side Ops Rating Wor	ksheet Performance Flowsh	eet Reactions [	Dynamics			
Design Connections Monitor Specs Specs Summary Subcooling Notes	Optional Checks Input Summary Iter Step Equili	View Initial Estimates brium Heat / Spec	Profile     Temp     Press     Flows	Tempera 8.000 6.000 4.000 2.000		s. Tray	y Po
	Specifications Reflux Ratio	Specified Value	Current Value <empty></empty>	Wt. Error <empty></empty>	Active	Estimate	
	Distillate Rate Reflux Rate	104.3 m3/h <empty></empty>	<empty> <empty></empty></empty>	<pre><empty></empty></pre>		<u> ব</u> ব	য । ।
	Vap Prod Rate Btms Prod Rate	0.0000 m3/h <empty></empty>	<empty> <empty></empty></empty>			V	
	View	Add Spec Group	Active	Update Inactive	Deg	grees of Fr	reedom
Delete	Column Environment	Run	Reset	Unconverged		V Updat	te Outle

Run the column



# **Adding Side Strippers**

<u>Side Strippers</u> are added to the column in order to improve the quality of the three main products (Kerosene, Diesel, and AGO). There are two types of side strippers available in HYSYS: Reboiled and Steam Stripped. We will install one reboiled side stripper and two steam stripped.

	AGO SS	Diesel SS	Kerosene SS
Draw Stage	22	17	9
Return Stage	21	16	8
Configuration	Steam Stripped	Steam Stripped	Reboiled
Product flow	$0.045 \times 681.9 \text{ m}^3/\text{hr}$	(0.102+0.087)×681.9	$0.094 \times 681.9 \text{ m}^3/\text{hr}$
	$= 30.69 \text{ m}^3/\text{hr}$	$= 128.88 \text{ m}^{3}/\text{hr}$	$= 64.1 \text{ m}^{3}/\text{hr}$

t Input Informati	on	م رد	ut Distributions —			
Name	End T [C]		Name	Begin T [C]	End T [C]	Fraction
Off Gas	10.00		Off Gas	-19.54	10.00	0.021
Lt St Run	70.00		Lt St Run	10.00	70.00	0.064
Naphtha	180.0		Naphtha	70.00	180.0	0.153
Kerosene	240.0		Kerosene	180.0	240.0	0.094
Light Diesel	290.0		Light Diesel	240.0	290.0	0.102
Heavy Diesel	340.0		Heavy Diesel	290.0	340.0	0.087
Atm Gas Oil	370.0		Atm Gas Oil	340.0	370.0	0.045
Residue	1200		Residue	370.0	825.2	0.434

	Temperature	Pressure	Flowrate
AGO Steam	150 °C	350 kPa	1150 kg/hr
Diesel Steam	150 °C	350 kPa	1350 kg/hr



First we need to add two steam streams to provide the heating effect for both AGO & Diesel Side Strippers

	Temperature	Pressure	Flowrate
AGO Steam	150 °C	350 kPa	1150 kg/hr
Diesel Steam	150 °C	350 kPa	1350 kg/hr

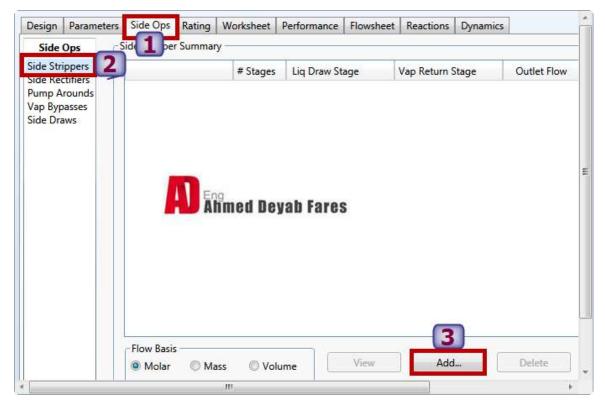
Worksheet	Stream Name	AGO STEAM
Conditions	Vapour / Phase Fraction	1.0000
Properties	Temperature [C]	150.0
Composition	Pressure [kPa]	350.0
Oil & Gas Feed	Molar Flow [kgmole/h]	63.84
Petroleum Assay K Value	Mass Flow [kg/h]	1150
User Variables	Std Ideal Liq Vol Flow [m3/h]	1.152
Notes	Molar Enthalpy [kJ/kgmole]	-2.370e+005
Cost Parameters	Molar Entropy [kJ/kgmole-C]	175.0
Normalized Yields	Heat Flow [kJ/h]	-1.513e+007
	Liq Vol Flow @Std Cond [m3/h]	1.133
	Fluid Package	Refinery
	Utility Type	
		۰ III
	L	

OK

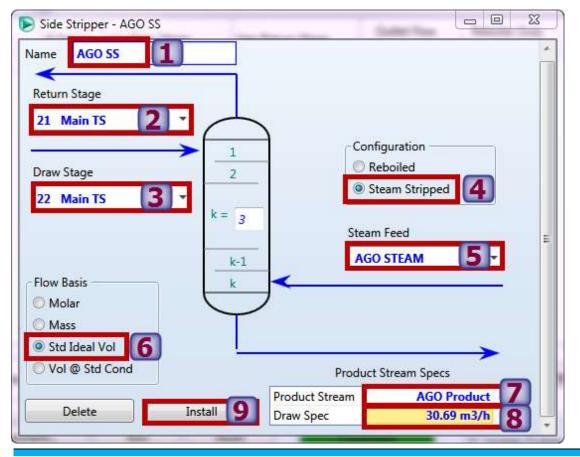
orksheet Attachme	ents Dynamics	
Worksheet	Stream Name	Diesel Steam
Conditions	Vapour / Phase Fraction	1.0000
Properties	Temperature [C]	150.0
Composition	Pressure [kPa]	350.0
Oil & Gas Feed	Molar Flow [kgmole/h]	74.94
Petroleum Assay K Value	Mass Flow [kg/h]	1350
User Variables	Std Ideal Liq Vol Flow [m3/h]	1.353
Notes	Molar Enthalpy [kJ/kgmole]	-2.370e+005
Cost Parameters	Molar Entropy [kJ/kgmole-C]	175.0
Normalized Yields	Heat Flow [kJ/h]	-1.776e+007
	Liq Vol Flow @Std Cond [m3/h]	1.330
	Fluid Package	Refinery
	Utility Type	
		< III
	OK	



Go to the *Side Ops* tab inside the atmospheric tower to *add* the three side stripers:



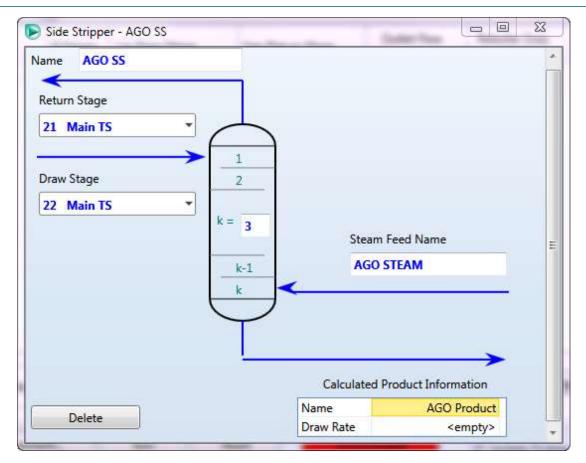
#### First add the AGO Side Stripper



By: Eng. Ahmed Deyab Fares- http://www.adeyab.comMobile: 002-01227549943- Email: eng.a.deab@gmail.com







#### Close the window and run the column

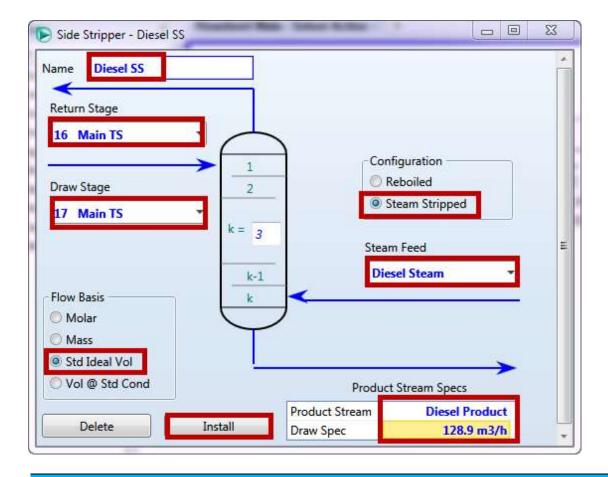
#### Make sure that the column is converged

ide Strippers ide Rectifiers Pump Arounds		# Stages	Liq Draw Stage	Vap Return Stage	Outlet Flow [kgmole/h]	*
/ap Bypasses	AGO SS	3	22_Main TS	21_Main TS	196.6	
Side Draws	Flow Basis Molar Mass	© Volur	ne	Add	Delete	m
Delete	Column Environme	nt	Run Res	set Con	verged [	Ŧ
٠					E.	



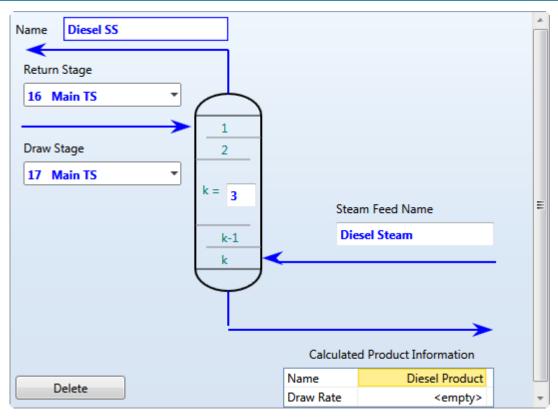
#### Add the Diesel Side stripper:

Side Strippers Side Rectifiers Pump Arounds		# Stages	Liq Draw Stage	Vap Return Stage	Outlet Flow [kgmole/h]
Vap Bypasses Side Draws	AGO SS Flow Basis Molar Mass	3 © Volur	22_Main TS	Click Here	196.
Delete	Column Environmer	nt	Run Res	set Conv	verged 🗸 🗸
	III				- F



By: Eng. Ahmed Deyab Fares- http://www.adeyab.comMobile: 002-01227549943- Email: eng.a.deab@gmail.com





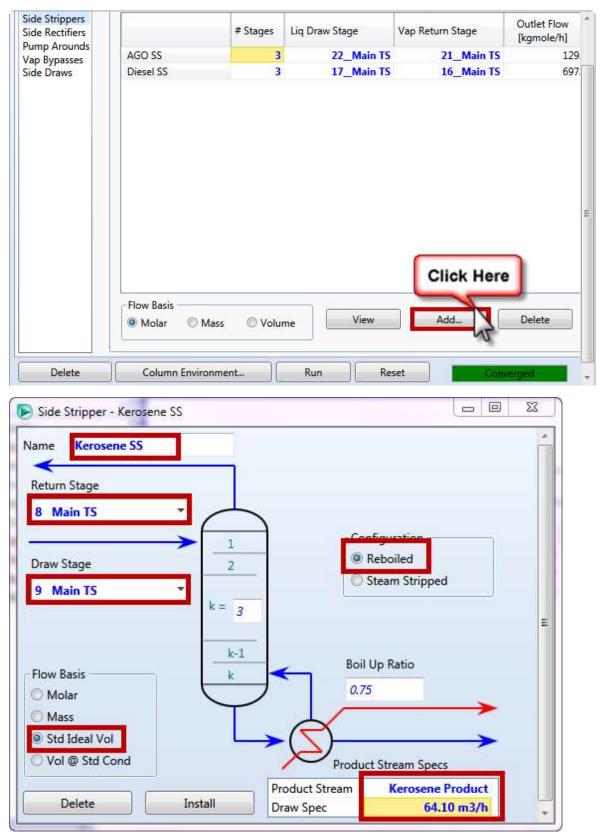
#### Close the window and run the column

#### Make sure that the column is converged

Side Strippers Side Rectifiers		# Stages	Liq Draw Stage	Vap Return Stage	Outlet Flow (kgmole/h)
Pump Arounds Vap Bypasses	AGO SS	3	22_Main TS 🔻	21_Main TS	129
Side Draws	Diesel SS	3	17_Main TS	16_Main TS	697
	Flow Basis Molar	Mass © Volur	me View	ITES	E Delete
Delete	Column Envir	onment	Run Re	set Conv	rerged
•		m.			•

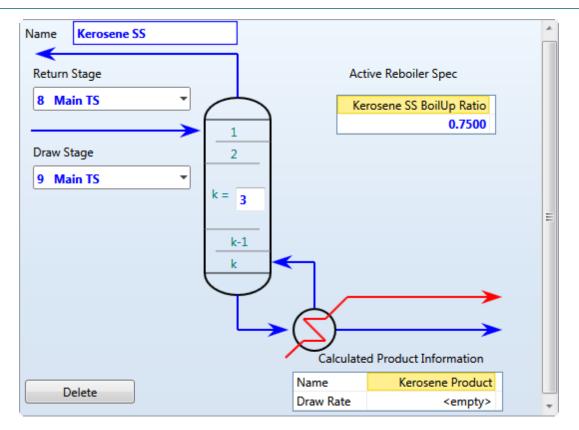


#### Add the Kerosene Side stripper:



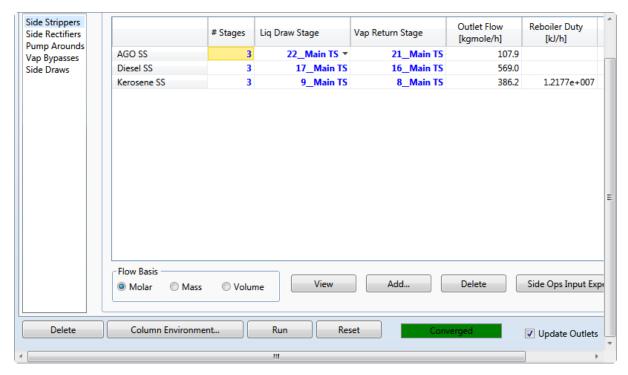






#### Close the window and run the column

#### Make sure that the column is converged



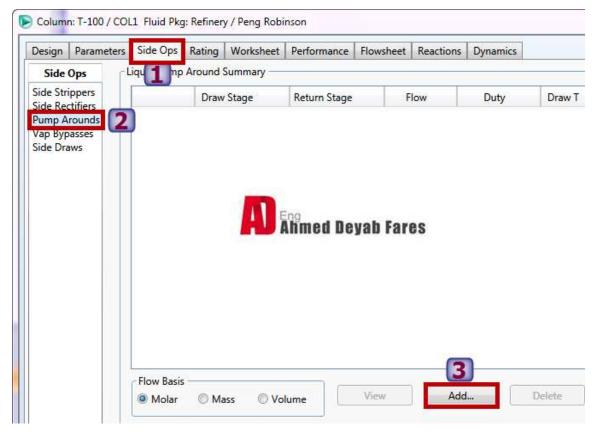


# Adding Pump Arounds

**<u>Pump Arounds</u>** help to improve the column's efficiency. They operate by drawing a liquid stream from one stage cooling it, and pumping it into a higher stage. In effect, this process adds to the reflux between these two stages.

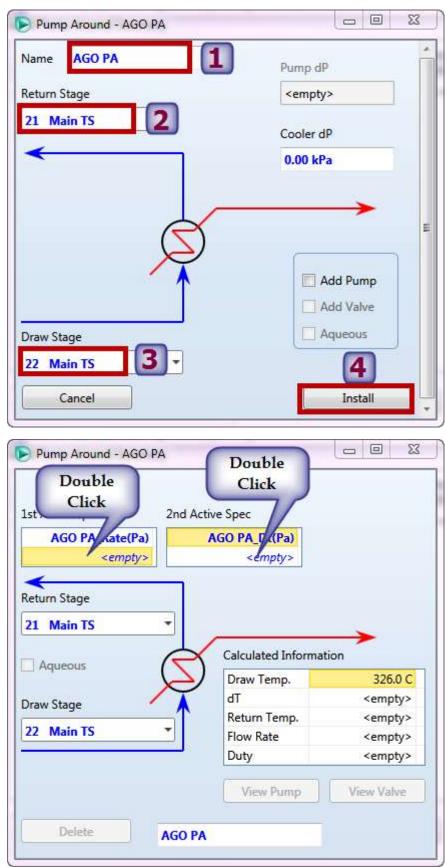
	AGO PA	Diesel PA	Kerosene PA
Draw Stage	22	17	9
Return Stage	21	16	8
Flowrate	200 m <sup>3</sup> /h	200 m <sup>3</sup> /h	330 m <sup>3</sup> /h
Duty	-3.7e7 kJ/h	-3.7e7 kJ/h	-4.5e7 kJ/h

Go to the *Side Ops* tab inside the atmospheric tower to *add* the three Pump Arounds:





#### Add the AGO Pump Around (PA)







Pump Around Spec: AGO PA_Rate(Pa)         Parameters       Summary         Spec Type         Flow Rate         Name       AGO PA_Rate(F         Pump Around       AGO         Flow Basis       Std Ideal V         Spec Value       200.0 m3	Parame Spec Duty Pa) PA Vol	Around	DA_Duty(Pa)
Delete 1st Active Spec		Delete	2 <sup>nd</sup> Active Spec
200.0 m3/h -3.7 Return Stage 21 Main TS	ve Spec O PA_Duty(Pa) 700e+007 kJ/h Calculated Inform		
Aqueous   Draw Stage   22 Main TS     Delete   AGO PA	Draw Temp. dT Return Temp. Flow Rate Duty View Pump	326.0 C <empty> <empty> <empty> -3.700e+007 kJ/h</empty></empty></empty>	

#### Close the window and run the column

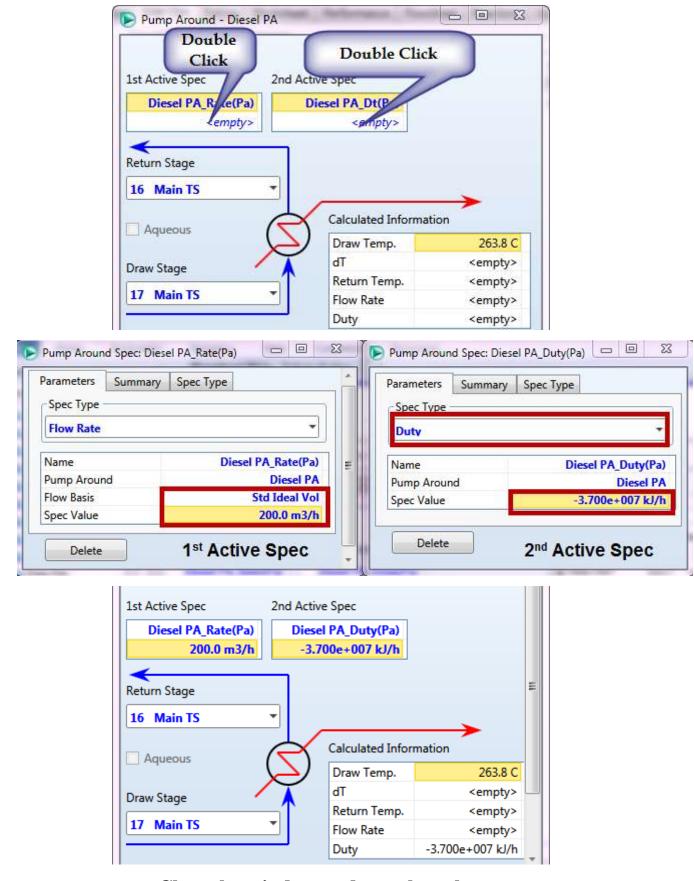
Make sure that the column is converged



#### Add the Diesel Pump Around

Side Ops	ers Side Ops R	ating Worksheet	Performance Flow	sheet Reactions	Dynamics	
side ops	Liquid Pump A	round Summary				
Side Strippers Side Rectifiers Pump Arounds		Draw Stage	Return Stage	Flow [kgmole/h]	Duty [kJ/h]	Draw T [C]
Vap Bypasses	AGO PA	22_Main TS	21_Main TS	731.3	-3.700e+007	322.7
	Flow Basis -	© Mass ◎ Volu	ume		ck Here	elete
Delete	Column E	invironment	Run	Reset	Converge	d
Name Diese	el PA		Pump dP			
Return Stage			<empty></empty>			
16 Main TS	•		Cooler dP			
	Ç		0.00 kPa	>		





#### Close the window and run the column Make sure that the column is converged



#### Add the Kerosene Pump Around

	Draw Stage	Return Stage	Flow [kgmole/h]	Duty [kJ/h]	Draw T [C]	Return T [C]	Expor	
AGO PA	22_Main TS	21_Main TS	<empty></empty>	-3.700e+007	322.7			
Diesel PA	17_Main TS	16_Main TS	USB 515 M 515 M	-3.700e+007	263.8			
Flow Basis			Clic	k Here				
Ø Molar	🔘 Mass 🔘 Volu		Add		elete	Side Op	os Input E	ixpert
	Name K	erosene PA						
					ump dP		_	
	Return Stag	je	Ţ		imp dP empty>			
		je	-	<	-			
	Return Stag	je	<b>.</b>	< Cc	empty>			
	Return Stag	je	•	< Cc	empty>	<b>→</b>		
	Return Stag	je		< Cc	empty>	<b>→</b>		
	Return Stag	je	]	< Cc	coler dP			
	Return Stag	je S		< Cc	coler dP	d Pump d Valve ueous		



Pump Around - Kerosene PA Double Click 1st Active Spec 2nd Active Kerosene PA_Rate(Pa) <empty> Return Stage 8 Main TS</empty>	Double Cli e Spec me PA_Dtkra) <empty></empty>	ck
Aqueous Draw Stage 9 Main TS	Calculated Inform Draw Temp. dT Return Temp. Flow Rate Duty	185.0 C <empty> <empty> <empty> <empty></empty></empty></empty></empty>
Around Spec: Kerosene PA_Rate(	Pump Arour Parameters Spec Type Duty Name	nd Spec: Kerosene PA_Duty  Summary Spec Type Kerosene PA_Duty(Pa
Pump Around Kerosene PA Flow Basis Std Ideal Vol Spec Value 330.0 m3/h	Pump Arou Spec Value Delete	nd Kerosene P. -4.500e+007 kJ/

Kerosene PA_Rate(Pa)	Kerosene PA_Duty(Pa)				
330.0 m3/h	-4.500e+007 kJ/h				
Return Stage					
8 Main TS	•				
Aqueous		Calculated Infor	mation		
	$\searrow$	Draw Temp.	185.0		
Draw Stage 🖌		dT	<empty:< td=""></empty:<>		
	$\neg T$	Return Temp.	<empty:< td=""></empty:<>		
9 Main TS	<b>•</b>	Flow Rate	<empty:< td=""></empty:<>		
		Duty	-4.500e+007 kJ/		



#### Close the window and run the column

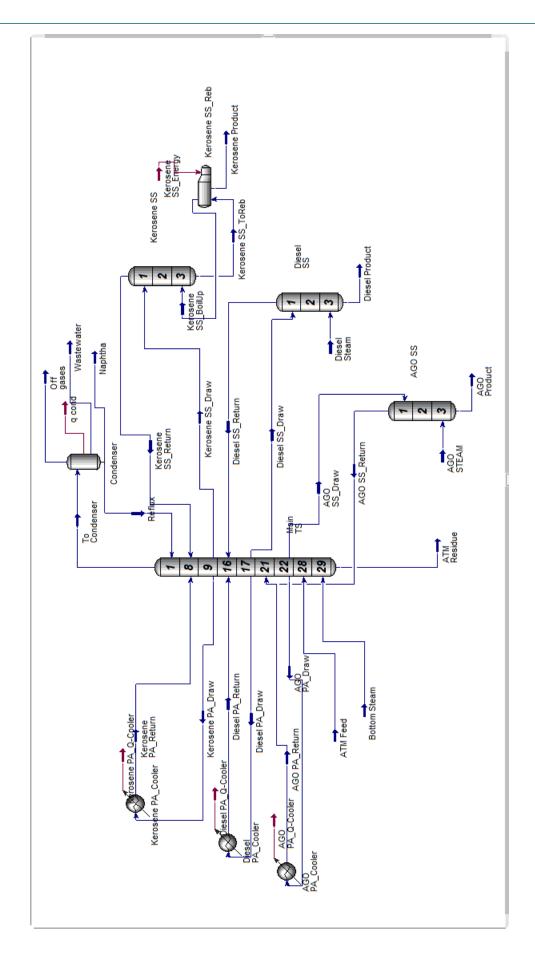
#### Make sure that the column is converged

Design Parar	neters	Side Ops F	Rating   Worksh	heet   I	Performance	Flows	heet   F	Reactions	Dynamics		
Side Ops	۲	iquid Pump A.	round Summary	у ——							
Side Strippers							Flo	w	Duty	Draw T	Return
Side Rectifiers			Draw Stage		Return Stage		[kgmo	ole/h]	[kJ/h]	[C]	[C]
Pump Arounds Vap Bypasses		AGO PA	22_Ma	ain TS	21_M	ain TS		731.3	-3.700e+007	322.7	2
Side Draws		Diesel PA	17_Ma	ain TS	16_M	ain TS		904.8	-3.700e+007	262.4	1
		Kerosene PA	9_Ma	ain TS	8_M	ain TS		2056	-4.500e+007	183.9	1
		Flow Basis - Molar	O Mass (	🔊 Volu	me	View	,	Add	D	elete	Sic

#### You can find the detailed flow sheet by entering the *Column Environment*

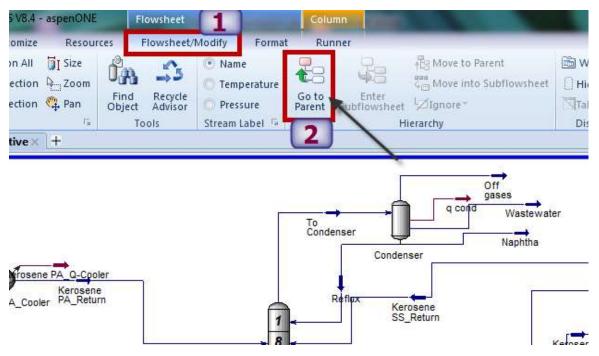


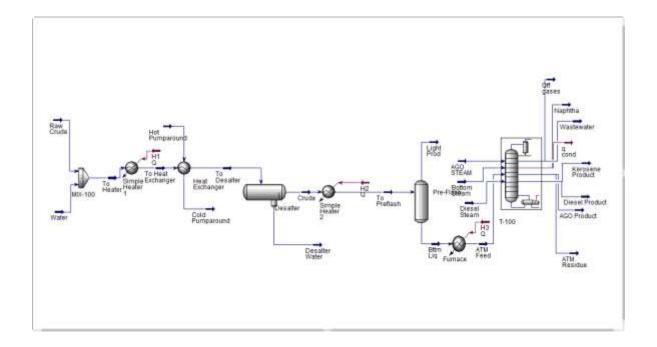






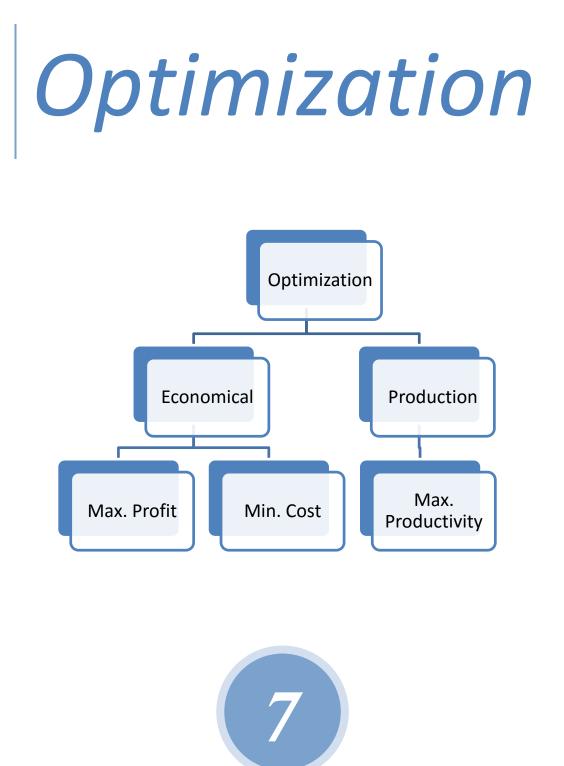
#### To return to the main environment:





# Save Your Case!







## Workshop

In this example, a simple distillation column to separate Tetrahydrofuran (THF) from Toluene is simulated. The object of the exercise is to select the product specifications such that profit is maximized. A special tool in HYSYS, the Optimizer, will be used to find the optimum operating conditions.

HYSYS includes additional modelling and decision support tools that can be used to enhance the usability of your models. In this module, you will use the HYSYS optimization tool available in HYSYS to investigate the debottlenecking and optimization of a crude column.

# Learning Objectives

Once you have completed this section, you will be able to:

- Use the Optimizer tool in HYSYS to optimize flowsheets
- Use the Spreadsheet to perform calculations



Example:

**3700 kg/hr** mixture of tetrahydrofuran & toluene (**44 mass% THF**) at **10°C** and **140 kPa** is to be separated by distillation to get each of them with purity of 99.5 mass% of THF & 94 mass% of Toluene (THF is the more volatile component).

• Use Wilson fluid package

#### The column specifications are:

- The condenser & reboiler pressure are 103 kPa & 107 kPa.
- The condenser works on **total condensation** conditions.
- Number of stages = 10.
- Feed enters from the 5<sup>th</sup> tray.

Calculate:

The reflux ratio and the distillate rate under the specified

conditions.

#### **Reflux Ratio**

Distillate	Rate		

......k<sub>gmol</sub>/hr

Data:

- Feed price= 0.05 \$/kg.
- Pure toluene selling price= 0.136 \$/kg
- Pure THF selling price= 0.333 \$/ kg
- Cooling Cost= 0.471 \$/ kw.hr
- Heating Cost= 0.737 \$/kw.hr

Note:

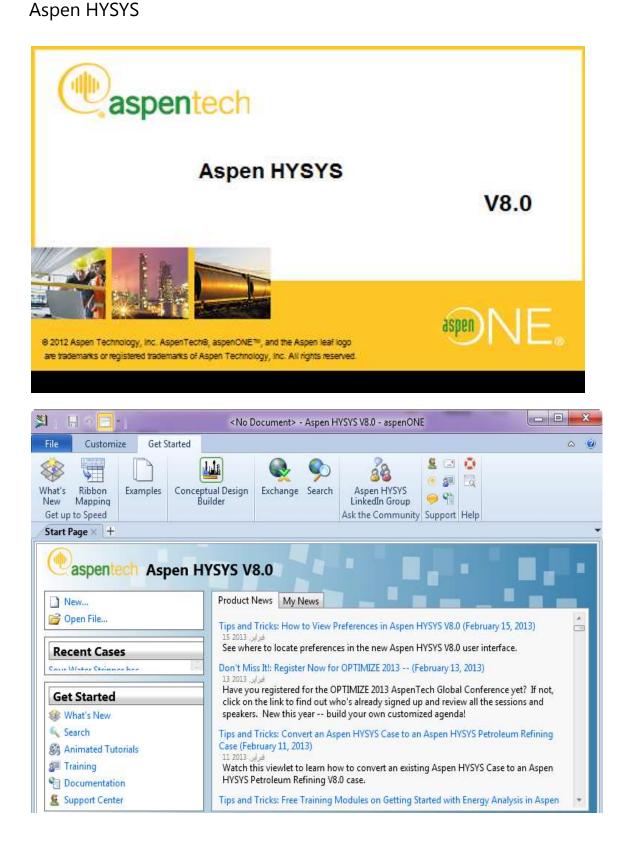
Profit = (Total Toluene selling price + Total THF selling price) - (Feed

cost + Heating cost + Cooling Cost)

•Use a range of 0.99 to 0.999 for THF limit & 0.9 to 0.99 for the toluene.



To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.0 >>>> Aspen HYSYS >>





5- First, Start a new case

51	1 1 E	«No Document»	- Aspen HYSYS V8.0 - aspenDNE	
File	1			o 💌
	New 2	Case 3	Aspen HYSYS	<u>°</u>
ø	Open +	Template	New (Ctrl + N)	felp
	Close Case +	Column	Create a new case.	
	Save	Reformer		
园	Save As	Hydrocracker	rences in Aspen HYSYS V8.0	(February 15, 2013)
•	Export +	Petroleum Distillation	i the new Aspen HYSYS V8.0 ( TIMI2E 2013 — (February 13)	
2	Script Manager		VIZE 2013 AspenTech Global ho's already signed up and re rid your own customized age	Conference yet? If eview all the sessions
	Pont +		HVSVS Case to an Aspen HVS	SYS Petroleum Refining +
Then	Print Setup			
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6- Add the Components

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#### 7- Choose the system components from the databank:

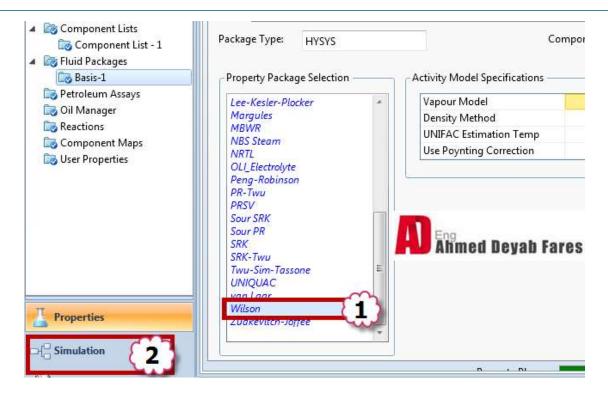
sice Databank HYSYS				Select	Pure Compone	nts • Filteri	All families
Component	Туре	Group		Search for	i i	Search by:	Full Name/Synonym
				Simulatio	in Name	Full Name / Synonym	Formula
			< Add	and the second sec	Methane	α	0
			0		Ethane	2	0
					Propane	G	(3
			Replace		i-Butane	i-C4	C4F
			webare		n-Butane	n-C4	CAH
					i-Pentane	FG	(3)
			Innove		n-Pentane n-Hexane	n-03 06	(3)
					n-Heptane	a	C7H
					n-Octane	CB	CBF
					n-Nonane		C9+
					n-Decane	C10	C10F
					n-C11	C11	Citt
					n-C12	C12	C12H

Now, select the suitable fluid package

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Properties <	Start Page X Fluid Packa	ges × +		-
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Properties	Add	Edit	C	opy
•	Messages Required Info : Fluid Package	s Selei		• ‡ ×
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In this case, select Wilson





Now you can start drawing the flow sheet for the process by clicking the Simulation button:

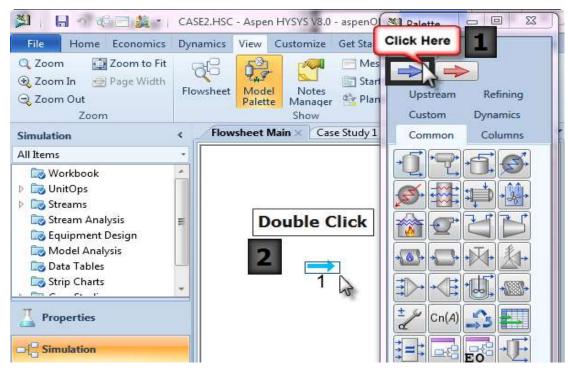
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🔯 UnitOps	Common Columns	
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🔯 Equipment Design 🗧		
Compared Model Analysis		1. Contraction
🔯 Data Tables		
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6 Energy Analysis		
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Now add a material stream to define the composition and the conditions

of the feed stream



#### From the palette:



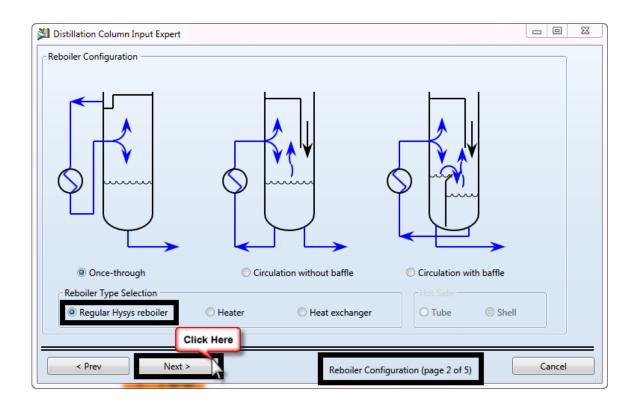
Add a distillation tower:

M Palette
🕂 🗗 🗙
Upstream Refining
Custom Dynamics
Common Columns
+ E + + + +
Dillation Column Sub-Flowshee
()





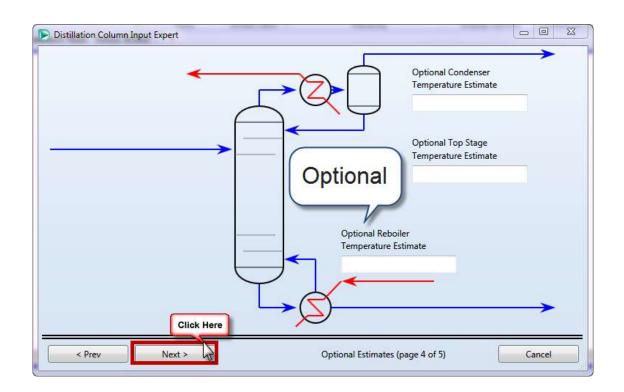
Distillation Column Input Expert Condenser Energy Stream	6 -	Condenser Total 3	×
Column Name T-100		0 Partial Ovhd Liquid Outlet 0 Full Rflx Ovhd	•
Inlet Streams 2	2	Water Draw	
Stream Inlet Stage	# Stages	Optional Side Draws	
1 5_Main TS << Stream >>	n = 10	Stream Type Draw Stage     <	
Stage Numbering Top Down O Bottom Up		eboiler Energy Stream g reb 7 Bottoms Liquid Outlet bttm 5	•
< Prev Next >	8	Connections (page 1 of 5)	





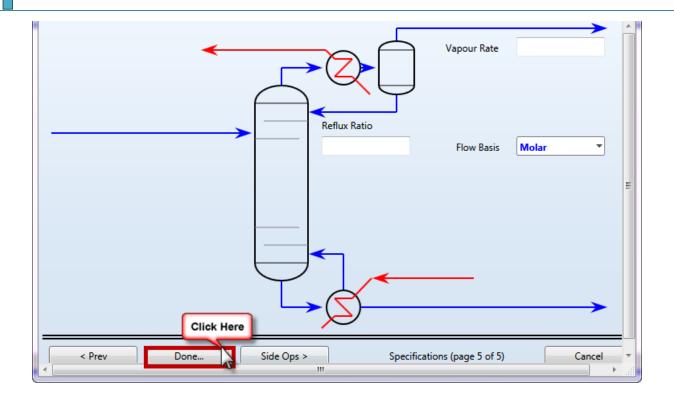


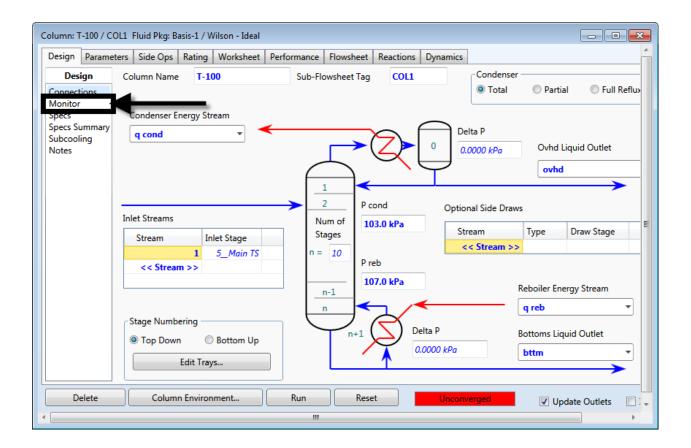
Distillation Column Input Expert	
	Condenser Pressure
	Condenser Pressure Drop 0.0000 kPa
	Reboiler Pressure Drop
	0.0000 kPa
	Reboiler Pressure
Click Here	
< Prev Next > 3	Pressure Profile (page 3 of 5)







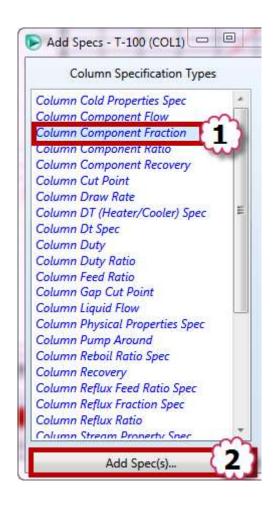








pecifications			65.00	2 4	6	8 10	12
pecifications	Specified Value	Current Value	Wt. Error	Active	Estimate	Current	
Reflux Ratio	· <empty></empty>	1.209	<empty></empty>		~		
Distillate Rate	<empty></empty>	20.83	<empty></empty>		<b>V</b>		
Reflux Rate	<empty></empty>	25.18	<empty></empty>				
Btms Prod Rate	<empty></empty>	24.23	<empty></empty>		$\checkmark$		
View	Click Here	Active	Update Inactive	De	grees of Fr	eedom	2
Column Environment	Run	Reset	Unconverged		🔽 Updat	e Outlets	🔲 Igr





Comp Frac Spec: THF Pu	rity	_ O X		Comp Frac Sp	ec: Toluene	e purity	
Parameters Summary	Spec Type			Parameters	Summary	Spec Type	
Name		THF Purity		Name			Toluene purity
Stage		Condenser		Stage			Reboiler
Flow Basis	м	ass Fraction		Flow Basis			Mass Fraction
Phase		Liquid		Phase			Liquid
Spec Value		0.9950		Spec Value			0.9400
Components:	TetraHyFuran << Component >>		•	Components:		<< Co	Toluene omponent >>
Target Type	© Stream	Stage		Target Type		Stream	Stage
Delete		Eng Ahme	d D	eyab Fares			

<empty> <empty> <empty> <empty> 0.9950 0.9400</empty></empty></empty></empty>	1.209 20.83 25.18 24.23 0.9950 0.9400	<empty> <empty> <empty> <empty> -0.0001 -0.0005</empty></empty></empty></empty>	<ul> <li>■</li> <li>■</li></ul>	ন ন ন	- - - 1	
<empty> <empty> 0.9950</empty></empty>	25.18 24.23 0.9950	<empty> <empty> -0.0001</empty></empty>		V		
<empty> 0.9950</empty>	24.23 0.9950	<empty> -0.0001</empty>				
0.9950	0.9950	-0.0001		Ţ	1	
					1	
0.9400	0.9400	-0.0005			- II.	
Group	Active	Update Inactive	De	egrees of Fr	reedom	0
R	Reset	Unconverged		🗸 Updat	e Outlets	
			Reset Unconverged			

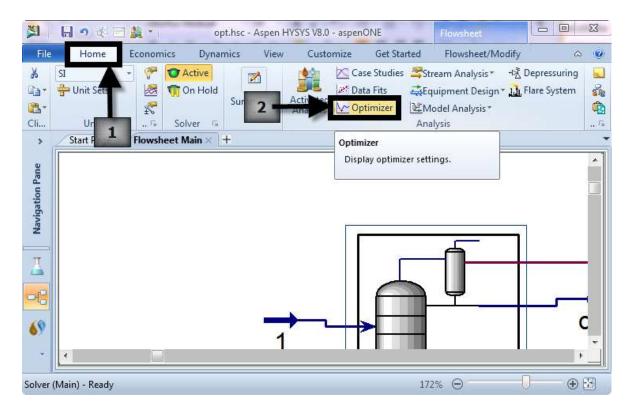


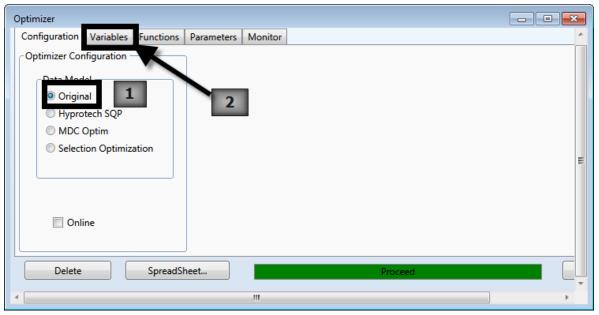
# **Optimization**

We need to check if the operating conditions are optimum or not.

The Variables to check are: THF Purity & Toluene Purity

Using the Optimizer tool:





By: Eng. Ahmed Deyab Fares - http://www.adeyab.com Mobile: 002-01227549943 - Email: eng.a.deab@gmail.com





Optimizer			
Click Here	Edit	Delete	Save Cu
Delete	SpreadSheet		Proceed
٠		11	

Flowsheet	Object	<u>Variable</u>	Variable Specifics	<u>o</u> k <b>(</b>
Case (Main) 1-100 (COCT) Navigator Scope Flowsheet	1 Cond Q Reb Q THF Toluene OptimizerSpreadobact T-100 FeederBlock_1 ProductBlock_THF ProductBlock_Toluene	Spec Is Active Spec Value Stage Efficiency Stage Heat Flow Stage Pressure Temperature Est User Variables	Btms Prod Rate Condenser Duty Distillate Rate Reboiler Duty Reflux Rate Beflux Batio THF Purity Spec Toluene Purity Spec	Object Filter G All C Streams C UnitOps C Logicals C ColumnOp
C Case C Basis C Utility ariable Description:	Spec Value (THF Purity Spec	) 		C Custom

And do the same steps to add the other variable

Use a range of 0.99 to 0.999 for THF limit & 0.9 to 0.99 for the toluene.



onfiguration	Variables	Functions	Parameters	Monitor				
djusted (Prin	nary) Varial	oles —						
Object	1	Variable Desci	ription	Low Bound	Current Value	High Bound	Reset Value	Enabled
÷	T-100	Spec Value	(Thf purity)	0.9900	0.9950	0.9990	<empty></empty>	
1 V	T-100	Spec Value	(Tol purity)	0.9000	0.9400	0.9900	<empty></empty>	N
		5.0			C	<u> </u>		. ]
Add		Edit. C	lick Her	e		Save Current	Reset Cur	rent

Now we have to start building the profit module using the spreadsheet operation:

Connections	Parameters	Formulas	Spreadsheet Calculation	on Order User Variables
			Spreadsheet Name	SPRDSHT-1
Imported Va	riables			
Cell Object		ť (	Variable Description	on
				Ad
				Del
Exported Va	- 11			

By: Eng. Ahmed Deyab Fares<br/>Mobile: 002-01227549943- http://www.adeyab.com<br/>- Email: eng.a.deab@gmail.com



#### Profit= Income - Cost

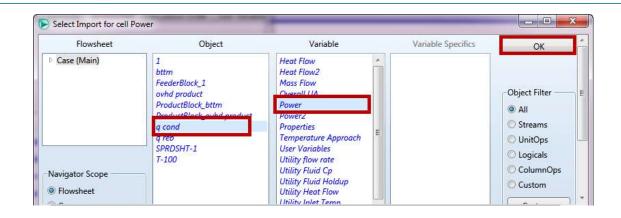
Profit = (Total Toluene selling price + Total THF selling price) - (Feed

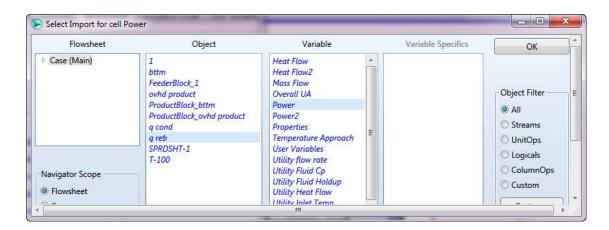
cost + Heating cost + Cooling Cost)

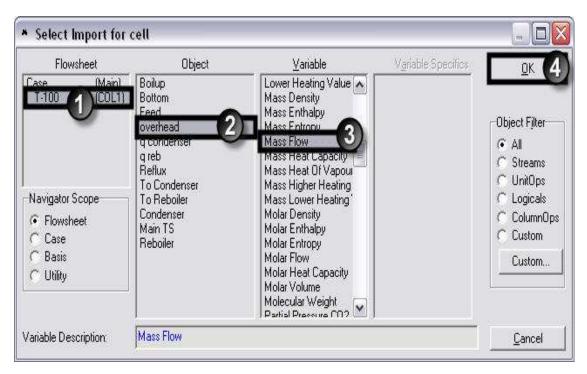
	rent Cell C8 Variable: Ins	1 ert Lables	Export for values		
	A	Right Click		D	
1	Cond Duty		Cooling Cost		
2	Reb Duty	1	Heating Cost		
3	ovhd production ral	0			
4	THF purity		Pure THF Price		
5	Bttm Production rat				
6	toluene purity		Pure Toluene Price		
7	feed flow rate		Feed Price		
8			Profit		
9					-

Connections	Parameters	Formulas	Spreadsheet	Calculation Order	User Variable		
- Current Ce Impo	II rted From:	q cond			Exportable []		
B1	Variable:	Power	Power				
	A	1	Right Click	c			
1	cond du	ty					
2	reb du	ty	Сор	V	Ctrl+		
3	ovhd prod ra	te	Past		Ctrl+		
4	thf puri	ty					
5	bttm prod ra	te	Send	i To			
6	tol puri	ty	View	Associated Object	_		
7	feed flowra	te	Impo	ort Variable	2		
8			- Andrewski - A	ort Formula Result onnect Import/Expo			











Connec	tions Parameters Fo	ormulas Spreadsheet	Calculation Order User	Variables Notes
	Variable Type:		▼ Export	able 🔽
[	D8 Variable:		Angles	sin: Rad 🔻
=(d4	1*b4*b3+d6*b6*b5)-(d	17*b7+d1*b1+d2*b2)		
	A	В	С	D
1	cond duty	378.9 kW	cooling cost	0.4710
2	reb duty	548.4 kW	heating cost	0.7370
3	ovhd prod rate	1504 kg/h		
4	thf purity	0.9950	thf sp	0.3330
5	bttm prod rate	2196 kg/h		
6	tol purity	0.9400	tol sp	0.1360
7	feed flowrate	3700 kg/h	feed price	5.000e-002
8			profit	11.35
		Function Help	Spreadsheet Only	/

The profit formula will be in D8:

#### = (d3\*b3\*b4+d5\*b5\*b6)-(d1\*b1+d2\*b2+d7\*b7)

Optimizer Configuration Variables Func	tions meters wome	1		
Cel 2	D8 Minimi 11.3532564 Maxim			
Constraint Functions	Value Cond RHS Cell	Current Value Penalty Val		
			Delete	
				4 Click Here
Delete Sp	readSheet	Proce	ed	Start





Optimizer									x
Configu	ration Variable	s Functions	Parameters	Monitor					-
	ent Value	65.69	<b>D8</b> 926863	<ul> <li>Minimize</li> <li>Maximize</li> </ul>					
Nur	LHS Cell	Current Value	Cond RH	IS Cell	Current Value	Penalty Value		Add Delete	]
	Delete	SpreadSh	eet		Optir	mum found (Sm	allDeltaX)		-
•									•

Now you can go to the monitor tab inside the column to see the optimum values for the THF & Toluene purities.

Current Value     Wt. Error     Active       ty>     0.9303 <empty>       ty&gt;     19.48     <empty>       ty&gt;     24.12     <empty>       ty&gt;     20.94     <empty></empty></empty></empty></empty>
ty>     0.9303 <empty>       ty&gt;     19.48     <empty>       ty&gt;     24.12     <empty>       ty&gt;     20.94     <empty></empty></empty></empty></empty>
ty>         19.48 <empty>         I           ty&gt;         24.12         <empty>         I           tv&gt;         20.94         <empty>         I</empty></empty></empty>
ty>         24.12 <empty>         I           tv&gt;         20.94         <empty>         I</empty></empty>
20.94 <empty> 🗅</empty>
0.9900 -0.0000
107 0.9407 -0.0003 🔽

# Save Your Case!



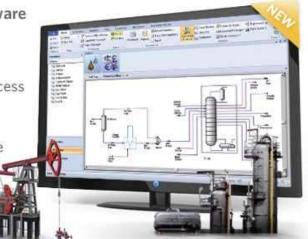
# Gas Gathering

# Experience the New Aspen HYSYS\*.



The best process simulation software is now easier to use and faster to learn than ever!

Aspen HYSYS is a comprehensive process modeling system used by the world's leading oil & gas producers, refineries, and engineering companies to optimize process design and operations.







# Workshop

In this example, a gas gathering system located on varied terrain is simulated using the steady state capabilities of HYSYS. The following figure shows the physical configuration of this system superimposed on a topographic map. The system consists of four wells distributed over an area of approximately 2.0 square km, connected to a gas plant via a network of pipelines.

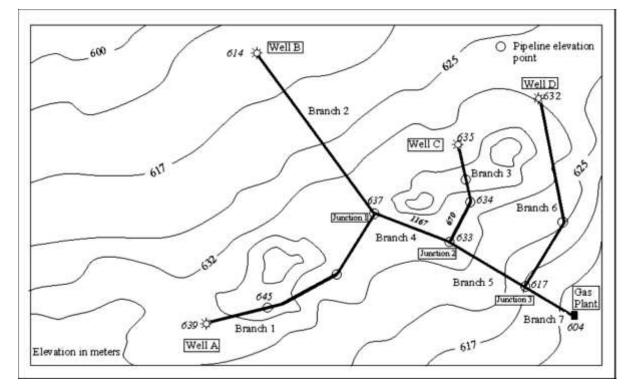
# Learning Objectives

Once you have completed this module, you will be able to use the Pipe Segment in HYSYS to model pipelines.

### Example:



There are 4 gas wells, we need to gather the gas from the wells and transfer it to the plant through pipe lines shown below:



The composition of the four wells is the same:

Component	Mole Fraction	Component	Mole Fraction				
Methane	0.6230	n-pentane	0.00405				
Ethane	0.2800	n-hexane	0.00659				
Propane	0.0163	C7+	0.00992				
i-butane	0.00433	$N_2$	0.00554				
n-butane	0.00821	CO <sub>2</sub>	0.0225				
i-pentane	0.00416	H <sub>2</sub> S	0.0154				
	C7+: MW=122, $\rho=47.45 \text{ lb/ft}^3$						

	GasWell 1	GasWell 2	GasWell 3	GasWell 4
Temperature °C (°F)	40 (105)	45 (115)	45 (115)	35 (95)
Pressure kPa (psia)	4135 (600)	3450 (500)	<empty></empty>	<empty></empty>
Flow kgmole/h (Ibmole/hr)	425 (935)	375 (825)	575 (1270)	545 (1200)

The pipe segments data are given below:



Branch	Segment	Length meters	Elevation meters	Elevation Change meters
Branch 1	GasWell 1		639	
	1	150	645	6
	2	125	636.5	-8.5
	3	100	637	0.5
Branch 2	GasWell 2			614
	1	200	637	23
Branch 3	GasWell 3		635.5	
	1	160	648	12.5
	2	100	634	-14
	3	205	633	-1
Branch 4	Branch 1 & 2		637	
Brunen 4	1	355	633	-4
Branch 5	Branch 3 & 4		633	633
	1	300	617	-16
Branch 6	GasWell 4		632.5	
	1	180	625	-7.5
	2	165	617	-8
Branch 7	Branch 5 & 6		617	
	1	340	604	-13

Pipe Branch	Diameter		
Branch 1	76.2 mm (3°)		
Branch 2	101.6 mm (4")		
Branch 3	76.2 mm (3")		
Branch 4	101.6 mm (4")		
Branch 5	152 mm (6")		
Branch 6	76.2 mm (3")		
Branch 7	152 mm (6")		

Schedule 40 steel pipes is used throughout and all branches are buried at

a depth of 1 m (3 ft). All pipes are uninsulated

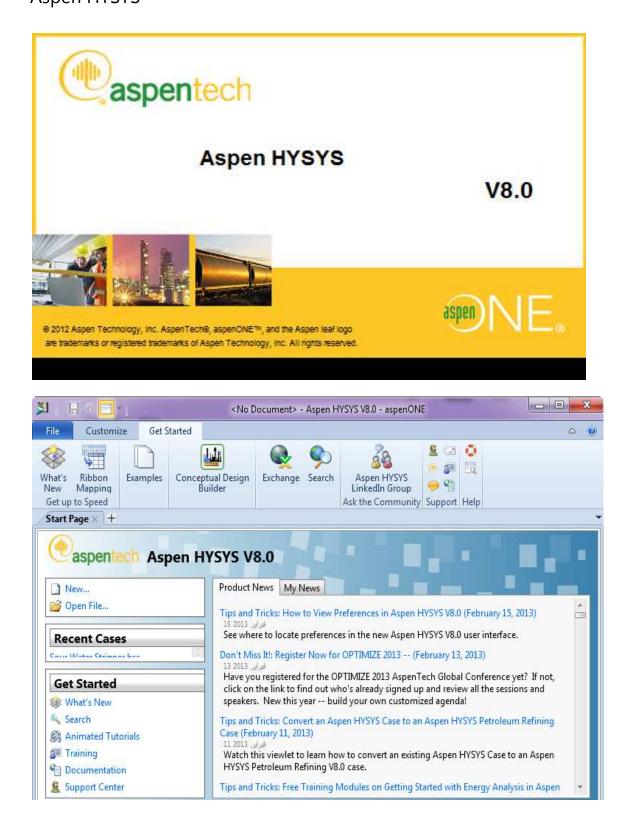
Consider inner and outer HTC and the pipe wall in heat transfer

estimation. (Ambient Temperature=5°C)

- Calculate the pressure drop and the heat loses inside each branch.

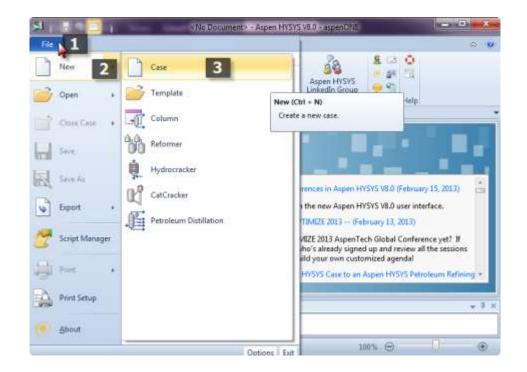


To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.x >>>> Aspen HYSYS >> Aspen HYSYS





8- First, Start a new case



#### 9- Add the Components

M		Untitled - A	Aspen HYSYS V8.0	) - aspe	nONE	Course 1	
File Home View	Customize	Get Starte	d				۵ 🔞
Copy* Judat Paste Navigate	Components e Properties ponents	Petroleum Assays Refining Ta	Hypotheticals	Oil	Aspen Properties Options	PVT Laboratory Measurements PVT Data	
Properties	< Start F	age ×⁄Com	ponent Lists $ imes$	+			•
All Items Component Lists Fluid Packages Petroleum Assays Oil Manager Reactions Component Maps	1	List (	Vame .			Source	
User Properties		Add U	Ехро			Delete	-
Strange Analysis			m	n			<u> </u>
• Litergy Analysis	Messager     Required	Info:Fluid Pi	ackages S				÷ 4 ×
	-18-1				100	%Θ	•



#### 10- Choose the system components from the databank:

arce Databank: HYSVS				Selects	Pure Compon	enta *	Filter	All families
Component	Туре	Group		Search for	T.	1	Search by:	Full Name/Synonym
				Simulatio	zn Name	Full Name / S	iynonym	Formula
			< Add		Methane		α	¢
					Ethane		62	G
					Propane		G	G
			Replace		i-Butane		i-C4	GI
			meprace	k	n-Butane		n-C4	C4F
					i-Pentane		÷CS	CI
			lanos		n-Pentane		n-C5	GF
			Innovi		n-Hexane		C6	C6H
					n-Heptane		0	C7H
					n-Octane		C8	C84
					n-Nonane		C9	C9+
					n-Decane		C10	C10F
					n-C11		C11	Cith
					n-C12		C12	C12H

Component	Туре	Group	]	Search for:
Methane	Pure Component	-		
Propane	Pure Component		2	Simulation Name
Ethane	Pure Component			1 -
			< Add	n-
				i-P
				n-P
			Replace	n-l
				n-H
				n-
			Remove	n-1
				n-l
			_	

After adding the pure components (N<sub>2</sub>, H<sub>2</sub>S, CO<sub>2</sub>, C1, C2, C3, n-C4, i-C4, n-C5, i-C5, n-C6, H<sub>2</sub>O) we have to add the last component (C7<sup>+</sup>) which is not a pure component as it represents all components above C7 including C7 in the feed.

To define C7+ we have to create it as a hypothetical component as the following:



#### From the drop menu select Hypothetical instead of pure components

atabank: HYSYS	A Eng	ed Deyab Fa	res	Select:	Pure Compone	
mponent	Туре	Group		Search for:	Hypothetical	
Methane	Pure Component				Hypothetical S	DIIO
Ethane	Pure Component			Simulation N	Vame	Full Name / Syr
Propane	Pure Component		(	1	n-Heptane	
i-Butane	Pure Component		< Add		n-Octane	
n-Butane	Pure Component				n-Nonane	
i-Pentane	Pure Component				n-Decane	
n-Pentane	Pure Component		Replace		n-C11	
n-Hevane	Pure Component				(12	

#### Select create and edit hypos

nitial Boiling Point:	30.00 C	Interv	al 🔹	10.00 C
Final Boiling Point:	900.0 C			
New Hypo Group	Generate H	typos		
Name	Added ?	Normal Boiling Point	Molecular Weight	Liquid Density

Click on New Hypo





	othetical poGroup1	<ul> <li>Method</li> <li>Type</li> </ul>		Create and E Base Propert	
New Hypo Group	_	Here 2		ase r topen	
Name	Added ?	Normal Boiling Point	Molecula	r Weight	Liquid Density

After adding a hypo component you can edit the name, add the properties you have, and estimate the unknown properties as follows:

			Select:	Hypothetical	<ul> <li>Method:</li> </ul>	Create and E	dit Hypos 🔻
	Group		Hypo Group:	HypoGroup1	🕶 Туре:	Base Propert	ties 🔹
ıt							
t							
t							
t		<< Add All			_		
ıt			New Hypo Gro	up New Hypo			
t							
t		4 < Add	Name	Normal Boiling Point	Molecular Weight	Liquid Density [kg/m3]	Tc [C]
t				C7+* <b>2</b> 110.0	00 <empty></empty>	-	<empty< td=""></empty<>
t						.,	
t		Remove					
t							
t							
			٠				Þ
			Estimate Unkno	wn Delete Hypo			
		3	Estimate Onkno	Deleteriypo			
		,	Estimate onkild				

Finally add the hypo component to the component list



Properties <	Start Page × Component	List - 1 × +		
All Items   All Items  Component Lists  Component List - 1	Source Databank: HYSYS			
C Fluid Packages	Component	Туре	Group	
Cil Manager	Methane	Pure Component		
Reactions	Ethane	Pure Component		
📷 Component Maps 📷 User Properties	Propane	Pure Component		
	i-Butane	Pure Component		<< Add All
	n-Butane	Pure Component		
	i-Pentane	Pure Component		
	n-Pentane	Pure Component		< Add
	n-Hexane	Pure Component		
	CO2	Pure Component		
	H2S	Pure Component		Remove
	Nitrogen	Pure Component		
	H2O	Pure Component		
	C7+* U	ser Defined Hypothetica	HypoGroup1	

Now, select the suitable fluid package

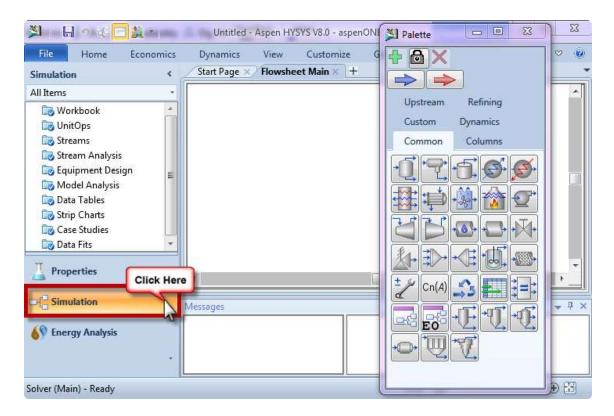
M	Untitled - Aspen HYSYS V	8.0 - aspenONE	
File Home View	Customize Get Started		∞ ⊚
Properties <	Start Page × Fluid Packages ×	+	-
All Items	Fluid Package	Component List	Property Packag
<ul> <li>Oil Manager</li> <li>Reactions</li> <li>Component Maps</li> <li>User Properties</li> </ul>	2		E
Properties	Add	Edit	Copy
Energy Analysis	Messages Required Info: Fluid Packages Sele		+ # ×
16		100% \ominus 🗌	•

In this case, select Peng-Robinson



File Home View C	ustomize Get Started		0
roperties <	Start Page × Basis-1 × +		
ll Items *	Set Up Binary Coeffs StabTest Ph	ase Order   Tabular   Notes	
Component Lists Component List - 1 Fluid Packages	Package Type: HYSYS		Component List !
🔯 Basis-1	Property Package Selection	Options	
Retroleum Assays	Lee-Kesler-Plocker	Enthalpy	Р
📷 Oil Manager	Margules	Density	
Co Reactions	MBŴR /	Modify Tc, Pc for H2, He	Mo
Component Maps	NBS Steam NRTL	Indexed Viscosity	
Contraction User Properties	OU_Electrolyte	Peng-Robinson Options	
	Peng-Robinson	EOS Solution Methods	Cubic E
Properties	PRSV	Phase Identification	
-	Sour SRK	Surface Tension Method	
C Simulation	Sour PR	Thermal Conductivity	
	m		+
Energy Analysis	Messages		

Now you can start drawing the flow sheet for the process by clicking the Simulation button:



Now add a material stream to define the composition and the conditions

of the feed stream



#### From the palette:

	CASE2.HSC	- Aspen I	HYSYS V8.0	- aspenO		
File Home Economics	Dynamics	View (	Customize	Get Sta	Click Here	1
Q Zoom In Q Zoom In Q Zoom Out Zoom	Flowsheet	Model Palette	Notes Manager Show	Mes 🚰 Stari		Refining Dynamics
Simulation	< Flow	sheet Ma	ain × Cas	e Study 1	Common	Columns
All Items  Workbook  UnitOps  Government Design  Model Analysis  Data Tables  Strip Charts  Properties  Simulation		<b>D</b> c	ouble C	lick		

	MoleFraction	Composition Basis
vlethane	0.6230	Mole Fractions
Ethane	0.2800	C Mass Fractions
<sup>D</sup> ropane	0.0163	
-Butane	0.0043	C Liq Volume Fractions
n-Butane	0.0082	C Mole Flows
-Pentane	J 0.0042	
n-Pentane	0.0040	C Mass Flows
n-Hexane	0.0066	- C Lig Volume Flows
202	0.0225	
425	0.0154	Companition Controls
Vitrogen	0.0055	Composition Controls
120	0.0000	Erase
27+*	0.0099	
		Normalize
		Cancel
Equalize Composit	ion Total 1.0000	ок



After adding the compositions and the conditions for the first well, add another stream for well 2 and define the composition from the first stream as follows:

Conditions     Vapour / Phase Fraction       Properties     Temperature [C]       Proposition     Pressure [kPa]       K Value     Molar Flow [kgmole/h]       User Variables     Std Ideal Liq Vol Flow [m3/h]       Notes     Molar Enthalpy [kJ/kgmole]       Cost Parameters     Molar Entropy [kJ/kgmole-C]	<pre><mpty> <mpty> <mpty <mpty=""> <mpty> <mpty< th=""></mpty<></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></mpty></pre>
Properties     Temperature [C]       Properties     Pressure [kPa]       Composition     Molar Flow [kgmole/h]       K Value     Mass Flow [kg/h]       User Variables     Std Ideal Liq Vol Flow [m3/h]       Notes     Molar Enthalpy [kJ/kgmole]       Cost Parameters     Molar Entropy [kJ/kgmole-C]	<empty> <empty> <empty> <empty></empty></empty></empty></empty>
Composition     Pressure [kPa]       Molar Flow [kgmole/h]       K Value     Mass Flow [kg/h]       User Variables     Std Ideal Liq Vol Flow [m3/h]       Notes     Molar Enthalpy [kJ/kgmole]       Cost Parameters     Molar Entropy [kJ/kgmole-C]	<empty> <empty> <empty></empty></empty></empty>
K Value     Molar Flow [kgmole/n]       K Value     Mass Flow [kg/h]       User Variables     Std Ideal Liq Vol Flow [m3/h]       Notes     Molar Enthalpy [kJ/kgmole]       Cost Parameters     Molar Entropy [kJ/kgmole-C]	<empty> <empty></empty></empty>
Mass Flow [kg/h]       User Variables       Notes       Molar Enthalpy [kJ/kgmole-C]	<empty></empty>
Sta Idear Liq Vol Flow [m3/n]           Notes         Molar Enthalpy [kJ/kgmole]           Cost Parameters         Molar Entropy [kJ/kgmole-C]	
Cost Parameters Molar Entropy [kJ/kgmole-C]	<empty></empty>
I wolai chaobà [wyxduioic.c]	
Heat Flow [k,1/h]	<empty></empty>
	<empty></empty>
Liq Vol Flow @Std Cond [m3/h]	<empty></empty>
Fluid Package	Basis-1
Utility Type	
	1
Vorksheet Attachments Dynamics Unknown Compositions	

vailable Streams	Chosen Stream Conditions	ç.	
iasWell1	Vap Phase Fraction	0.97523	
aasWell 3	Temperature	40.000	
äasWell 4	Pressure	4135.0 192.78	
	Molar Flow		
	Mass Flow	4607.9	
opy Stream Conditions	_ Std Ideal Lig Vol Flow	12.57	
opy Stream Conditions	Molar Enthalpy	-8.862e+004	
🔲 Vapour Fraction 🛛 🔲 Molar Enthalpy	Molar Entropy	162.25	
Temperature T Molar Entropy		tole Fractions	
Pressure	Methane	0.623000	
	Ethane	0.280000 -	
Composition	Propane	0.016300	
Flow Cost Parameters	i-Butane	0.004330	
1 Town 1 Cost 1 diamotors	n-Butane	0.008210	
	i-Pentane	0.004160	
	n-Pentane	0.004050	
	n-Hexane	0.006590	
	C02	0.022500	
	H2S	0.015400	
	Nitrogen	0.005540	

By: Eng. Ahmed Deyab Fares- http://www.adeyab.comMobile: 002-01227549943- Email: eng.a.deab@gmail.com

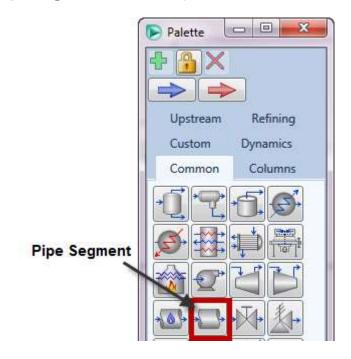


0.9803 45.00 3450 170.1
3450 170.1
170.1
110070011
1000
4066
11.09
-8.807e+004
165.3
-1.498e+007
<empty></empty>
Basis-1
1.

Add the conditions for the second stream

Add the conditions & Compositions for the other two streams as above

Now, Add a **Pipe Segment** from the palette





The pipe segment is used to simulate a wide variety of piping situations ranging from single/multiphase plant piping with rigorous heat transfer estimation, to large capacity looped pipeline problems

Design Rating	Worksheet Performance Flow Assurance Dynamics	
Design	Name: Branch 1	
Connections		
Parameters		
Calculation Emulsions	Inlet Outlet	
Jser Variables	Gas well 1 2 B1 out 3	
Notes		
	Fluid Package Energy	
	Basis-1 • q1 4 •	

On the **Sizing** page, you construct the length-elevation profile for the Pipe Segment. Each pipe section and fitting is labeled as a segment. To fully define the pipe sections segments, you must also specify pipe schedule, diameters, pipe material and a number of increments.

- The first pipe, Branch 1 is broken into three segments.

Design	Rating	Worksheet	Performance	Flow Assurance	Dynamics	
Rati	ng	Length - Ele	vation Profile			
Sizing		Segment				
Heat Tra	ansfer	Fitting/Pipe	-			
		Length/Equ	vivalent Length			
		Elevation C	hange			
		Outer Diam	neter			
		Inner Diam	eter			
		Material				
		Roughness				
		Pipe Wall C	onductivity			
		Increments				
		FittingNo				
			Click Here			
		Append S	egment	Insert Segme	ent	View Segr
	[	Delete Se	gment	Clone Segm	ent	Clear Pr



- Add the first segment to the pipe unit operation by clicking the Append Segment

button. Specify the following information for the segment.

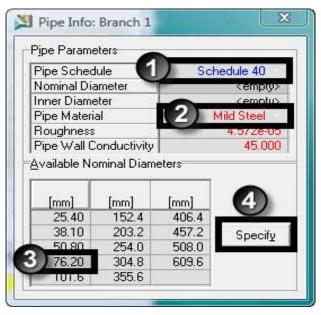
- To specify the diameter, click the View Segment button.

Rating	-Length - Elevation Profile		
Sizing	Fitting/Pipe	Pine	<u> </u>
Heat Transfer	Length	150.0	
	Elevation Change	6.000	
	Outer Diameter	<empty></empty>	
	Inner Diameter	<empty></empty>	
	Material	Mild Steel	
	Roughness	4.572e-005	
	Pipe Wall Conductivity	45.00	
	Increments	5	-
	Append Segment	Insert Segment	<u>V</u> iew Segment
	Delete Segment	<u>C</u> lone Segment	Cle <u>a</u> r Profile
Design Rating	Worksheet Performanc	e Dynamics Depos	ition

- Select Schedule 40 as the Pipe Schedule.

- From the Available Nominal Diameters group, select **76.20 mm (3 inch)** diameter pipe and click the **Specify** button. The Outer and Inner Diameter will be calculated by HYSYS.

- Use the default Pipe Material, Mild Steel





- Two more segments are needed to complete the branch.

In this cell	Enter	Enter
Segment	2	3
Fitting/Pipe	Pipe	Pipe
Length	125 m (410 ft)	100 m (325 ft)
Elevation	-6.5 m (-21 ft)	0.5 m (1 ft)
Schedule	40	40
Nominal Diameter	76.2 mm (3 inch)	76.2 mm (3 inch)

esign Rating	Worksheet	Performance	Flow Assurance	Dynamics		
Rating	Length - Ele	vation Profile -				
,	Segment			1	2	:
nsfer	Fitting/Pipe	£		Pipe	Pipe	Pip
<b>_</b>	Length/Equ	ivalent Length		150.0	125.0	100.0
m	Elevation C	hange		6.000	-8.500	0.5000
	Outer Diam	eter		88.90	88.90	88.90
	Inner Diam	eter		77.93	77.93	77.93
_	Material			Mild Steel	Mild Steel	Mild Stee
	Roughness			4.572e-005	4.572e-005	4.572e-005
	Pipe Wall C	onductivity		45.00	45.00	45.00
	Increments			5	5	5
	FittingNo			<empty></empty>	<empty></empty>	<empty></empty>
	Append S		Insert Segm		View Segment	

The Pipe Segment is not yet able to solve because we have not specified

any information about the heat transfer properties of the pipe.

#### Heat Transfer page

On this page, you select the method that HYSYS will use for the heat transfer calculations.

For all pipes in this simulation, use the Estimate HTC method.



Rating	Specify By C Heat Loss C Ove	rall HTC C Segment F	HTC 🕞 Estimate HTC	
izing leat Transfer	Heat Transfer Coefficien	t Estimation Ambient Temp	erature: 5.0000 C	
	nclude Inner HTC:	Correlation	Profes	
	nclude Insulation:	Insulation Type	Urethane Foam	
		Thermal Conductivity	1.8000e-002 W/m-	
		Thickness	<empty></empty>	
	nclude Outer HTC:	Ambient Medium	Ground	
		GroundType	Dry Peat	
		Ground Conductivity	0.17000 W/m-K	
	- 4.	Buried Depth	1.0000 m	
Design Rating	Worksheet Performanc	e Dynamics Depos	sition	

Now add the remaining unit operations to your case.

Design	Name: PIPE-100	
Connections Parameters Calculation User Variables	Injet GasWell 2	Outlet B2 Out
Notes		
	Fluid <u>P</u> ackage Basis-1	Energy B2 Q
Design Rating	g Worksheet Performance Dynamic	cs Deposition
	No Segment Added	☐ Ignored



Rating	Length - Elevation Profile		
Sizing	Segment	1	<b>^</b>
Heat Transfer	Eitting/Pipe	Pine	1
	Length	200.0	
	Elevation Change	23.00	
	Uuter Diameter	<empty></empty>	
	Inner Diameter	<empty></empty>	2
	Material	Mild Steel	
	Roughness	4.572e-005	
	Pipe Wall Conductivity	45.00	
6	Append Segment	Insert Segment	<u>V</u> iew Segment.
(1)	Delete Segment	<u>C</u> lone Segment	Cle <u>a</u> r Profile
Design Rating	Worksheet Performance	e Dynamics Deposi	ition 📔

jpe Param	eters	~	
<sup>D</sup> ipe Scheo	lule	Sch	nedule 40
Nominal Di	ameter	-	<empty></empty>
nner Diam	eter		<empty></empty>
<sup>D</sup> ipe Materi	al		Mild Steel
Roughness			4.572e-05
Din - Sultall C	1 6 5	1	15 000
	Conductivity ominal Diam		45.000
· · · · · · · · · · · · · · · · · · ·			45.000
vailable N	ominal Diam	eters	45.000
vailable No	ominal Diam [mm]	eters [mm]	
vailable No [mm] 25.40	ominal Diam [mm] 152.4	eters [mm] 406.4	45.000 Specify
[mm] 25.40 38.10	[mm] [52.4 203.2	eters [mm] 406.4 457.2	



Rating	Specify By	Segment HTC CEstimate H
Sizing		
Heat Transfer	Overall Heat Transfer Coefficient	
fred frensier	Ambient Temp	3) 5.0000 C
	Uverall HTL (based on U.U.)	<empty></empty>
0	Individual Heat Transfer Coefficient	
	Internal Film (based on 0.D)	<empty></empty>
	External Film (based on 0.D)	<empty></empty>
	Pipe Wall (based on 0.D)	<empty></empty>
	Ext.Insulation (based on 0.D)	<empty></empty>
Design Ratin	g Worksheet Performance Dynam	nics Deposition

Rating	Specify By	rall HTC C Segment F	HTC @ Estimate HT	
Sizing Heat Transfer	Heat Transfer Coefficien	ient Estimation Ambient Temperature: 5.0000 (		
	Include Inner HTC:	Correlation	Profes	
	Include Insulation:	Insulation Type	Urethane Foam	
		Thermal Conductivity	1.8000e-002 W/m- <empty></empty>	
		Thickness		
	Include Outer HTC:	Ambient Medium	Ground	
		GroundType	Dry Peat	
		Ground Conductivity	0.17000 W/m-K	
		Buried Depth	1.0000 m	
Design Rating	Worksheet Performanc	e Dynamics Depos	sition	
Design		C J Dynamics J Depo.	sidori	



Rating	Length - Elevation Profi			172
Sizing	Segment	1	2	3
Heat Transfer	Fitting/Pipe	Pipe	Pipe	Pipe
	Length	160.0	100.0	205.0
	Elevation Change	12.50	-14.00	-1.000
	Outer Diameter	88.90	88.90	88.90
	Inner Diameter	77.93	77.93	77.93
	Material	Mild Steel	Mild Steel	Mild Steel
	Roughness	4.572e-005	4.572e-005	4.572e-005 💌
				▶.
	Append Segment	Insert Segment	⊻iew Segment	
	Delete Segment	<u>C</u> lone Segment	Cle <u>a</u> r Profile	
Design Rating	Worksheet Performan	ce Dynamics Depos	ition	

Rating	Specify By	rall HTC CSegment F		
Sizing Heat Transfer	Heat Transfer Coefficien			
	Include Inner HTC:	Correlation	Profes	
	Include Insulation:	Insulation Type	Urethane Foam	
		Thermal Conductivity	1.8000e-002 W/m-	
		Thickness	<empty></empty>	
	Include Outer HTC:	Ambient Medium	Ground	
		GroundType	Dry Peat	
		Ground Conductivity	0.17000 W/m-K	
		Buried Depth	1.0000 m	

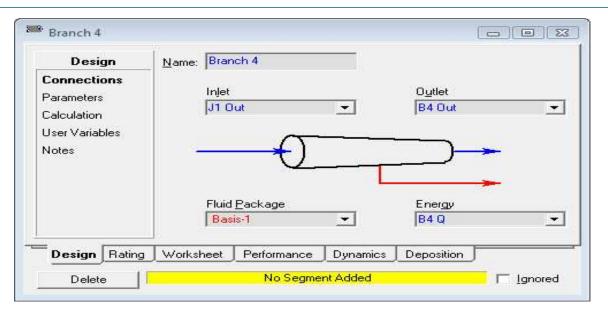
Now, add a mixer operation to mix the outlet streams from both branch 1 & branch 2

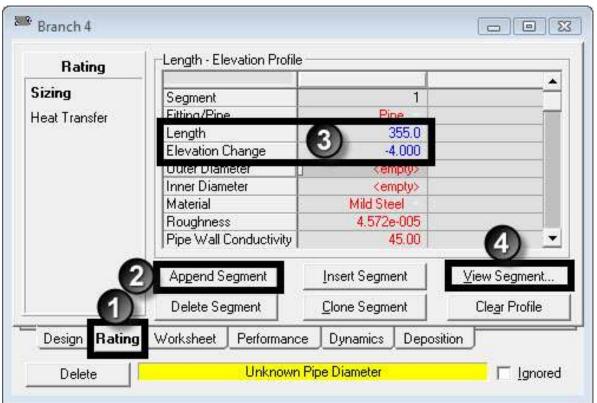


Design	Name Junction 1		
Connections Parameters			
User Variables			
Notes	·>		
	Injets	O <u>u</u> tlet	
	B1 out	J1 Out	<u>•</u>
	B2 Out << Stream >>	Fluid <u>P</u> ackage	
		Basis-1	<u>•</u>
Design Rating	Worksheet Dynamics		

Design	
Connections	<u>_</u>
Parameters	
User Variables	
Notes	
	Automatic Pressure Assignment
	Automatic Pressure Assignment
	C Equalize All









<sup>p</sup> jpe Parame	eters	-	
Pipe Sched	ule	1 Sch	edule 40
Nominal Dia	ameter	25	( empty)
nner Diame	eter		<empty)< td=""></empty)<>
<sup>p</sup> ipe Materia	al	1	Aild Steel
Roughness		1	4.572e-05
Pipe Wall C	onductivity	2	45.000
[mm]	[mm]	[mm]	0
[mm] 25.40	[mm] 152.4	[mm] 406.4	3
and the second se	second distance in the last second	terrest of the second se	Specifu
25.40	152.4	406.4	3 Specify

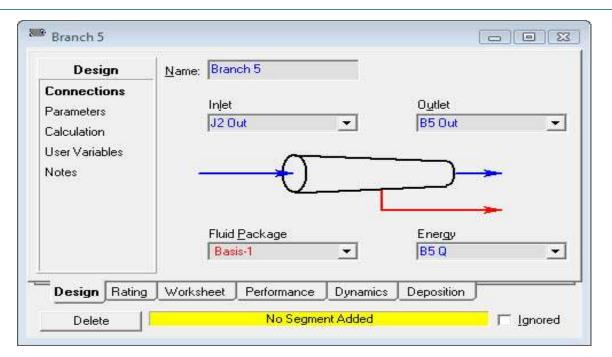
Rating	Specify By C Heat Loss C Ove	rall HTC ( <u>S</u> egment H	HTC 🙃 Estimate HT
Sizing Heat Transfer	Heat Transfer Coefficien	t Estimation Ambient Temp (© <u>G</u> lobal	erature: 5.0000 C
	Include Inner HTC:	Correlation	Profes
	Include I <u>n</u> sulation:	Insulation Type Thermal Conductivity Thickness	Urethane Foam 1.8000e-002 W/m-
	Include Outer HTC:	Ambient Medium	<pre></pre>
		GroundType	Dry Peat
		Ground Conductivity Buried Depth	0.17000 W/m-K 1.0000 m
Design Rating	Worksheet   Performanc	e Dynamics Depo	sition

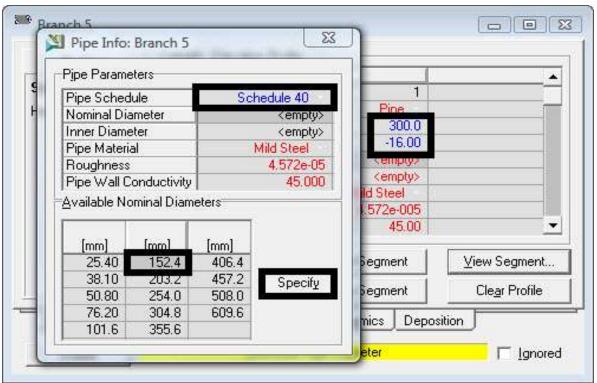


Design	Name Junction 2		
Connections Parameters User Variables Notes		$\rightarrow$	
	Injets B4 Out B3 Out I << Stream >>	Outlet J2 Out ✓ Fluid <u>P</u> ackage Basis-1 ✓	
Design Rating	Worksheet Dynamics		_

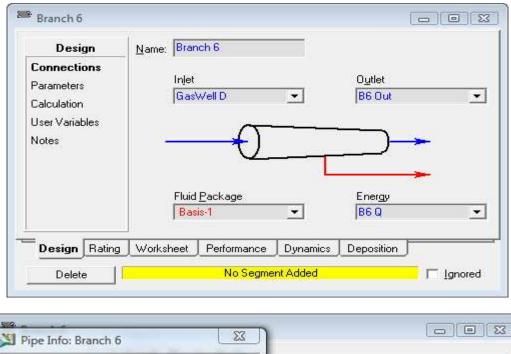
Design		
Connections		
Parameters (1)		
User Variables		-
Notes		
G	Automatic Pressure Assignment	
Ľ	Equalize <u>All</u> Set Ugiter to Lowest Inlet	

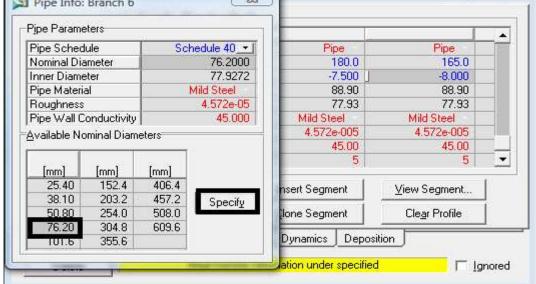








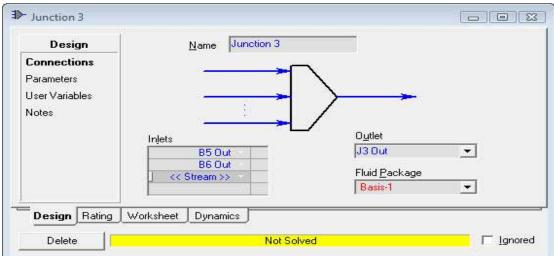


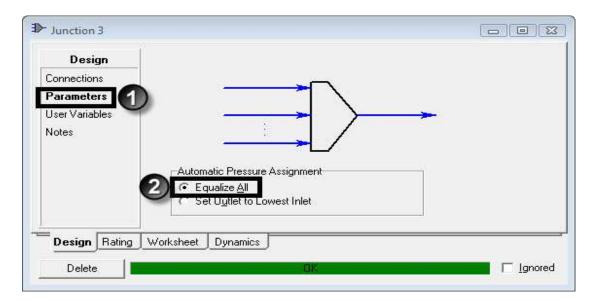


Rating	Specify By C Heat Loss C Ove	rall HTC C <u>S</u> egment H	HTC  Estimate HTC
Sizing Heat Transfer	Heat Transfer Coefficien	Ambient Temp	
-	✓ Include Pipe Wall: ✓ Include Inner HTC:	ি <u>G</u> lobal Correlation	C By Segment Profes
	nclude Insulation:	Insulation Type Thermal Conductivity	Urethane Foam 1.8000e-002 W/m-
		Thickness	<empty></empty>
	🔽 include Outer HTC:	Ambient Medium	Ground
		GroundType	Dry Peat
		Ground Conductivity	0.17000 W/m-K
		Buried Depth	1.0000 m
Design Rating	Worksheet Performance	e Dynamics Depo:	sition





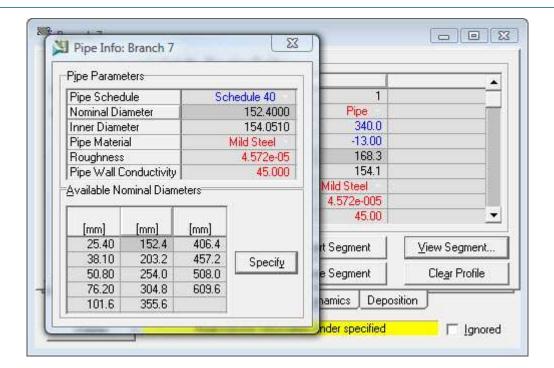




#### The last branch

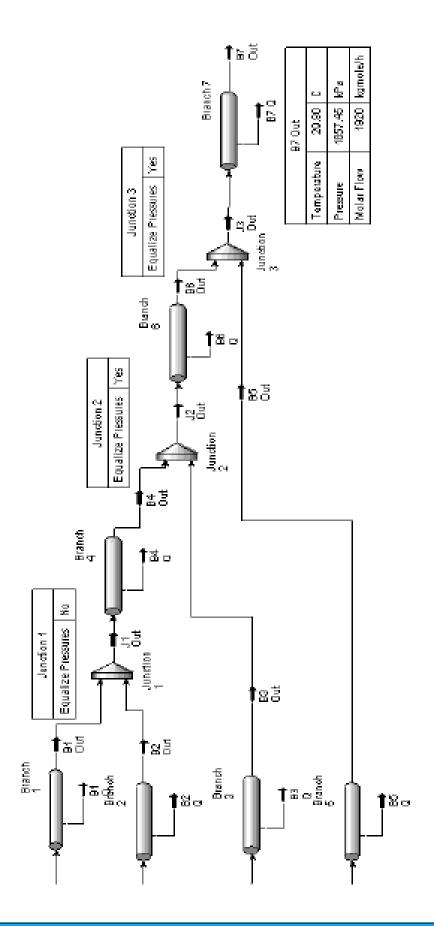
Design	Name: Branch 7	
Connections Parameters Calculation	Injet J3 Out	0 <u>u</u> tlet B7 Out
User Variables Notes		
	Fluid <u>P</u> ackage Basis-1	Ener <u>a</u> y B7 Q 💌





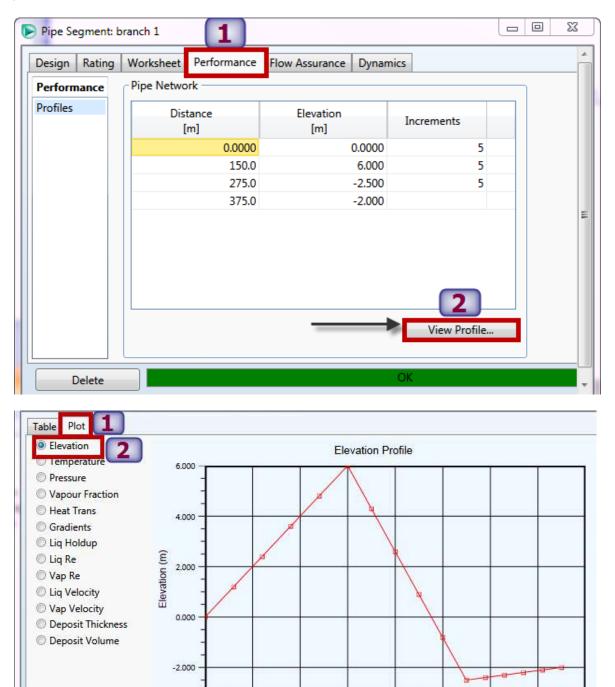
Rating	Specify By C Heat Loss C Ove	rall HTC ( <u>S</u> egment H	HTC 🕞 Estimate HTC	
izing eat Transfer	Heat Transfer Coefficien	t Estimation Ambient Temp	erature: 5.0000 C	
	nclude Inner HTC:	Correlation	Profes	
	nclude Insulation:	Insulation Type	Urethane Foam	
		Thermal Conductivity	1.8000e-002 W/m-	
		Thickness	<empty></empty>	
	nclude Outer HTC:	Ambient Medium	Ground	
		GroundType	Dry Peat	
		Ground Conductivity	0.17000 W/m-K	
		Buried Depth	1.0000 m	
Design Rating	Worksheet Performance	e Dynamics Depos	sition	







You can go to the performance tab inside each segment to view the profile



0.000

50.00

100.0

150.0

200.0

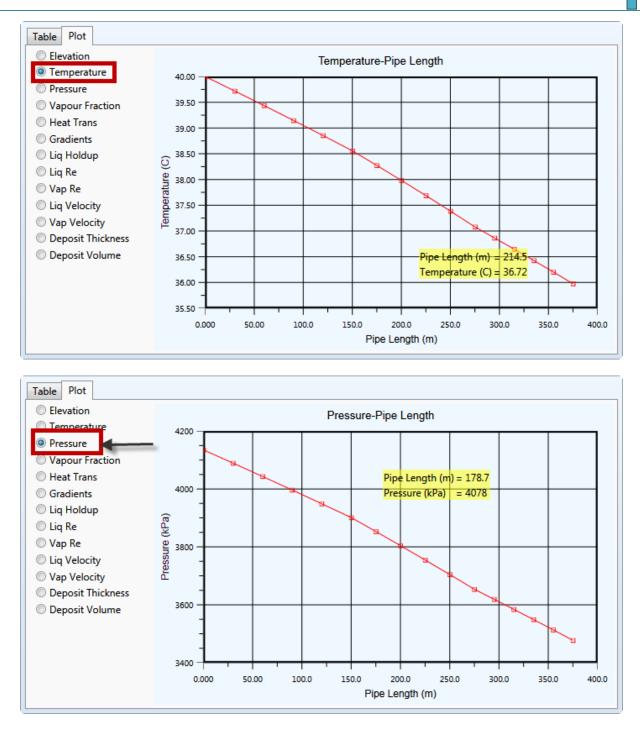
Profile (m)

250.0

300.0

350.0





You can also go to the parameters page to see the pressure drop & heat losses inside each branch:



E egment: b	ranch 1					23
Design Rating	Worksheet	Performance	Flow Assurance	Dynamics		*
Design	Horizontal	Pipe Flow Corre	lation		]	
Connections Parameters	2 pqs and	1 Brill (1979)	•	View Correlation		
Calculation Emulsions User Variables	Vertical Pip	e Flow Correlat	ion			
Notes	Beggs an	d Brill (1979)	•	View Correlation		
	Inclined Pip	e Flow Correlat	ion			=
	Beggs an	d Brill (1979)	•	View Correlation		
	Additional					
Pressure Dro		Accl. Pr. Drop Js/Brill only)	Heat Loss	es		
	Delta P 65	7.5	Du	uty 8731		
		Gravit	ation Energy Char	nge		-
•						•

## Save Your Case!



# NGL Fractionation

## Experience the New Aspen HYSYS\*.



The best process simulation software is now easier to use and faster to learn than ever!

Aspen HYSYS is a comprehensive process modeling system used by the world's leading oil & gas producers, refineries, and engineering companies to optimize process design and operations.







## Workshop

Recovery of natural-gas liquids (NGL) from natural gas is quite common in natural gas processing. Recovery is usually done to:

- Produce transportable gas (free from heavier hydrocarbons which may condense in the pipeline).
- Meet a sales gas specification.
- Maximize liquid recovery (when liquid products are more valuable than gas).

Aspen HYSYS can model a wide range of different column configurations. In this simulation, an NGL Plant will be constructed, consisting of three columns:

- De-Methanizer (operated and modeled as a Reboiled Absorber column)
- De-Ethanizer (Distillation column)
- De-Propanizer (Distillation column)

## Learning Objectives

Once you have completed this section, you will be able to:

- Add columns using the Input Experts.
- Add extra specifications to columns.



## **NGL Fractionation Train**

It's required to process a crude natural gas to remove the heavier hydrocarbons from it thus the composition of it would be suitable for transportation by passing the crude gas which comes from two different wells to three towers: De-Methanizer, De-Ethanizer and De-Propanizer.

The first well at (-140 oF, 330 psia and flow rate of 3575 lbmol/hr) have the following

Component	Mol frac	Component	Mol frac
N2	0.0025	n-C4	0.0085
CO <sub>2</sub>	0.0048	i-C5	0.0036
C1	0.7041	n-C5	0.002
C2	0.1921	n-C6	0.0003
C3	0.0706	n-C7	0.0002
i-C4	0.0112	n-C8	0.0001

conditions and compositions: (Fluid Package: Peng Robinson)

The second one at (-120 °F, 332 psia and flow rate of 475 lbmol/hr) have the following conditions and composition

Component	Mol frac	Component	Mol frac
N2	0.0057	n-C4	0.0197
CO <sub>2</sub>	0.0029	i-C5	0.0147
C1	0.7227	n-C5	0.0102
C2	0.1176	n-C6	0.0037
C3	0.075	n-C7	0.0047
i-C4	0.0204	n-C8	0.0027

There's also an energy supplied to the De-Methanizer of (2e6 BTU/hr) which is used to improve the efficiency of the separation.

The De-Methanizer (reboiled absorber) has the following specifications:

- Feed 1 Material Stream enters the column from the top stage inlet
- Feed 2 Material stream enters from the 2nd stage
- Ex-duty Energy Stream enters from the 4th stage
- Number of stages = 10
- Top Stage pressure = 330 psia & Reboiler pressure = 335 psia
- Top Stage temperature =  $-125^{\circ}F$  & Reboiler temperature =  $80^{\circ}F$

- Ovhd Prod Rate = 2950 lbmole/hr (1338 Kg/hr)

After running the column with the above specifications, the <u>design is</u> <u>then modified to ensure that the overhead molar fraction of the</u> <u>methane is 0.96</u>



Most of methane is removed from the top of the tower and the bottom stream is pumped to 2790 kpa then it enters to the De-Ethanizer (distillation Column) where most of the ethane in the crude is taken as an overhead product then it is processed to use in different applications.

The de-ethanizer has the following specifications:

Connections	
Name	DC2
No. of Stages	14
Inlet Stream/Stage	DC2 Feed/6
Condenser Type	Partial
Overhead Vapour Product	DC2 Ovhd
Overhead Liquid Product	DC2 Dist
Bottoms Liquid Outlet	DC2 Btm
Reboiler Duty Energy Stream	DC2 Reb Q
Condenser Duty Energy Stream	DC2 Cond Q
Pressures	
Condenser	2725 kPa (395 psia)
Condenser Delta P	35 kPa (5 psi)
Reboiler	2792 kPa (405 psia)
Temperature Estimates	
Condenser	-4°C (25°F)
Reboiler	95°C (200°F)
Specifications	
Overhead Vapour Rate	320 kgmole/h (700 lbmole/hr)
Distillate Rate	0 kgmole/h
Reflux Ratio	2.5 (Molar)

After running the column with the above specifications, the design is modified to ensure that the bottom stream has ratio between  $C_2/C_3 = 0.01$ 



Then the bottom product is sent to a valve where the pressure of it decrease to 1690 kpa, the outlet flow from the valve is sent to a de-propanizer (distillation Column) where most of propane is removed from the top and the heavier hydrocarbons is removed from the bottom

The specifications of the de-propanizer are:

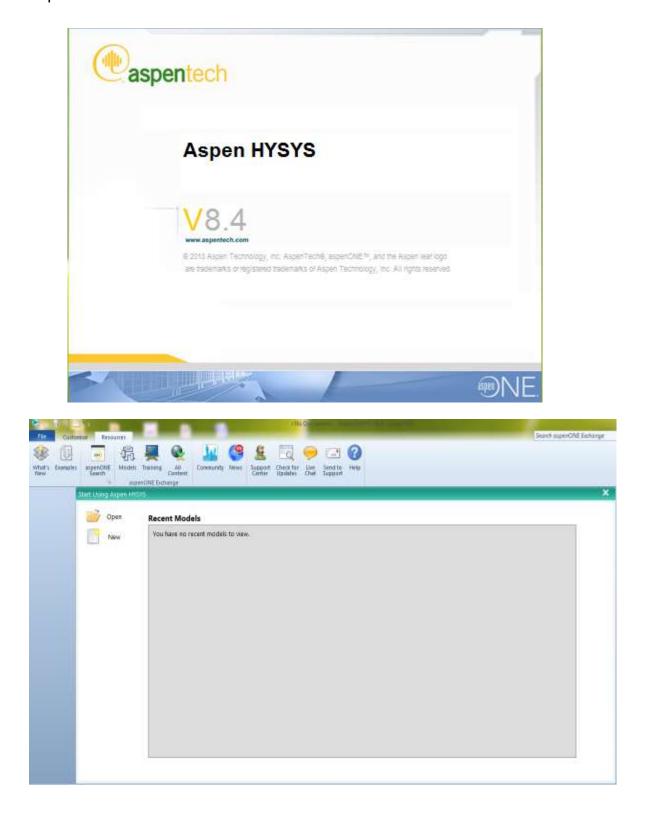
In this cell	Enter
Connections	
Name	DC3
No. of Stages	24
Inlet Streams/Stage	DC3 Feed/11
Condenser Type	Total
Ovhd Liquid Outlet	DC3 Dist
Bottom Liquid Outlet	DC3 Btm
Reboiler Duty Energy Stream	DC3 Reb Q
Condenser Duty Energy Stream	DC3 Cond Q
Pressures	
Condenser	1585 kPa (230 psia)
Condenser Condenser Delta P	1585 kPa (230 psia) 35 kPa (5 psi)
Condenser Delta P	35 kPa (5 psi)
Condenser Delta P Reboiler	35 kPa (5 psi)
Condenser Delta P Reboiler Temperature Estimates	35 kPa (5 psi) 1655 kPa (240 psia)
Condenser Delta P Reboiler Temperature Estimates Condenser	35 kPa (5 psi) 1655 kPa (240 psia) 38°C (100°F)
Condenser Delta P Reboiler Temperature Estimates Condenser Reboiler	35 kPa (5 psi) 1655 kPa (240 psia) 38°C (100°F)

After running the column with the above specifications, the <u>design is</u> <u>modified to ensure that the overhead molar fraction of the i-C4 & n-</u> <u>C4 =0.15 AND propane bottom product molar fraction = 0.02</u>



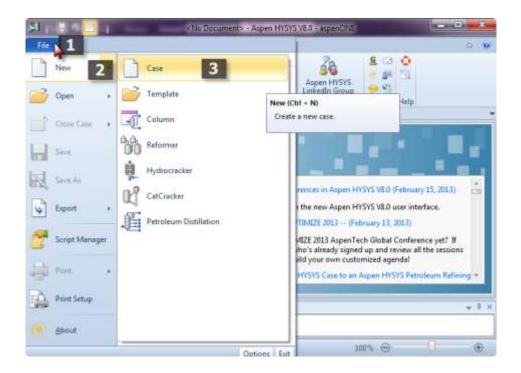
To start the program, From Start Menu, Select All Programs >>

Aspen Tech >> Process Modeling V8.x >>>> Aspen HYSYS >> Aspen HYSYS





#### 11- First, Start a new case



#### 12- Add the Components

×	-	-	Untitled - A	Aspen HYSYS V8.0	) - aspe	nONE	Country 1	
File Home	View	Customize	Get Starte	d				a 🕐
X Cut Copy* Xaviga Clipboard	te 🖏 Upda	Components te Properties iponents	Petroleum Assays Refining 5	✤ Hypotheticals *	Oil *	Aspen Properties Options	PVT Laboratory Measurements PVT Data	
Properties		< Start F	age × Com	ponent Lists $ imes$	+			•
All Items Component Fluid Packag Petroleum A Oil Manager Reactions Component G User Properti	es 🚺 ssays Maps		2	Vame			Source	E
Properties	is	Messager	Add Import	Expc			Delete	* # ×
						100	% Θ	•



#### 13- Choose the system components from the databank:

urce Databank: HYSYS				Select	Pure Compone	ots •	Filter	Al families
Component	Туре	Group		Search for			Search by:	Full Name/Synonym
				Simulatio	on Name	Full Name / 3	iynonym	Formula
			< Add		Methane		a	0
			1 Store 1		Ethane		(2	0 G
					Propane i-Butane		G 1-04	C3
			Replace		n-Butane		n-C4	Cal
			A ANTONIO II		i-Pentane		+03	CIH
					n-Pentane		n-CS	GH
			lano-e		in-Hexane		C6	C6H
					n-Heptane		07	C7H
					n-Octane		C8	CBH
					n-Nonane		0	C9H
					n-Decane		C10	C10H
					n-C11		C11	CITH
					n-C12		C12	C12H

	-	-	l	Search for:
Component	Туре	Group		Search ron.
Methane	Pure Component		_	
Propane	Pure Component		2	Simulation Name
Ethane	Pure Component			1 -
			< Add	n-
				i-F
				n-P
			Replace	n-
				n-H
				n-
			Remove	n-1
				n-
	ОК			

After adding the pure components (N<sub>2</sub>, CO<sub>2</sub>, C1, C2, C3, n-C4, i-C4, n-

C5, i-C5, n-C6, C7, C8)

Now, select the suitable fluid package



劉 日 - □-	Untitled - Aspen H	IYSYS V8.0 - aspenONE		
File Home View	Customize Get Started			~ 0
Properties	Start Page X Fluid Packa	ges × +		
All Items	Fluid Package	Compo	onent List	Property Packag
<ul> <li>Petroleum Assays</li> <li>Oil Manager</li> <li>Reactions</li> <li>Component Maps</li> <li>User Properties</li> </ul>				F
Properties	Add	Edit		apy
6 Energy Analysis	Messages			• • • ×
	Required Info : Fluid Packages	Sele		· * * ^
			100% Θ	•

In this case, select Peng-Robinson

	Untitled - Aspen HYSYS V8.0 - aspenONE	
File Home View	Customize Get Started	♡ 🥝
Properties	< Start Page × Basis-1 × +	
All Items	Set Up Binary Coeffs StabTest Phase Order Tabular Notes	*
<ul> <li>Component Lists</li> <li>Component List - 1</li> <li>Image Fluid Packages</li> </ul>	Package Type: HYSYS	Component List S
Basis-1	Property Package Selection Options	E
Retroleum Assays	Enthalpy	Pi
🔯 Oil Manager	Margules Density	
Reactions	MBWR Modify Tc. Pc for H2. He	Moc
Component Maps	NBS Steam NRTL Indexed Viscosity	
🕞 User Properties	Peng-Robinson Options	
	Peng-Robinson EOS Solution Methods	Cubic EC
Properties	PRSV Phase Identification	
	Sour SRK Sour PR Surface Tension Method	
$\Box_{\Box}^{\Box}$ Simulation	CRK Thermal Conductivity	
6 Energy Analysis	Messages	* # ×
	100% 🖂	•

Now you can start drawing the flow sheet for the process by clicking the Simulation button:





🔰 🛛 🖟 🗖 💒 🔹 Untitled - Aspen HYSYS V8.0 - aspenONI	🎽 Palette 🗖 🗖 🖾	23
File         Home         Economics         Dynamics         View         Customize         G           Simulation          Start Page ×         Flowsheet Main ×         +		
All Items Workbook UnitOps Streams Stream Analysis All Analysis Caupment Design Model Analysis Data Tables Strip Charts Case Studies Data Fits Properties Click Here Simulation Messages Fenergy Analysis	Upstream       Refining         Custom       Dynamics         Common       Columns	× 4 ×
Solver (Main) - Ready		Ð 🚼

Now add a material stream to define the composition and the conditions of the feed stream

From the palette:

	CASE2.HSC	- Aspen H	HYSYS V8.0	- aspenO	Dalette	<u> </u>
File Home Economics	Dynamics	View C	Customize	Get Sta	Click Here	1
Q Zoom In ⊡ Zoom to Fit Q Zoom In ⊡ Page Width Q Zoom Out Zoom	Flowsheet	Model Palette	Notes Manager Show	Mes 🔄 Mes		Refining Dynamics
Simulation	< Flow	sheet Ma	ain × Cas	e Study 1	Common	Columns
All Items  Workbook  UnitOps  Grams  Streams  Stream Analysis  Contemport Design  Model Analysis  Data Tables  Strip Charts  Properties  Strip Charts  Strip		Do 2	ouble C	lick		



Looking	MoleFraction	Composition Basis
Methane	0.7041	Mole Fractions
CO2	0.0048	C Mass Fractions
Ethane	0.1921	
<sup>p</sup> ropane	0.0706	Liq Volume Fractions
-Butane	0.0112	- C Mole Flows
n-Butane	0.0085	
i-Pentane	0.0036	C Mass Flows
n-Pentane	0.0020	C Lig Volume Flows
n-Hexane	0.0003	
n-Heptane	0.0002	Contraction Contrals
Nitrogen	0.0025	Composition Controls
n-Octane	0.0001	Erase
		Normalize
		Cancel
Equalize Compositi	ion Total 1.0000	- ОК

After adding the compositions and the conditions for the first stream, add another stream for feed 2:

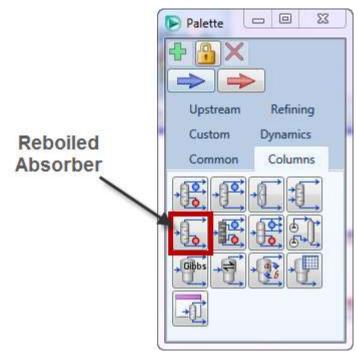
	MoleFraction	Composition Basis
lethane	0.7227	Mole Fractions
02	0.0029	C Mass Fractions
thane	0.1176	
ropane	0.0750	C Liq ⊻olume Fractions
Butane	0.0204	- C Mole Flows
-Butane	0.0197	
Pentane	0.0147	C Mass Flows
-Pentane	0.0102	- C Lig Volume Flows
-Hexane	0.0037	Cig volume riows
-Heptane	0.0047	
itrogen	0.0057	Composition Controls
-Octane	0.0027	Erase
	-	
		Normalize
		Cancel
Equalize Compositio	n Total 1.0000	ок



#### PART 1: DE- METHANIZER COLUMN

The De-Methanizer is modeled as a reboiled absorber operation, with two feed streams and an energy stream feed, which represents a side heater on the column.

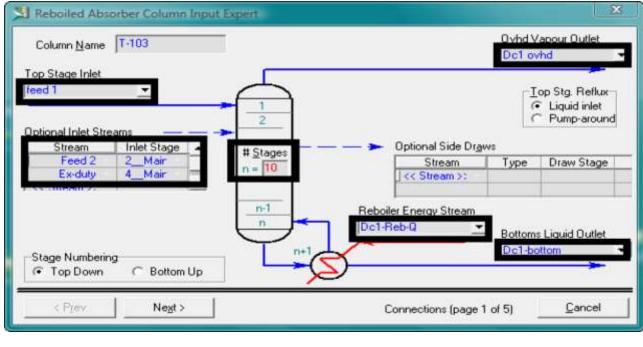
- Add an **Energy** stream with the duty = 2.1 e6 kJ/hr
- Double-click on the **Reboiled Absorber** icon on the Object Palette.

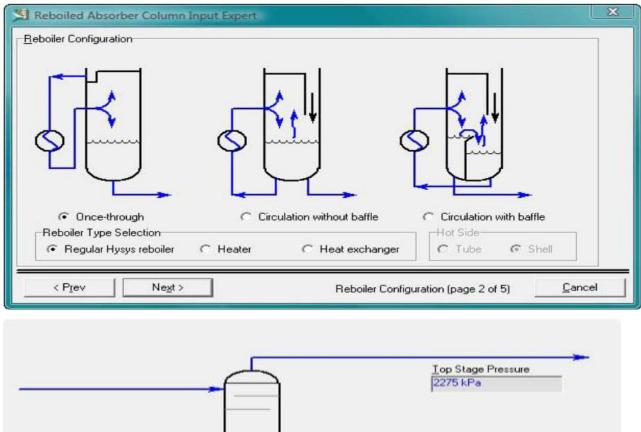


#### **De-Methanizer Specs:**

- Feed 1 Material Stream enters the column from the top stage inlet
- Feed 2 Material stream enters from the 2nd stage
- Ex-duty Energy Stream enters from the 4th stage
- Number of stages = 10
- Top Stage pressure = 330 psia
- Reboiler pressure = 335 psia
- Top Stage temperature =  $-125^{\circ}F$
- Reboiler temperature = 80 °F
- Ovhd Prod Rate = 2950 lbmole/hr (1338 Kg/hr)
- C1 fraction in the Ovhd stream = 0.96







 < Prev</td>
 Negt >

 Pressure Profile (page 3 of 5)
 Cancel

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Seboiled Absor	rber Column Input Expert	X
		Optional <u>T</u> op Stage Temperature Estimate -87.22 C
		Optional Reboiler Temperature Estimate 26.67 C
< PIen	Ne <u>x</u> t >	Optional Estimates (page 4 of 5)
Reboiled Abso	rber Column Input Expert	Boil-up Ratio
< Prev		Specifications (page 5 of 5)
• Column: T-103 / C	OL5 Fluid Pkg: Basis-1 / Peng-Robinson	
Design Connections Monitor Specs Specs Summary Subcooling Notes	Optional Checks Input Summary View Initial Estimates Iter Step Equilibrium Heat / Spec	Profile         Temperature vs. Tray Position from Top           © Temp         10.00           © Press         6.000           C Press         6.000           C Flows         3.000           10.00         1           2.000         1           2.000         1
	Specifications           Ovhd Prod Rate         Specified Value           Btms Prod Rate         2950 lbmole/hr           Boilup Ratio <empty></empty>	<empty> <empty> 🔽 🔽</empty></empty>
Design Paramete		Active Upgate Inactive Degrees of Freedom 0
	rs Side Ops Rating W et Performance Column Environment Run <u>R</u> eset	

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Although the column is converged, it is not always practical to have flow rate specifications. These specifications can result in columns which cannot be converged or that produce product streams with undesirable properties if the column feed conditions change.

An alternative approach is to specify either component fractions or component recoveries for the column product streams.

	Specified Value	Current Value	Wt. Euro	Active	Estimate	Current
Ovhd Prod Rate	2950 lbmole/hr	2.95e+003	-C 1			
Btms Prod Rate	<empty></empty>	1.10e+003	<empty></empty>			
Boilup Ratio	<empty></empty>	1.90	<empty></empty>		J V	
View	Add Spec Group A		late Inactive	1	es of Free	. 17

Column Cold Properties Spec Column Component Flow Column Component Fraction Column Component Ratio Column Component Recovery Column Cut Point Column Draw Rate Column DT (Heater/Cooler) Spe Column Dt Spec Column Duty Column Duty	
Column Component Ratio Column Component Recovery Column Cut Point Column Draw Rate Column DT (Heater/Cooler) Spe Column Dt Spec Column Duty	111
Column Component Recovery Column Cut Point Column Draw Rate Column DT (Heater/Cooler) Spe Column Dt Spec Column Duty	
Column Duty Ratio	1
Column Feed Ratio Column Gap Cut Point Column Liquid Flow Column Physical Properties Spec Column Pump Around Column Reboil Ratio Spec Column Recovery Column Reflux Feed Ratio Spec	



Name		C1 in ovhd
Stage		1Main TS
Flow Basis		Mole Fraction
Phase		Vapour
Spec Value		0,9600
Components:	J	Methane
	<< Con	nponent >>
Target Type	C Stream	• 🕞 Stage
= Parameters	Summary	Spec Type

Run the column:

				Specifi	ed Value	Current Val	ue	Wt. Error	Active	Estimate	Current
		Ovhd Prod R	ate	13	38 kgmole/h	1.35e+(	003	0.0090	Г	9	Г
		Btms Prod Ra	ste		(empty)	4	485	<empty></empty>	Г		Г
		Boilup Ratio			(empty)	2	00	(empty)	Г		Г
		ovhd			(empty)	<emp< td=""><td>ty)</td><td><empty></empty></td><td>Г</td><td></td><td>Г</td></emp<>	ty)	<empty></empty>	Г		Г
		C1 in ovhd			0.9600	0.9	960	-0.0000		4	7
		⊻iew		Add Spec	<u>G</u> roup A	active	Upg	(ate Inactive	Degr	ees of Free	dom 0
Design	Parameters	Side Ops	Rating	Worksheet	Performance	Flowshee	I) F	leactions D	mamics	]	
Delete	1	mn Environn		Ryn	Reset	1	in com			ate Outlets	

After running the column, add a pump to transfer the bottom liquid to the De-ethanizer:



Design		Name P-100			
Connections Parameters Curves Links Jser Variables	Injet Dc1-bottom	-	Outlet Dc2-feed	<u>·</u>	
Notes	Energ P-10		Fluid Package	<u>•</u>	
	Worksheet Perf	ormance Dynamics			

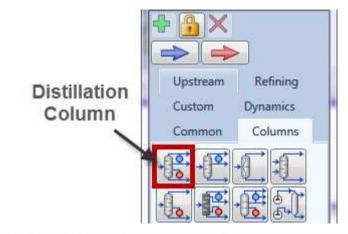
The pump outlet pressure is 2790 kPa (from Worksheet)

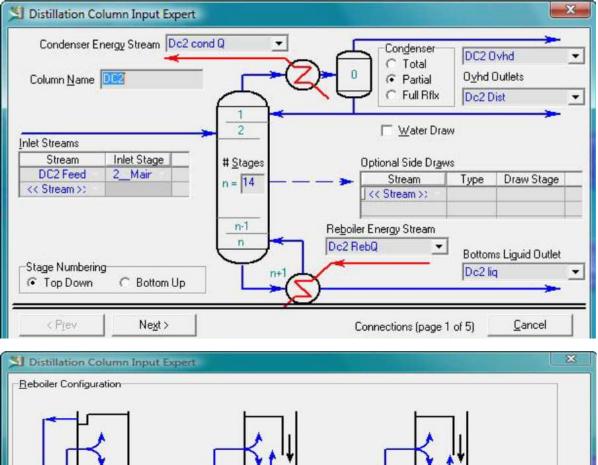
Worksheet	Name	Dc1-bottom	Dc2-feed	P-100-hp
a****	Vapour	0.0000	0.0000	<empty></empty>
Conditions Properties	Temperature [C]	20.06	20.77	<empty></empty>
	Pressure [kPa]	2310	2790	<empty></empty>
monition	Molar Flow [kgmole/h]	485.0	485.0	<empty></empty>
Composition PF Specs	Mass Flow [kg/h]	1.837e+004	1.837e+004	<empty></empty>
	Std Ideal Lig Vol Flow [m3/h]	42.65	42.65	<empty></empty>
	Molar Enthalpy [kJ/kgmole]	-1.104e+005	-1.103e+005	<empty></empty>
	Molar Entropy [kJ/kgmole-C]	120.7	120.8	<empty></empty>
	Heat Flow [kJ/h]	-5.353e+007	-5.350e+007	2620e+004
				1
esign Rating	Worksheet Performance Dyna	mics		n <b>F</b> lanored



#### PART 2: DE- ETHANIZER COLUMN

The outlet from the pump is then fed to the de-ethanizer:





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C Heater

Once-through

Reboiler Type Selection

< Prev

Regular Hysys reboiler

Ne<u>x</u>t >

C Circulation without baffle

C Heat exchanger

Circulation with baffle

G Shell

Cancel

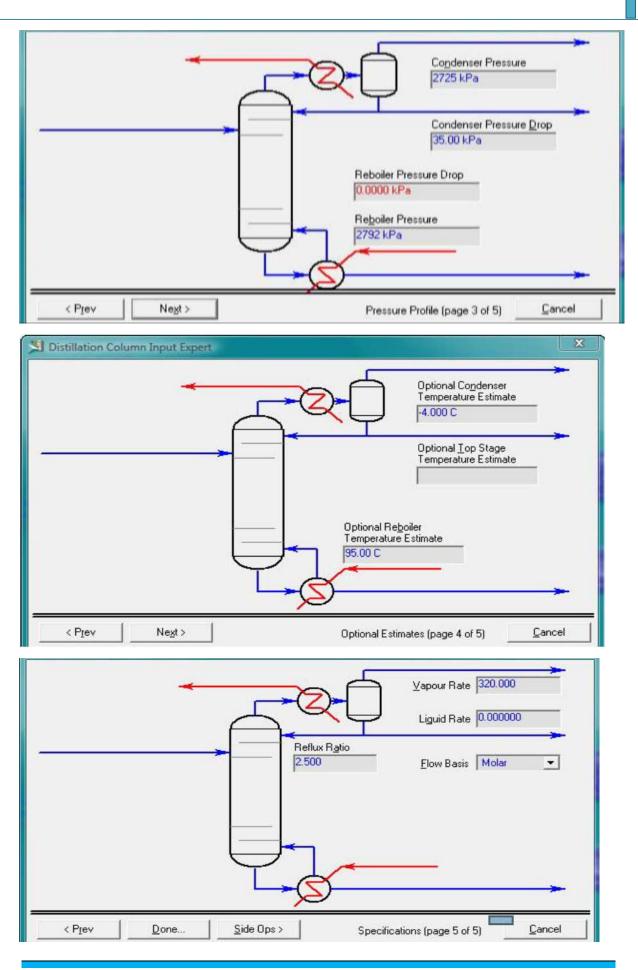
Hot Side

C Tube

Reboiler Configuration (page 2 of 5)





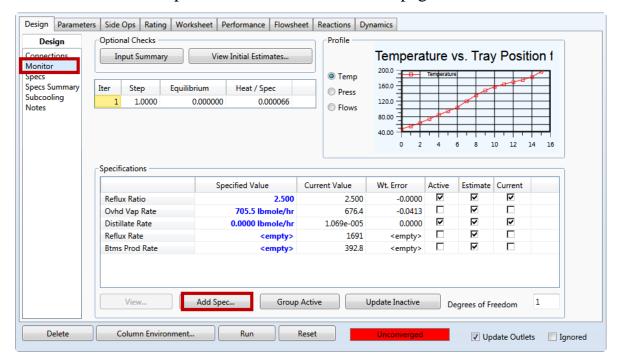


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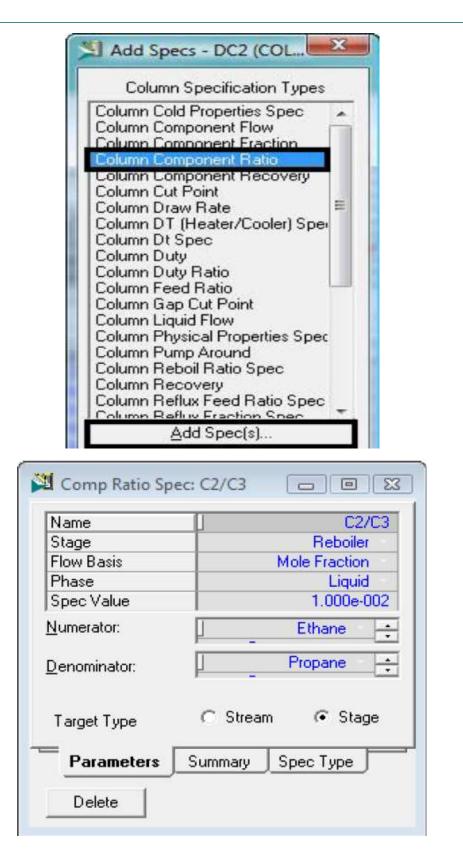


and the second second second		C Total			
Condenser Energy Stream Dc2 cond Q		Delta P 35.00 kPa	Partial C Full     DC2 Ovhd     Overhead Outlets     Dc2 Dist	Reflu	
Injet Streams Stream Injet Stage DC2 Feed 2_Mair <stream>:</stream>	2 P cond Num of Stages n = 14 P reb 2725 kPa P reb	Stream   << Stream >:	Type Draw Stag	ye	
Stage Numbering Top Down C Bottom Up Edit Trays		aPB	ottoms Liguid Outlet	- -	
	Dc2 cond Q Injet Streams Stream Inlet Stage DC2 Feed 2_Mair << Stream >: Stage Numbering © Top Down © Bottom Up	Dc2 cond Q     Image: Cond Q       Injet Streams     P cond       Stream     Inlet Stage       DC2 Feed     2 Mair       < <td>C Stream &gt;:       Stage Numbering       © Top Down     Bottom Up</td> <td>Dc2 cond Q     O     Delta P       Injet Streams     1     P cond     Optional Side Draw       Injet Stream     Inlet Stage     2725 kPa     Stream       DC2 Feed     2 Mair     Inter Stream     I       &lt;&lt;&lt; Stream &gt;:     P reb     2792 kPa     Fill       Stage Numbering     Inter Stream     P reb     P reb       Image: Stage Numbering     Image: Stage Numbering     Image: Stage Numbering     Image: Stage Numbering</td> <td>Dc2 cond Q        <ul> <li>P cond</li> <li>Dc2 Dist</li> <li>Dc2 Dist</li> <li>Dc2 Dist</li> <li>Dc2 Dist</li> <li>Dc2 Dist</li> <li>Dc2 Feed</li> <li>Mair</li> <li>C Stream &gt;:</li> <li>P reb</li> <li>P reb</li> <li>P reb</li> <li>P reb</li> <li>Dc2 RebQ</li> <li>Bottoms Liguid Outlet</li> <li>Dc2 RebQ</li> <li>Bottoms Liguid Outlet</li> <li>Dc2 Liguid</li> <li></li></ul></td>	C Stream >:       Stage Numbering       © Top Down     Bottom Up	Dc2 cond Q     O     Delta P       Injet Streams     1     P cond     Optional Side Draw       Injet Stream     Inlet Stage     2725 kPa     Stream       DC2 Feed     2 Mair     Inter Stream     I       <<< Stream >:     P reb     2792 kPa     Fill       Stage Numbering     Inter Stream     P reb     P reb       Image: Stage Numbering     Image: Stage Numbering     Image: Stage Numbering     Image: Stage Numbering	Dc2 cond Q <ul> <li>P cond</li> <li>Dc2 Dist</li> <li>Dc2 Dist</li> <li>Dc2 Dist</li> <li>Dc2 Dist</li> <li>Dc2 Dist</li> <li>Dc2 Feed</li> <li>Mair</li> <li>C Stream &gt;:</li> <li>P reb</li> <li>P reb</li> <li>P reb</li> <li>P reb</li> <li>Dc2 RebQ</li> <li>Bottoms Liguid Outlet</li> <li>Dc2 RebQ</li> <li>Bottoms Liguid Outlet</li> <li>Dc2 Liguid</li> <li></li></ul>

Add the Column component ratio from the monitor page as follows:



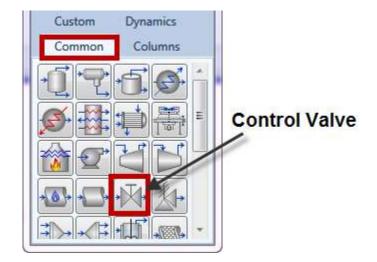






		Specified Value	Current Value	Wt. Error	Active	Estimate	Current
	Reflux Ratio	2.500	2.50	-0.0000			
	Ovhd Vap Rate	320.0 kgmole/ł	306	-0.0445	Г	V	
	Distillate Rate	0.0000 kgmole/ł	4.71e-006	-0.0000	2		2
	Reflux Rate	<empty></empty>	764	<empty></empty>		2	
	Btms Prod Rate	<empty></empty>	179	<empty></empty>			Г
	C2/C3	1.000e-002	9.99e-003	-0.0005			2
	<u>⊻</u> iew	Add Spec Group	Active Up	date Inactive	Degr	ees of Free	dom 0
Design Para	meters Side Ops Rating	Worksheet Performan	ce Flowsheet F	Reactions Dy	namics	J	
Delete	Column Environment	R <u>u</u> n <u>R</u> eset		BICHER 1	☑ Upd	late Outlets	

Add a valve on the bottom liquid stream:



Design Rating	Worksheet Dynamics		
Design	- 0	Notes a second	
Connections	Name	VLV-100	
Parameters			
User Variables Notes			
Notes			
	1	$\rightarrow$ $\times$ $\vdash$	$\rightarrow$
	Inlet	Outlet	
	Inlet	Outlet	
	Inlet DC2 Btm	Outlet DC3 Feed	•
	C		•
	C		•
	C		•
	C		•



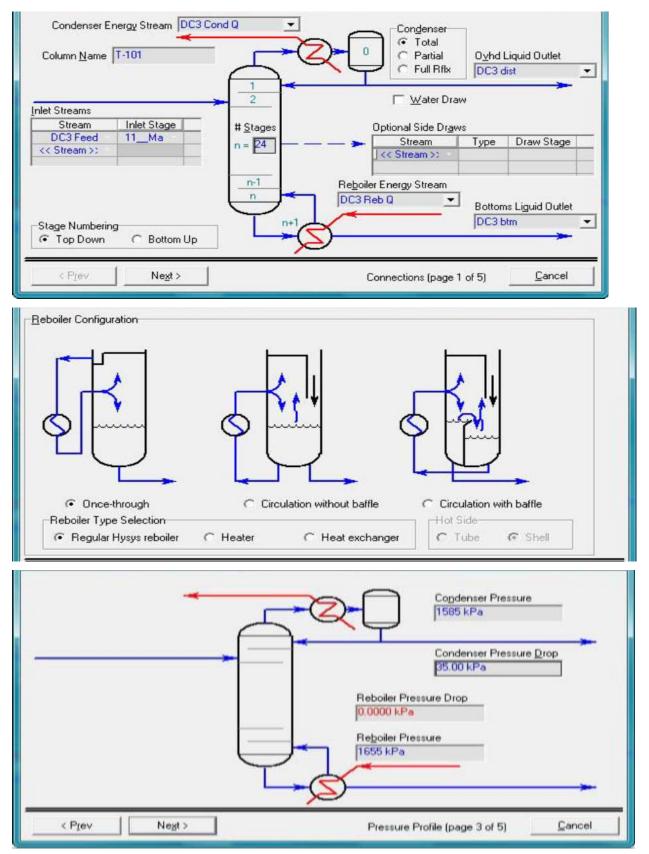
#### Outlet pressure from the valve = 1690 kPa (from the **Worksheet** tab)

onditions operties	Vapour Temperature [C]	0.0000	0.3210
	Temperature [C]	91 10	07.00
operties		31.10	67.39
and a second	Pressure [kPa]	2792	1690
omposition	Molar Flow [kgmole/h]	179.2	179.2
F Specs	Mass Flow [kg/h]	9036	9036
00000	Std Ideal Liq Vol Flow [m3/h]	16.78	16.78
	Molar Enthalpy [kJ/kgmole]	-1.233e+005	-1.233e+005
	Molar Entropy [kJ/kgmole-C]	121.5	122.3
	Heat Flow [kJ/h]	-2.211e+007	-2.211e+007



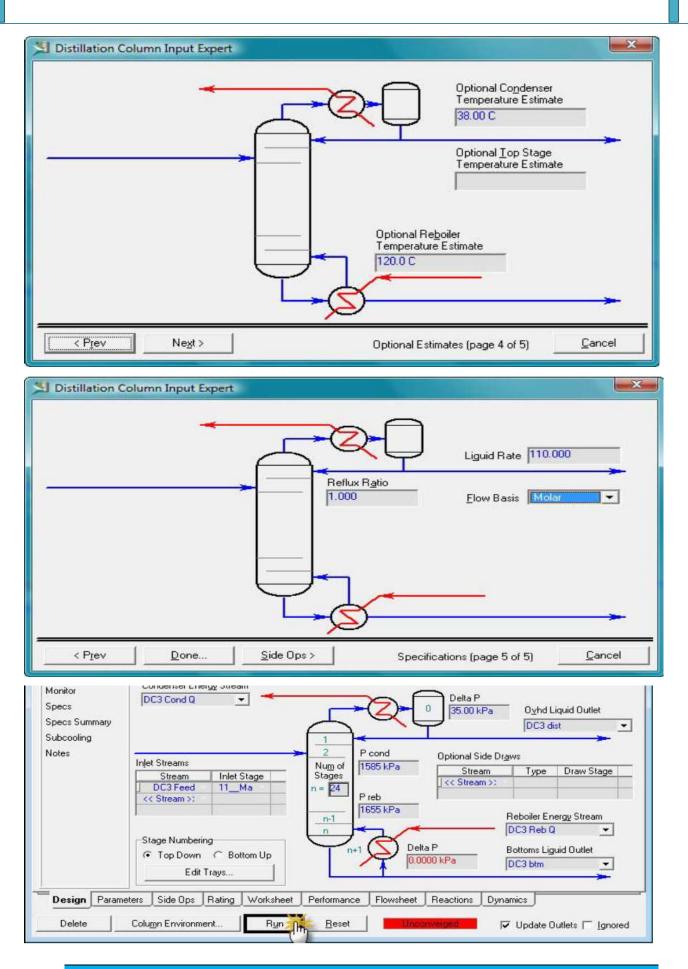
#### PART 3: DE- PROPANIZER COLUMN

#### Add a distillation column (De-propanizer):









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#### Now, let's add a new 2 specifications instead of the current:

Connections	Inp	ut Summary	View In	iitial Estimates			95.00 90.00 85.00		
Monitor Specs Specs Summary Subcooling Notes	1 1 2 3	Step 1.0000 1.0000 0.0001	Equilibrium 0.028719 0.000257 0.000003	Heat / Spec 0.028396 0.003076 0.000271	- 0	Temp Press Flows	80.00 75.00 66.00 65.00 55.00 55.00 55.00	5 10	15
	Reflu: Distilla Reflu:	ic <u>a</u> tions x Ratio ate Rate x Rate Prod Rate	<u>l</u>	cified Value 1.000 110.0 kgmole/h <empty> <empty></empty></empty>	Curren	t Value 1.00 110 110 69.2	Wt. Error 0.0000 0.0005 <empty> <empty></empty></empty>		Estimate
		⊻iew	Add Spec.	<u>G</u> roup A	Active	Upg	ate Inactive	Degr	ees of Fre

Column Specification Types Column Cold Properties Spec	
Column Component Flow Column Component Fraction Column Component Recovery Column Cut Point Column Draw Rate Column DT (Heater/Cooler) Sper Column Dt Spec Column Duty Column Duty Ratio Column Feed Ratio Column Feed Ratio Column Gap Cut Point Column Liquid Flow Column Physical Properties Spec Column Pump Around	m
Column Reboil Ratio Spec Column Recovery Column Reflux Feed Ratio Spec	





Name		C3	Name	1	iC4 ar	a property of the second second
Stage		piler	Stage		Conder	
Flow Basis	Mole Fraci	and a second sec	Flow Basis		Mole Frac	
Phase	the second s	biug	Phase	-		biu
Spec Value	2.000	De-002	Spec Value	LI.	1.500	le-002
Components:	Propane << Component >>		Components:	-	i-Butane n-Butane < Component >>	
Target Type	C Stream (@ S	Stage	Target Type	C S	tream (• S	itage
Parameters	Summary Spec Type	e	Paramete	sis Summa	wy Spec Typ	e
						_
Delete			Delete			
Delete	2 1,000 0	000016 0.015967	Delete			
pecs Summary	4 1.0000 0 5 1.0000 0	0.000016 0.015867 0.000001 0.002043 0.000000 0.000228		50.00 40.00 0 5	10 15	20 22
pecs Summary	4 1.0000 0	0.000001 0.002043 0.000000 0.000228		40.00 0 5		
pecs Summary ubcooling	4 1.0000 00 5 1.0000 00 Specific <u>a</u> tions	0.000001 0.002043 0.000000 0.000228 Specified Value	Current Value	40.00 5	Active Estimate	Current
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pecs Summary ubcooling	4 1.0000 00 5 1.0000 00 Specifications Reflux Ratio	0.000001 0.002043 0.000000 0.000228 Specified Value	Current Value 1.79	40.00 0 5 Wt. Error 0.7926	Active Estimate	Current
pecs Summary ubcooling	4 1.0000 00 5 1.0000 00 Specifications Reflux Ratio Distillate Rate Reflux Rate Btms Prod Rate	0.000001 0.002043 0.000000 0.000228 Specified Value 1.000 110.0 kgmole/h <empty> <empty></empty></empty>	Current Value 1.79 122 219 57.3	Wt. Error 0.7926 0.1085	Active Estimate	
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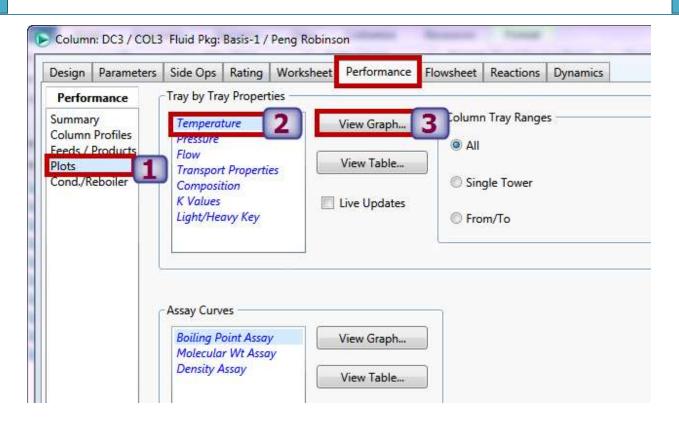
After running the column, you can view the results from the **Performance** 

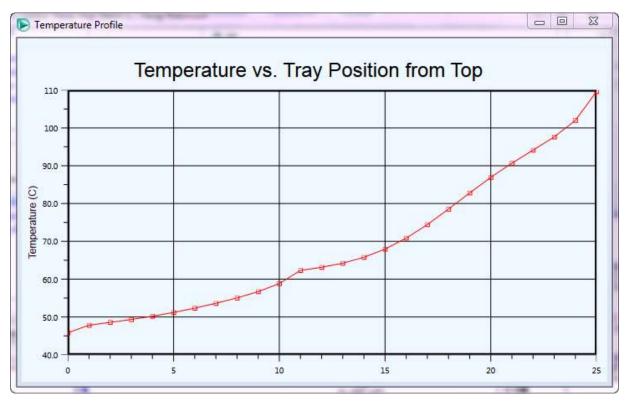
page (for any column)



Design	Parameter	s Side Ops	Rating Works	heet Performa	nce Flowshe	et Reactions	Dynamics	
Perfor	mance	Feeds			12		- AD	
Summa				DOD F 1				
CONTRACTOR OF THE OWNER OWNE	Profiles			DC3 Feed				
Feeds /	Products	Flow Rat	e (kgmole/h)	178.18	33			
Plots Cond./Reboiler		Nitrogen	í .	0.00	00			
		CO2		0.00	00			
		Methane		0.00	00			
		Ethane		0.00	57			
		Propane		0.66	56			
		i-Butane		0.12				
		Products -						
		Froducts						
				DC3 Dist	DC3 Btm	E		
		Flow Rat	e (kgmole/h)	120.62	37 57	.5596		
		Nitrogen	1	0.00	0 00	.0000		
		CO2		0.00	0 00	.0000		
		Methane		0.0000 0.0000		.0000		
		Ethane		0.0098 0.0000		.0000		
		Propane		0.9752 0.0200				
		i-Butane		0.01		.3613		
				0.01	38 0			
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esign   1 Perform ummary olumn P	Parameters ance Re Bo	Fluid Pkg: Basis Side Ops Rati	-1 / Peng Robinson ng Worksheet Pe 1.817	rformance Flows	sheet   Reactions	Dynamics	© Mass	© Idea
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esign I Perform ummary olumn P eeds / Pr lots	Parameters ance rofiles oducts poiler C 1	Fluid Pkg: Basis Side Ops Rati flux Ratio ilup Ratio 2 ondenser	-1 / Peng Robinson ng Worksheet Pe 1.817 4.204 Temperature [C] 45.83	rformance Flows Flows © Er Pressure [kPa] 1585	hergy Net Liquid [kgmole/h] 219.135	Dynamics Basis Molar Liq Vol @ Net Vapour [kgmole/h]	© Mass Std Cond Net Feed	C Idea C Act. Net Dr.
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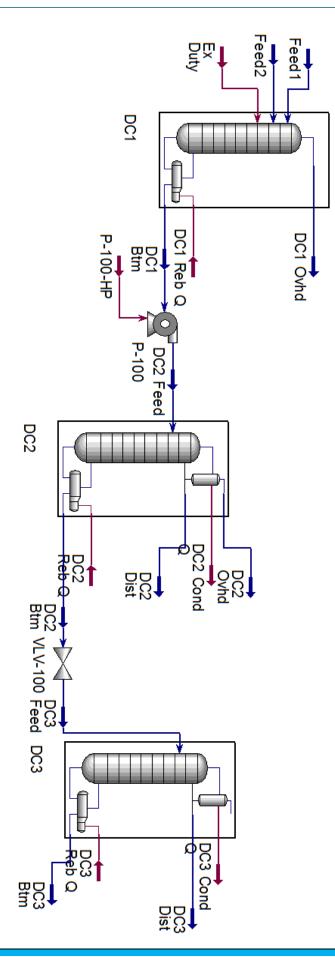






## **Save Your Case!**





220



# Oil Stabilization Optimization



## Workshop

A poor-boy stabilization scheme is used to separate an oil and gas mixture into a stabilized oil and a saleable gas. A simple three-stage separation with heating between each stage is used and the object of the exercise is to select the let-down pressure and temperatures such that the products revenue less the utilities cost is maximized. A special tool in HYSYS, the Optimizer, will be used to find the optimum operating conditions. HYSYS includes additional modelling and decision support tools that can be used to enhance the usability of your models. In this module, you will use the HYSYS optimization tool available in HYSYS to investigate the crude debottlenecking optimization of column. and а

## Learning Objectives

Once you have completed this section, you will be able to:

- Use the Optimizer tool in HYSYS to optimize flowsheets
- Use the Spreadsheet to perform calculations



## **Oil Stabilization**

A feed stream @ 10°C, 4125 kPa with a flowrate of 1 MMSCFD is fed to a heater (duty= $4.25*10^5$  kJ/hr) before entering the first separator where the separated liquid is heated in a second heater (duty= $3.15*10^5$  kJ/hr). The outlet from the heater is then sent to a letdown valve in order to decrease the pressure to 2050 kPa before entering the second separator where the separated liquid is heated through a third heater (duty= $1.13*10^5$  kJ/hr). The outlet from the third heater is then throttled through a valve (outlet pressure = 350 kPa) and then fed to a third separator to obtain the final liquid oil product.

Each gas stream from the  $2^{nd} \& 3^{rd}$  separators is fed to a separate compressor to raise the pressure to 4125 kPa and then mixed (using a mixer) with the gas stream from the  $1^{st}$  separator to get the final gas product stream.

Notes:

Comp	Mol frac	Comp	Mol frac					

Prossure drep across all beaters and congraters a

Comp	Mol frac	Comp	Mol frac
C1	0. 316	n-C5	0.053
C2	0.158	C6	0.027
С3	0.105	С7	0.026
i-C4	0.105	C8	0.026
n-C4	0.105	С9	0.026
i-C5	0.053		

Calculate:

- The total liquid product = ..... barrel/hr
- The total gas product = ..... m<sup>3</sup>\_gas/hr



## **Oil Stabilization Optimization**

In this case, we want to maximize the total operating profit while achieving an RVP of Liquid Product less than 96.5 kPa. The incomes from the Plant are both the Gas and Liquid Products. The operating costs are the Steam Costs for each Heater plus the Power Cost for each Compressor.

Profit = Income - Cost

Profit= (Gas Product + Liquid Product) – (Steam Costs + Compression Cost)

#### Prices & costs:

Oil Price= 15 \$/bbl

Gas Price =0.106 \$/m<sup>3</sup>\_gas

Steam Cost= 0.682 \$/kW-h

Compression Cost=0.1 \$/kW-h

#### The variables to be adjusted:

- Heater duties (for the 3 heaters). Use range of 0 1e6 kJ/hr
- Valves outlet pressures.
  - Use range of 650 3500 kPa for the first valve
  - Use range of 70 1000 kPa for the second valve

Calculate:

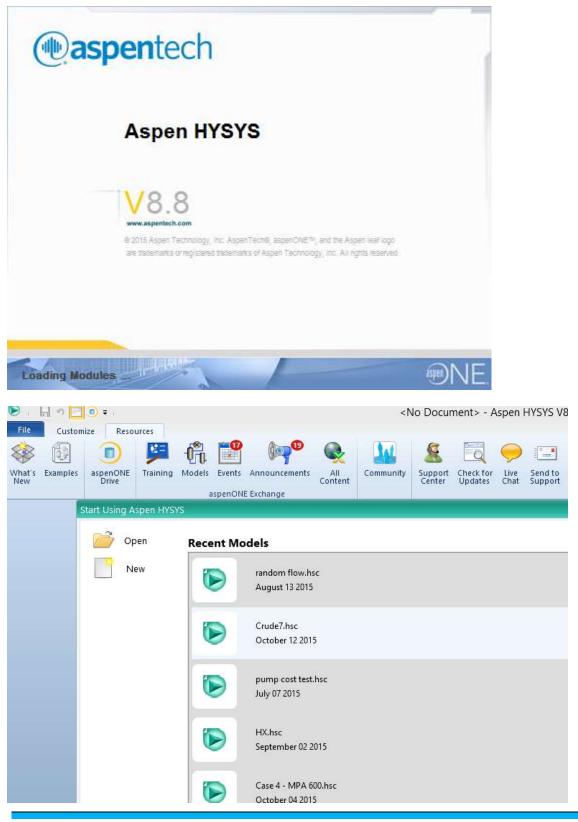
- The optimum values for the adjusted variables
- The maximum profit ..... \$/hr



To start the program, From Start Menu, Select All Programs >>

Aspen Tech >> Process Modeling V8 >>>> Aspen HYSYS >>

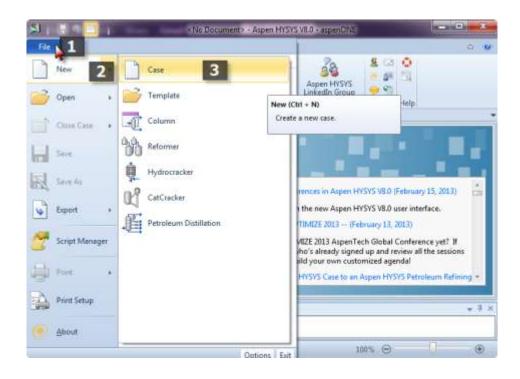
Aspen HYSYS



By: Eng. Ahmed Deyab Fares<br/>Mobile: 002-01227549943- http://www.adeyab.com<br/>- Email: eng.a.deab@gmail.com



#### 10- First, Start a new case



#### 11- Add the Components

M	Untit	led - Aspen HYSYS V8.	0 - aspe	nONE	Course 1	
File Home View C	lustomize Get	Started				a 🔞
Solution     Solution       Copy*     Navigate       Paste     Composition       Clipboard     Composition	Properties Petrole Assa	ys v	Oil *	Aspen Properties Options	PVT Laboratory Measurements PVT Data	
Properties <	Start Page X	Component Lists $\times$	+			-
All Items	<b>1</b> Add	List Name	'Py		Source Delete	
Properties	Import	Exp III Iuid Packages S	ort			, , , , , , , , , , , , , , , , , , ,
				100	%Θ	•

12- Choose the system components from the databank:





tart Page Compone	nt List - 1 × 1+							
arce Databank: HYSYS				Select	Pure Compone	nts •	Filteri	All families
Component	Туре	Group		Search for:	T.		Search by:	Full Name/Synonym
				Simulatio	in Name	Full Name / Sy	nonym	Formula
			< Add		Methane		α	(
			(		Ethane		C2	G
					Propane		CI	G
			Replace	-	i-Butane		i-C4	GB
			weptace		n-Butane		rbrC4	C41
					i-Pentane		+C5	(5)
			Innove		n-Pentane		n+C5	61
			- annos	1	n-Hexane		C6	C6H
					n-Heptane		07	C7H
					n-Octane		C8	CBF
					n-Nonane		C9	C9H
					n-Decane		C10	C10F
					n-C11		C11	Citt
					n-C12		C12	C12H

Now, select the suitable fluid package

劉 日 2 日	Untitled - Aspen HYSYS V	8.0 - aspenONE	
File Home View C	ustomize Get Started		⊘ ⊘
Properties <	Start Page × Fluid Packages ×	+	•
All Items   All Items  Component Lists	Fluid Package	Component List	Property Packag
Component List - 1 Fluid Packages Petroleum Assays			
Component Maps			E
User Properties	2		
□ { □ Simulation	Add	Edit	Сору
69 Energy Analysis	Messages Required Info : Fluid Packages Selev		<b>↓</b> ↓ ×
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In this case, select Peng-Robinson



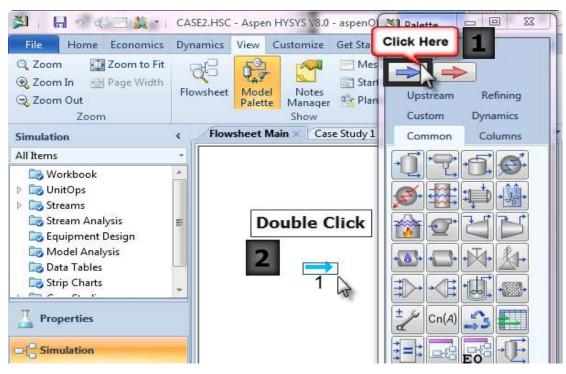
Now you can start drawing the flow sheet for the process by clicking the Simulation button:

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File         Home         Economics         Dynamics         View         Customize         G           Simulation          Start Page ×         Flowsheet Main ×         +		
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Properties Click Here      Messages      Fnergy Analysis		• # ×
Solver (Main) - Ready	(	Ð 🗄

Now add a material stream to define the feed stream composition and conditions



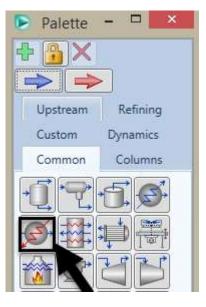
#### From the palette:



>	Material Stream: 1	-	
Worksheet Attachme	ents Dynamics		
Worksheet	Stream Name	1	Va
Conditions	Vapour / Phase Fraction	0.1941	
Properties	Temperature [C]	10.00	
Composition	Pressure [kPa]	4125	
Oil & Gas Feed Petroleum Assay	Molar Flow [kgmole/h]	49.69	
K Value	Mass Flow [kg/h]	2263	
User Variables	Std Ideal Liq Vol Flow [m3/h]	4.428	
Notes	Molar Enthalpy [kJ/kgmole]	-1.285e+005	-8
Cost Parameters	Molar Entropy [kJ/kgmole-C]	115.2	
Normalized Yields	Heat Flow [kJ/h]	-6.383e+006	-7
	Liq Vol Flow @Std Cond [m3/h]	4.513	
	Fluid Package	Basis-1	
	Utility Type		
		<	
Delete	OK Define from Stream	iew Assay	<b>+</b>



Add a heater with a duty of  $4.25 \times 10^5 \text{ kJ/hr}$  and pressure drop of 0.0



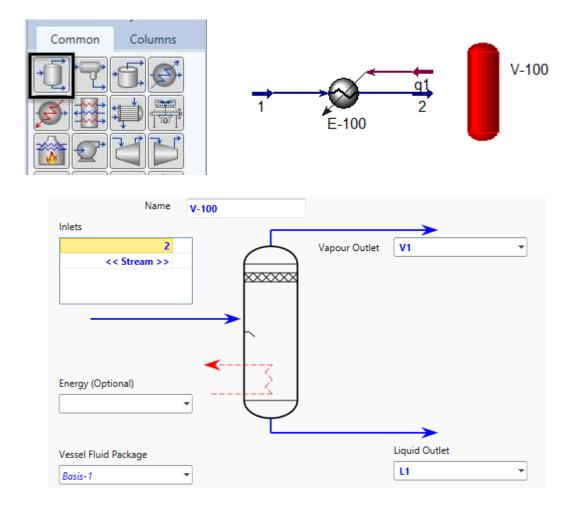
۲		Н	eater: E-100	- 🗆 🗙
Design Rating	Worksheet Perf	formance Dynamics		
Design		Name E-100		
Connections Parameters User Variables Notes	Inlet	-	Energy	
	Fluid Packa Basis-1	ige	Outlet	
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4				





		Heater: E-100	- • ×
Design Rating	Worksheet Performance Dynam	nics	
Design Connections Parameters User Variables Notes	Delta P 0.0000 kPa Delta T 57.89 C	Duty 425000 kJ/h	
Delete		OK	🔲 Ignored

#### Add the first separator





The *liquid* stream is then heated, add a second heater with a pressure

#### drop of 0.0 & duty of 3.15 \* 10<sup>5</sup>

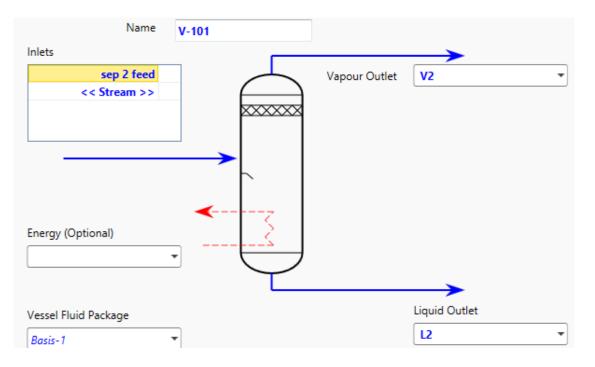
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Des		Delta	Р						
Connec Parame		1 0.00	00 kPa		2				
User Va	ariables	Delta	т			Duty		_	
Notes		56.0	2 C		- 6	315000 I	cJ/h	3	
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				$( \sum )$	) —		$\rightarrow$		
		-		$\sim$					
	Delete					OK			Ignored

#### Add a valve with outlet pressure of 2050 kPa

Worksheet	Name	heat2 out	sep 2 feed
Conditions	Vapour	0.0697	0.2839
Properties	Temperature [C]	90.07	78.17
Composition	Pressure [kPa]	4125	2050
PF Specs	Molar Flow [kgmole/h]	27.84	27.84
	Mass Flow [kg/h]	1649	1649
	Std Ideal Liq Vol Flow [m3/h]	2.889	2.889
	Molar Enthalpy [kJ/kgmole]	-1.410e+005	-1.410e+005
	Molar Entropy [kJ/kgmole-C]	138.3	139.8
	Heat Flow [kJ/h]	-3.925e+006	-3.925e+006
		-3.3236+600	-3.32324000







Add the second separator

The liquid from the second separator is now fed to a third heater with a pressure drop of 0.0 & duty of 1.13 \* 10<sup>5</sup>

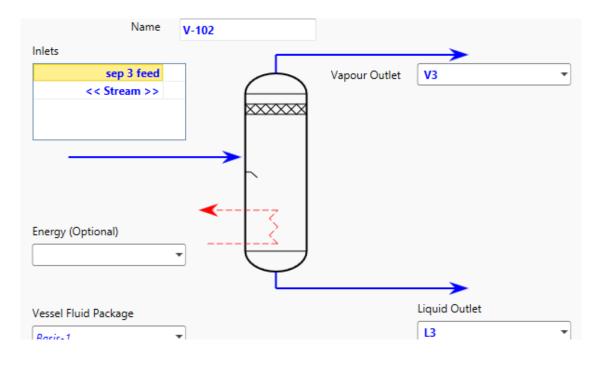
	Heater: E-10	02 – 🗆 🗙
Design Rating Wor Design Connections Parameters User Variables Notes	ksheet Performance Dynam Delta P Delta T 28.03 C	nics
Delete		OK
٠		•



#### Add a second valve with an outlet pressure of 350 kPa

Worksheet	Name	heat 3 out	can 2 fead
Conditions	Vapour	0.1788	sep 3 feed 0.6399
Properties	Temperature [C]	134.7	88.00
Composition	Pressure [kPa]	2050	350.0
PF Specs	Molar Flow [kgmole/h]	14.02	14.02
	Mass Flow [kg/h]	1038	1038
	Std Ideal Liq Vol Flow [m3/h]	1.666	1.666
	Molar Enthalpy [kJ/kgmole]	-1.547e+005	-1.547e+005
	Molar Entropy [kJ/kgmole-C]	164.7	171.0
	Heat Flow [kJ/h]	-2.169e+006	-2.169e+006

#### Add the third separator

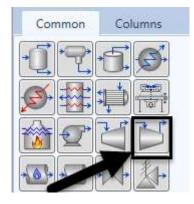




#### The vapor from the second separator is fed to a compressor to raise the

#### pressure to 4125 kPa

#### Add a compressor from the palette



Worksheet	Name	V2	comp 1 out	comp p1
Conditions	Vapour	1.0000	1.0000	<empty></empty>
Properties	Temperature [C]	106.7	145.9	<empty></empty>
Composition	Pressure [kPa]	2050	4125	<empty></empty>
PF Specs	Molar Flow [kgmole/h]	13.82	13.82	<empty></empty>
	Mass Flow [kg/h]	611.4	611.4	<empty></empty>
	LiqVol Flow [m3/h]	1.223	1.223	<empty></empty>
	Molar Enthalpy [kJ/kgmole]	-1.043e+005	-1.019e+005	<empty></empty>
	Molar Entropy [kJ/kgmole-C]	175.2	176.6	<empty></empty>
	Heat Flow [kJ/h]	-1.441e+006	-1.408e+006	3.313e+004

The vapor from the third separator is fed to a second compressor to raise the

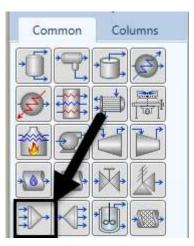
#### pressure to 4125 kPa

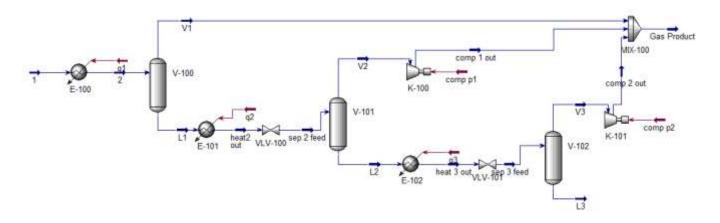
Add a **second** compressor with an outlet pressure of 4125kPa

Design Rating	Worksheet Performance Dynamics	5		
Worksheet	Na	V3	comp 2 out	comp p2
Conditions	Vapour	1.0000	1.0000	<empty></empty>
Properties	Temperature [C]	88.00	191.0	<pre><empty></empty></pre>
Composition	Pressure [kPa]	350.0	4125	<empty></empty>
PF Specs	Molar Flow [kgmole/h]	8.970	8.970	<empty></empty>
	Mass Flow [kg/h]	549.9	549.9	<empty></empty>
	LiqVol Flow [m3/h]	0.9460	0.9460	<empty></empty>
	Molar Enthalpy [kJ/kgmole]	-1.270e+005	-1.183e+005	<empty></empty>
	Molar Entropy [kJ/kgmole-C]	183.1	187.8	<empty></empty>
	Heat Flow [kJ/h]	-1.139e+006	-1.061e+006	7.753e+004



#### The three vapor streams will be mixed using a mixer





The RVP of the Liquid Product stream should be about 96.5 kPa to satisfy the pipeline criterion.

Use **cold properties** analysis to see the current Reid Vapor Pressure for the liquid product from the third separator:

From the attachments tab, select Analysis and then Create:





D	Material St	tream: L3	- 🗆 🗙
Worksheet Attack	iments		
Attachments	Attached Stream Analysis		
Unit Ops			View
Analysis 2			
		3	Create
			Delete
	🕞 Available Stream Ar	nalysis – 🗆 🗙	
	Boiling Point Curves	A	
	CO2 Freeze Out		
	Cold Properties Critical Properties		
	Envelope		
	Hydrate Formation	=	
	Petroleum Assay		
	Pipe Sizing Property Table		
	User Property		
	Add		
	Cold Properties: Co	Id Properties-L3	- • ×
Design Perfor	mance Dynamics		
Design	Name Cold Properties-L3		
Connections			
Notes	Stream L3	Select Stream	
	View Picker		
	Values Options		
	Properties		
	True VP at 37.8 C	121.3846 kPa	
	Reid VP at 37.8 C	97.9741 kPa	

<empty>

<empty>

49.1917

Ignored

1.3833

ASTM D97 Pour Point

Research Octane Num.

Refractive Index

Cetane Index

Delete



#### **Changing the Units**

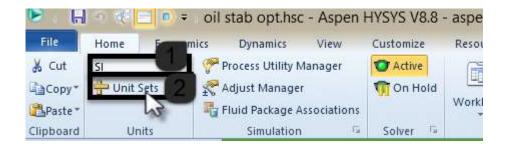
We need to change the default unit set to fit this case

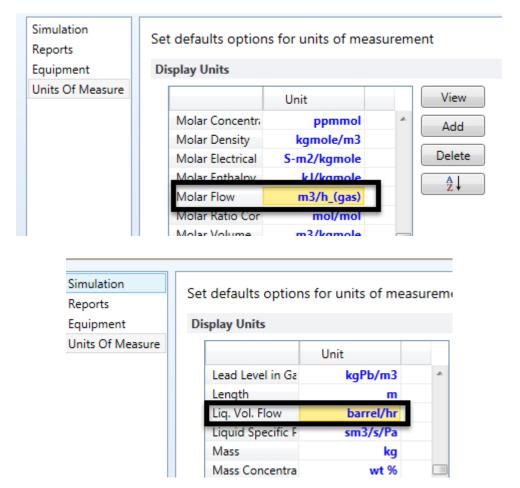
Change the units as follows:

Molar flow: m<sup>3</sup>\_gas/hr

Liq. Vol. Flow: barrel/hr

Std. Vol. Flow: barrel/hr







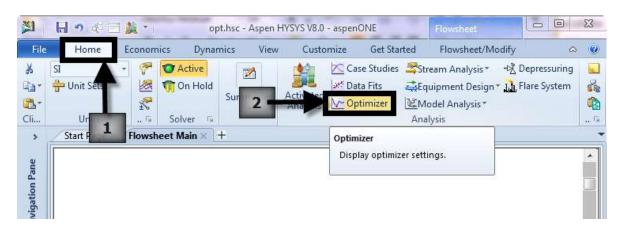
## **Optimization**

HYSYS contains a multi-variable Steady State Optimizer. Once your flowsheet has been built and converged, you can use the Optimizer tool to find the operating conditions which minimize or maximize an Objective Function. The Optimizer owns its own Spreadsheet for defining the Objective Functions as well as any constraint expressions to be used. This allows you to construct Objective Functions which maximize profit, minimize utilities or minimize exchanger UA.

In this case, we want to maximize the total operating profit while achieving an RVP of Liquid Product less than 96.5 kPa. The incomes from the Plant are both the Gas and Liquid Products. The operating costs are the Steam Costs for each Heater plus the Power Cost for each Compressor.

Profit = Income - Cost

Profit= (Gas Product + Liquid Product) – (Steam Costs + Compression Cost)



Use the Optimizer tool:





Optimizer	
Configuration Variables Functions Parameters Monitor	*
Optimizer Configuration	
Data Model	
Original	
O Hyprotech SQP	
MDC Optim	
Selection Optimization	
	E
Online	
Delete SpreadSheet Proceed	
Pibleed	
•	• •

The variables to be optimized in order to maximize the profit should be added now, these variables are:

Optimizer		
Click Here		
Add	Edit Delete	Save Cu
Delete	SpreadSheet	Proceed
•	III	

The 3 Heaters' duties and Valves outlet pressures





Flowsheet	Object	Variable	Variable Specific	OK
Case (Main) Navigator Scope Plowsheet Case	K-101 L1 L2 L3 MIX-100 ProductBlock_Gas Product ProductBlock_I3 q1 q2 q3 sep 2 feed sep 3 feed V1	Heat Flow2 Heat Flow2 Mass Flow Power Power2 User Variables		Object Filter All Streams UnitOps Logicals ColumnOp: Custom Custom.
D Basis D Analysis	V-100 V-101			Disconnect

After adding all the 5 variables, set the upper and lower ranges for each variable as follows:

iguration Varia	bles Functions Parameters	Monitor				
usted (Primary) V	ariables					
Object	Variable Description	Low Bound	Current Value	High Bound	Reset Value	Enable
q1	Heat Flow	0.0000	4.250e+005	1.000e+006	<empty></empty>	V
q2	Heat Flow	0.0000	3.150e+005	1.000e+006	<empty></empty>	V
q3	Heat Flow	0.0000	1.130e+005	1.000e+006	<empty></empty>	V
sep 2 feed	Pressure	650.0	2050	3500	<empty></empty>	$\mathbf{\nabla}$
sep 3 feed	Pressure	70.00	350.0	1000	<empty></empty>	

The Optimizer has its own Spreadsheet for defining the Objective and Constraint functions.

Now we have to start building the profit module using the spreadsheet operation:



				 ſ	Saus Current	Reat Corr
	Add Delete	Edit SpreadS	Del	(	Save Current Proceed	Reset Curr

Connections	Parameters	Formulas	Spreadsheet Calculation	on Order User Variables
			Spreadsheet Name	SPRDSHT-1
_Imported Va	ariables			
Cell	Object	t	Variable Descripti	ion
				Ad
				Del
Exported Va				

Profit= Income - Cost

Profit= (Gas Product + Liquid Product) – (Steam Costs + Compression Cost)

Prices & costs:

Oil Price= 15 \$/bbl

Gas Price =0.106 \$/m<sup>3</sup>\_gas

Steam Cost= 0.682 \$/kW-h

Compression Cost=0.1 \$/kW-h



The RVP spec for the liquid should be added in the spread sheet in order to use it as a constraint.

RVP spec= 96.5 kPa

First we need to increase the number of rows in the spread sheet to be 20 from the parameters tab:

Connection	Parameters	Formulas	Spreadsheet	Calculation Order U
Spreadsh	eet Parameters			Dynamic Execution —
Numbe	r of Columns		4	Before Pressure-Flo
Numbe	r of Rows	2	20	After Pressure-Flow
Units Se	ŧt	Ne	ewUser6	Each Composition S
				Alway Update Expo

Now return to the spreadsheet tab again and add all the profit equation parameters & variables.

	A	В	С	D
1	Heater 1 duty		Steam Cost	
2	Heater 2 duty			
3	Heater 3 duty			
4	Comp 1 power		Compression Cost	
5	Comp 2 power			
6				
7	Oil production		Oil Price	
8	Gas Production		Gas Price	
9				
10	RVP current		RVP Spec	
11				
12			Income	
13			Cost	
14			Profit	
4.5				

After adding the labels, import the variables in each labeled cell:





Spreadsheet: OptimizerSpread									
Connec	tions Parameters	Formulas	Spreadsheet	Calcula	ation Order	User Variables	Notes		
	nt Cell 81 Variable:					Angles in:	•		
	A		В		С	C	)		
1	Heater 1 d	uty Rig	ht Click	1 ect All					
2	Heater 2 d	ıty		Сору		Ctrl+	c		
3	Heater 3 de	uty		Paste		Ctrl+	v		
4	Comp 1 pov	ver							
5	Comp 2 pov	ver		Send To			•		
6				View Asso	ociated Objec	t			
7	Oil product	on		Import V	yiable	2	2		
8	Gas Product	ion		Export Fo	rmula Result				
9				Disconne	ct Import/Exp	ort			
10	RVP curr	ent			RVP Spe	c			
11									

>		Select Import for cell		- 0
Flowsheet	Object	Variable	Variable Specifics	ОК
Case (Main)	ProductBlock_Gas Product ProductBlock_L3 q1 q2 q3 sep 2 feed sep 3 feed V1 V-100 V-101	Heat Flow Heat Flow2 Mass Flow Overall UA Power Power2 Properties Temperature Approach User Variables Utility flow rate		Object Filter All Streams UnitOps Logicals ColumnOps
Navigator Scope Plowsheet Case Basis Analysis	V-102 V2 V3 VLV-100 VLV-101	Utility Fluid Cp		Custom

Add all duties for heaters & compressors the same way as we did in the previous step.



#### Do the same for Oil & gas production flow rates

D		Select Import for cell		- 🗆 🗙
Flowsheet	Object	Variable	Variable Specifics	ОК
Case (Main) Navigator Scope Flowsheet Case Basis Analysis	heat 3 out heat2 out K-100 K-101 L1 L2 L3 MIX-100 ProductBlock_Gas Product ProductBlock_L3 q1 q2 q3 sep 2 feed sep 3 feed V1	Properties Specific Gravity Specific Gravity rel Air Std Gas Flow Std Ideal Lig Mass Density Std Ideal Lig Vol Flow Std Liq Vol Flow Spec Steady State Specs Stock Tank Density Surface Tension Temperature Thermal Conductivity Total Component Mass Flows Total Component Mole Flows		Object Filter
Variable Description:	Std Ideal Liq Vol Flow			Cancel

		Select Import for cell		- 🗆 🗙
Flowsheet	Object	Variable	Variable Specifics	ОК
Case (Main) Navigator Scope Ilowsheet Case Basis Analysis	E-100 E-101 E-102 FeederBlock 1 Gas Product heat 3 out heat2 out K-100 K-101 L1 L2 L3 MIX-100 ProductBlock_Gas Product ProductBlock_L3 q1	Mass Flow Mass Heat Capacity Mass Heat Of Vapourization Mass Higher Heating Value Mass Lower Heating Value Master Comp Mass Flow Master Comp Molar Flow Master Comp Molar Flow Master Comp Volume Flow Master Comp Volume Frac Molar Density Molar Density Molar Enthalpy Molar Entropy Molar Flow Molar Heat Capacity		Object Filter All Streams UnitOps Logicals ColumnOps Custom Custom
Variable Description:	Molar Flow			Cancel

The RVP current value should be imported from the Analysis:





Case	Object	Variable	Variable Specifics	OK
Case Navigator Scope Flowsheet Case Basis Analysis	Cold Properties-L3	Aromatic Mole% ASTM D86 Cut Pt ASTM D97 Pour Pt ASTMD86 Curve Options. Cetane Index Cetane Index Options Flash Point Options Flash Pt Napthene Mole% Paraffin Mole% Refractive Index Reid VP Reid VP Research Octane Number True VP at 100 F User Variables		

#### The Prices should now added manually without importing it

	А	В	с	D
1	Heater 1 duty	118.1 kW	Steam Cost (\$/kW-h)	0.6820
2	Heater 2 duty	87.50 kW		
3	Heater 3 duty	31.39 kW		
4	Comp 1 power	9.203 kW	Compression Cost (\$/kW-h)	0.1000
5	Comp 2 power	21.54 kW		
6				
7	Oil production	4.530 barrel/hr	Oil Price (\$/bbl)	15.00
8	Gas Production	1056 m3/h_(gas)	Gas Price (\$/m3_gas)	0.1060
9				
10	RVP current	97.97 kPa	RVP Spec (kPa)	96.50
11				
12			Income	
13			Cost	
14			Profit	

Calculate the Income, Cost & Profit using the current formulas:

Income: =d7\*b7+d8\*b8

Cost: =(b1+b2+b3)\*d1+(b4+b5)\*d4

Profit: =d12-d13



	A	В	с	D
1	Heater 1 duty	118.1 kW	Steam Cost (\$/kW-h)	0.6820
2	Heater 2 duty	87.50 kW		
3	Heater 3 duty	31.39 kW		
4	Comp 1 power	9.203 kW	Compression Cost (\$/kW-h)	0.1000
5	Comp 2 power	21.54 kW		
6				
7	Oil production	4.530 barrel/hr	Oil Price (\$/bbl)	15.00
8	Gas Production	1056 m3/h_(gas)	Gas Price (\$/m3_gas)	0.1060
9				
10	RVP current	97.97 kPa	RVP Spec (kPa)	96.50
11				
12			Income (\$/hr)	179.9
13			Cost (\$/hr)	164.7 kW
14			Profit (\$/hr)	15.18 kW

After calculating the operating profit @ current conditions, use the optimizer to maximize the profit by changing the 5 variables which we added before

© Optimizer	- 🗆 ×
Configuration Variables Functions Parameters Monitor	
Cell D14 Current Value 15.1840954 OMinimize OMinimize Constraint Functions	
Nur     LHS Cell     Current Value     Cond     RHS Cell     Current Value     Penalty Value       1     B10     97.974     D10     96.500     1.0000       4     5     6     Delete	
Delete SpreadSheet Proceed	Start 7

Open the optimizer and go to Functions tab:



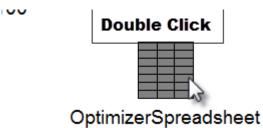
You may need to press the Start button 2 or 3 times to ensure reaching the optimum solution as follows:

>						Optim	izer		
Configu	ration	Variable	s Functions	Parame	ters Monitor				
	ent Valu traint Fu		76.24	D14 68474	<ul><li>Minimize</li><li>Maximize</li></ul>				
	LHS Ce		Current Value 96.474		RHS Cell D10	Current Value 96.500	Penalty Value 1.0000	Add Delete	
	Delete		SpreadSh				ptimum found (Sma		Start

You may see the new values for the variables from the Variables tab:

Configuration Varia	bles Functions Parameters	Monitor		
Adjusted (Primary) V	ariables			
Object	Variable Description	Low Bound	Current Value	High Bound
q1	Heat Flow	0.0000	0.0000	1.000e+006
q2	Heat Flow	0.0000	7406	1.000e+006
q3	Heat Flow	0.0000	5.357e+005	1.000e+006
sep 2 feed	Pressure	650.0	2055	3500
sep 3 feed	Pressure	70.00	70.78	1000

Now you can return back to the spreadsheet to observe the results:





	А	В	С	D
1	Heater 1 duty	0.0000 kW	Steam Cost (\$/kW	0.6820
2	Heater 2 duty	2.057 kW		
3	Heater 3 duty	148.8 kW		
4	Comp 1 power	3.797 kW	Compression Cost	0.1000
5	Comp 2 power	109.4 kW		
6				
7	Oil production	5.403 barrel/hr	Oil Price (\$/bbl)	15.00
8	Gas Production	1032 m3/h_(gas)	Gas Price (\$/m3_g	0.1060
9				
10	RVP current	96.47 kPa	RVP Spec (kPa)	96.50
11				
12			Income (\$/hr)	190.5
13			Cost (\$/hr)	114.2 kW
14			Profit (\$/hr)	76.25 kW

## Save Your Case!



#### Exercise:

One thing you may notice with the Optimized solution is that the Pressure of V3 has been decreased to 70 kPa (10 psia) which is less than atmospheric. This is not a desired condition for the inlet of a compressor. The inlet of the second compressor, cannot be less than 125 kPa (19 psia). What is the maximum profit if you adhere to this guideline?



## You may check the website for more data & courses

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