



UNIVERSIDADE FEDERAL DO RIO DE JANEIRO
ESCOLA DE QUÍMICA



EQE776 Modelagem e Simulação de Processos

Aula 05. Dimensionamento de coluna desbutanizadora em Aspen Hysys

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E-mail: roymel@eq.ufrj.br

Recapitulando

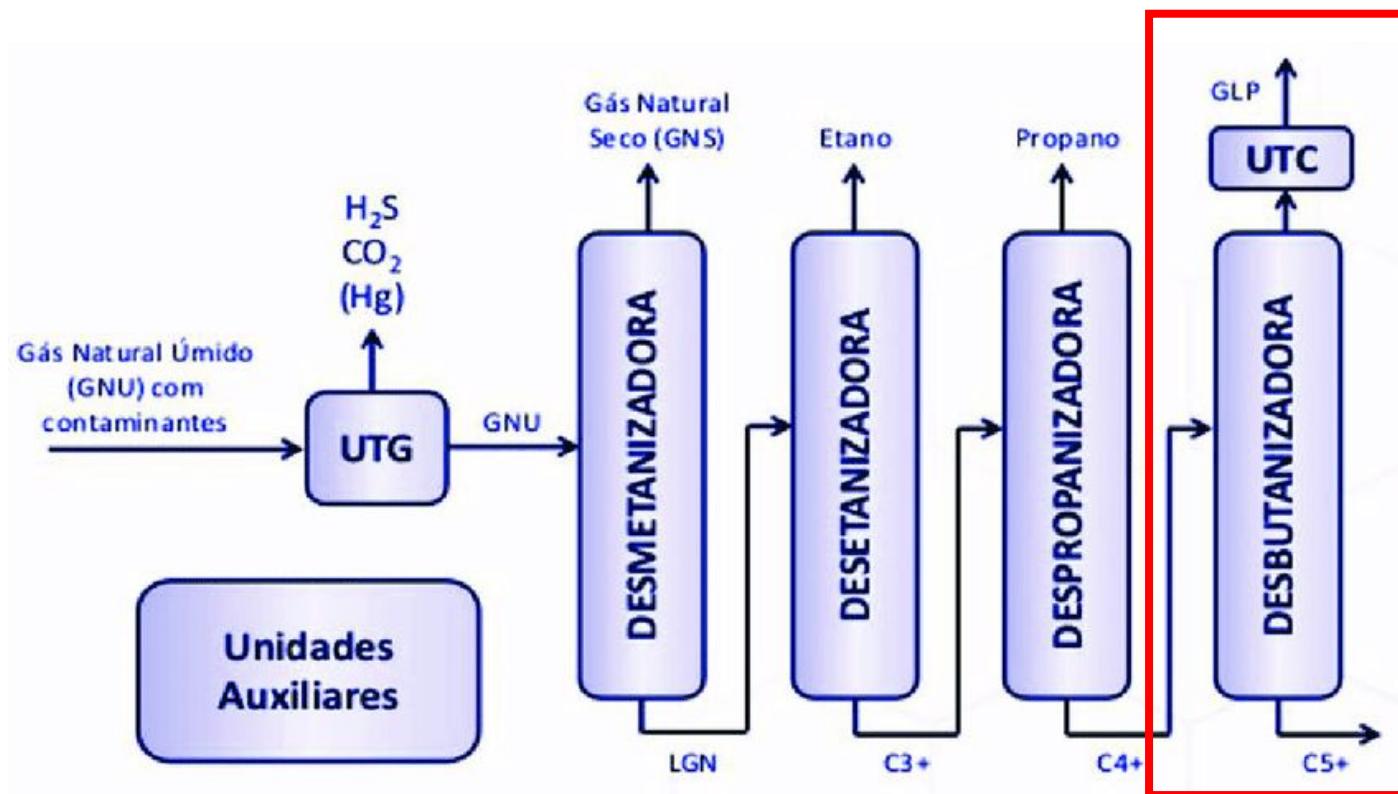
- Modelagem e simulação de reator PFR não isotérmico

Temas da aula

- Dimensionamento de coluna desbutanizadora em Aspen Hysys

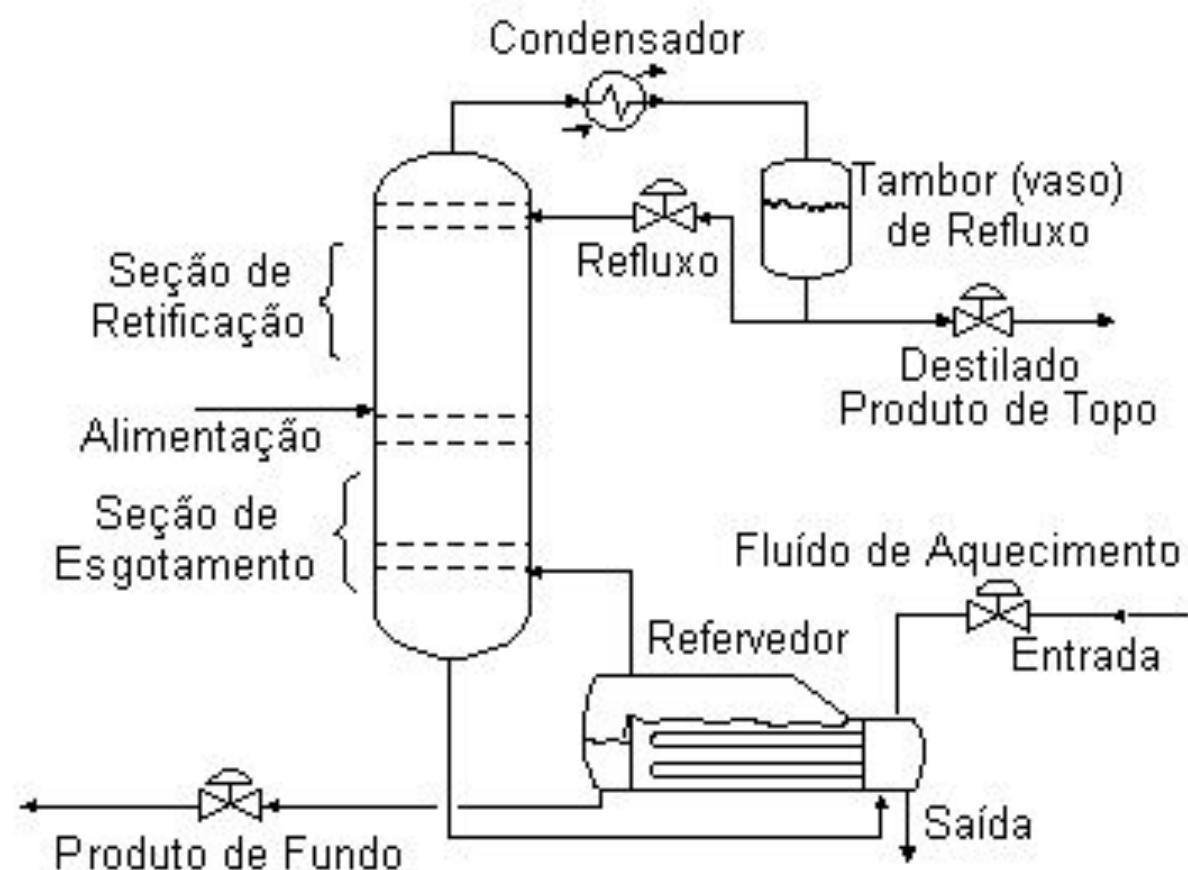
Apresentação do problema

As plantas de processamento de gás natural contam com uma série de colunas de destilação para a separação dos componentes, de modo a obter os diferentes produtos segundo as especificações de qualidade.



Apresentação do problema

A missão da coluna desbutanizadora é separar os componentes C4 e mais leves, que obtidos pela corrente de topo (GLP), do C5 e mais pesados, que são obtidos pela corrente de fundo (gasolina natural).



Apresentação do problema

Condições da correntes de alimentação à coluna:

- Temperatura: 70 °C
- Pressão: 15 bar
- Vazão: 10000 kg/h

Apresentação do problema

Composição da corrente de alimentação à coluna:

- Fração molar C2: 0,080
- Fração molar C3: 0,430
- Fração molar i-C4: 0,100
- Fração molar n-C4: 0,200
- Fração molar i-C5: 0,080
- Fração molar n-C5: 0,070
- Fração molar n-C6: 0,020
- Fração molar n-C7: 0,010
- Fração molar n-C8: 0,005
- Fração molar n-C9: 0,005

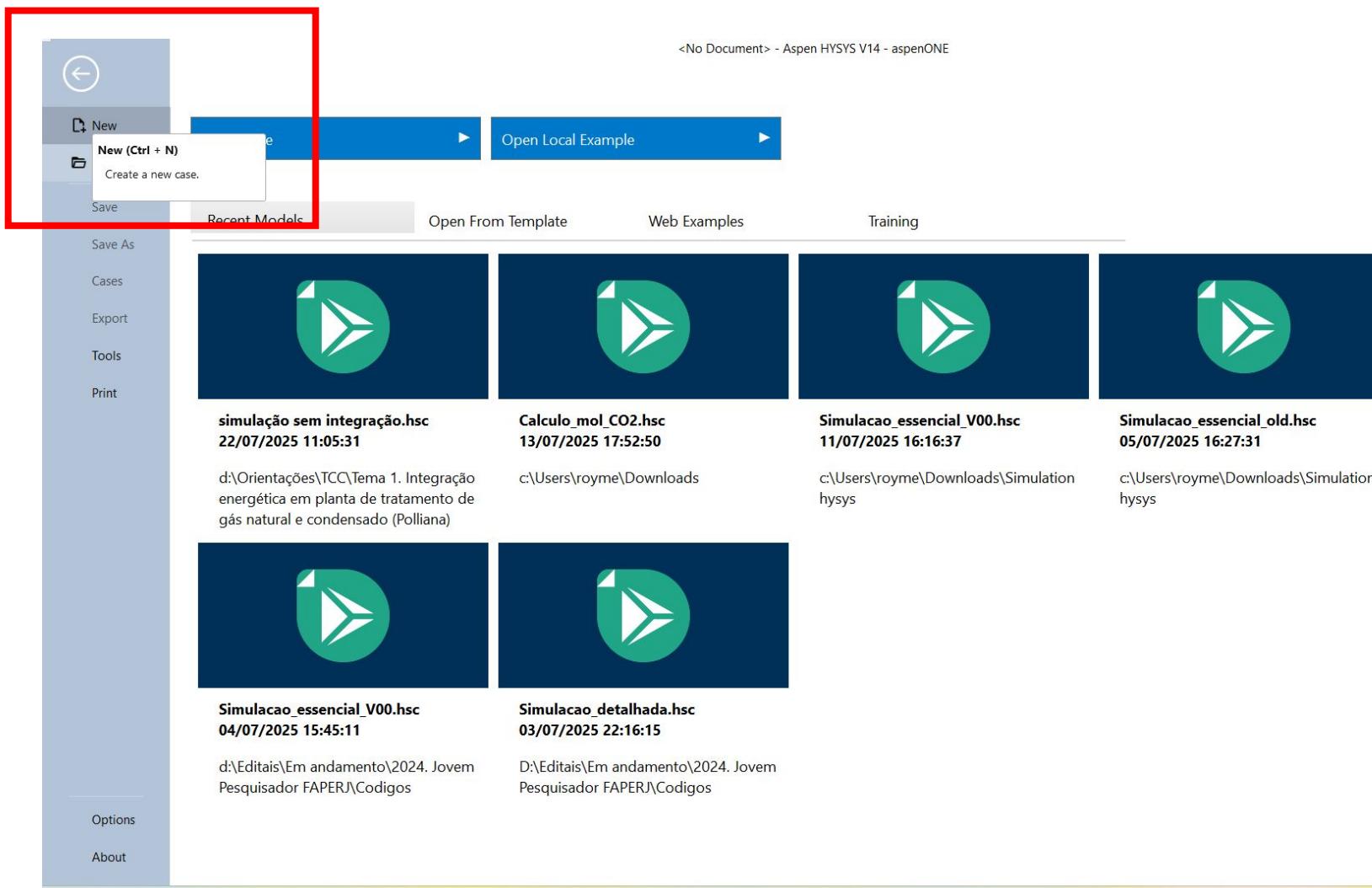
Apresentação do problema

Metas de projeto:

- Condensador total
- C5 no topo \leq 2% molar
- C4 no fundo \leq 2% molar
- Pressão de operação no topo da coluna: 12 bar
- Pressão de operação no fundo da coluna: 12,2 bar
- Eficiência dos pratos 70%
- Internos: pratos de bandeja perfurada (“Sieve”).

Dimensionamento em Hysys

Criar novo caso



Dimensionamento em Hysys

Especificação dos componentes

The screenshot shows the Aspen HYSYS V14 software interface. The main window title is "Untitled - Aspen HYSYS V14 - aspenONE". The toolbar at the top includes standard file operations (File, Home, View, Customize, Resources) and various tools like Methods Assistant, Map Components, Hypotheticals Manager, and Oil Manager.

The left sidebar, titled "Properties", contains a tree view of "Component Lists" (Component List - 1, Fluid Packages, Petroleum Assays, Reactions, Component Maps, User Properties). A red box highlights the "Component List - 1" node under "Component Lists".

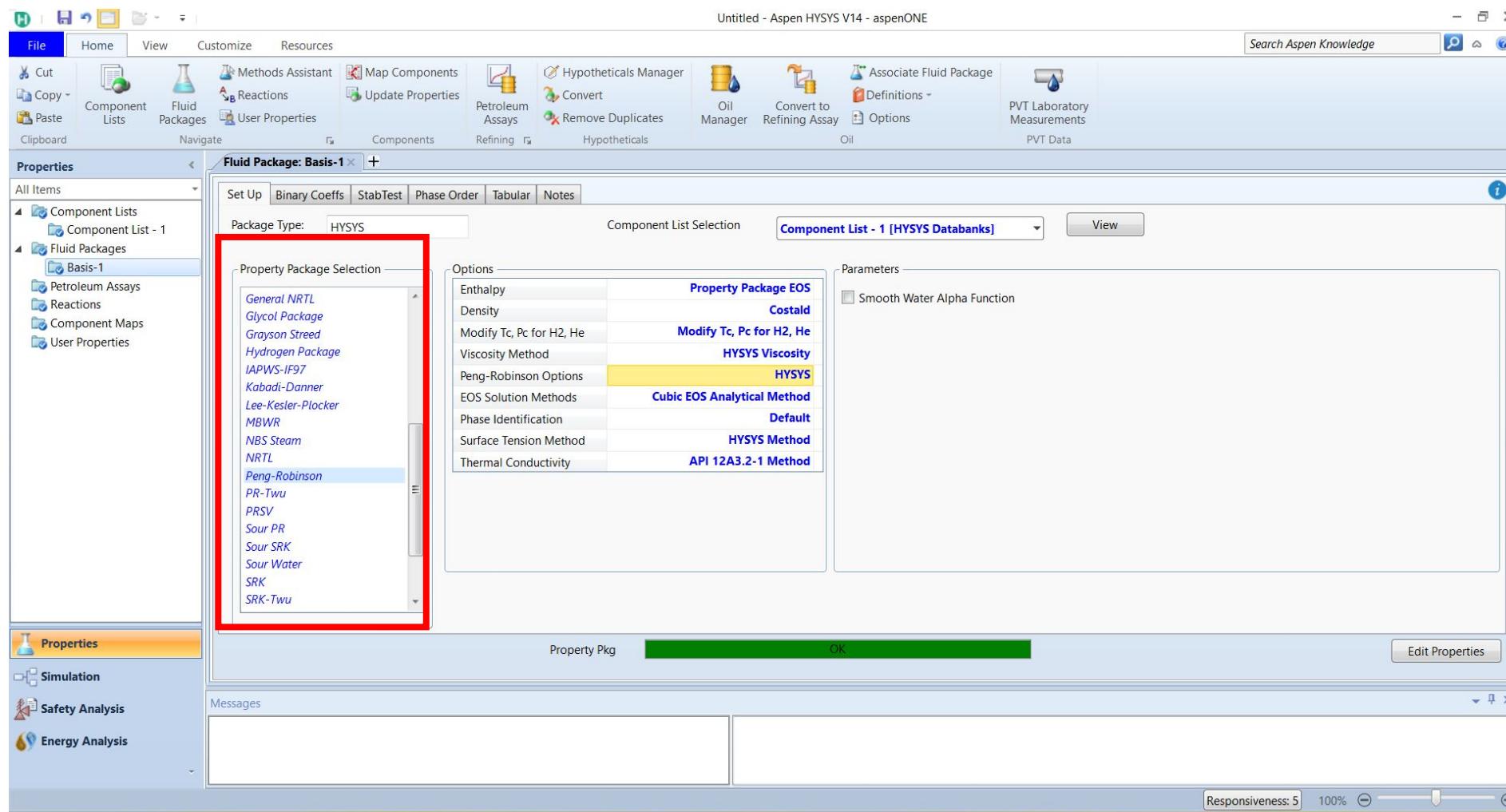
The central workspace is titled "Component List View: Component List - 1 [HYSYS Databanks]". It displays a table of components from the "Source Databank: HYSYS". The table has columns: Component, Type, and Group. The components listed are Ethane, Propane, i-Butane, n-Butane, i-Pentane, n-Pentane, n-Hexane, n-Heptane, n-Octane, and n-Nonane, all categorized as "Pure Component".

On the right side, there is a search interface with dropdowns for "Select: Pure Components", "Filter: Hydrocarbons", and a search bar containing "nonane". Below this is a list of simulation names, full names/synonyms, and formulas, such as n-DotriC32, n-Dotriacontane, C32H66, and n-HexatriC36, n-HexaTriContane, C36H74.

At the bottom, a status bar shows "Status: OK" and a message box says "Required Info : Fluid Packages -- Select property package". The bottom right corner shows "Responsiveness: 5" and "100%".

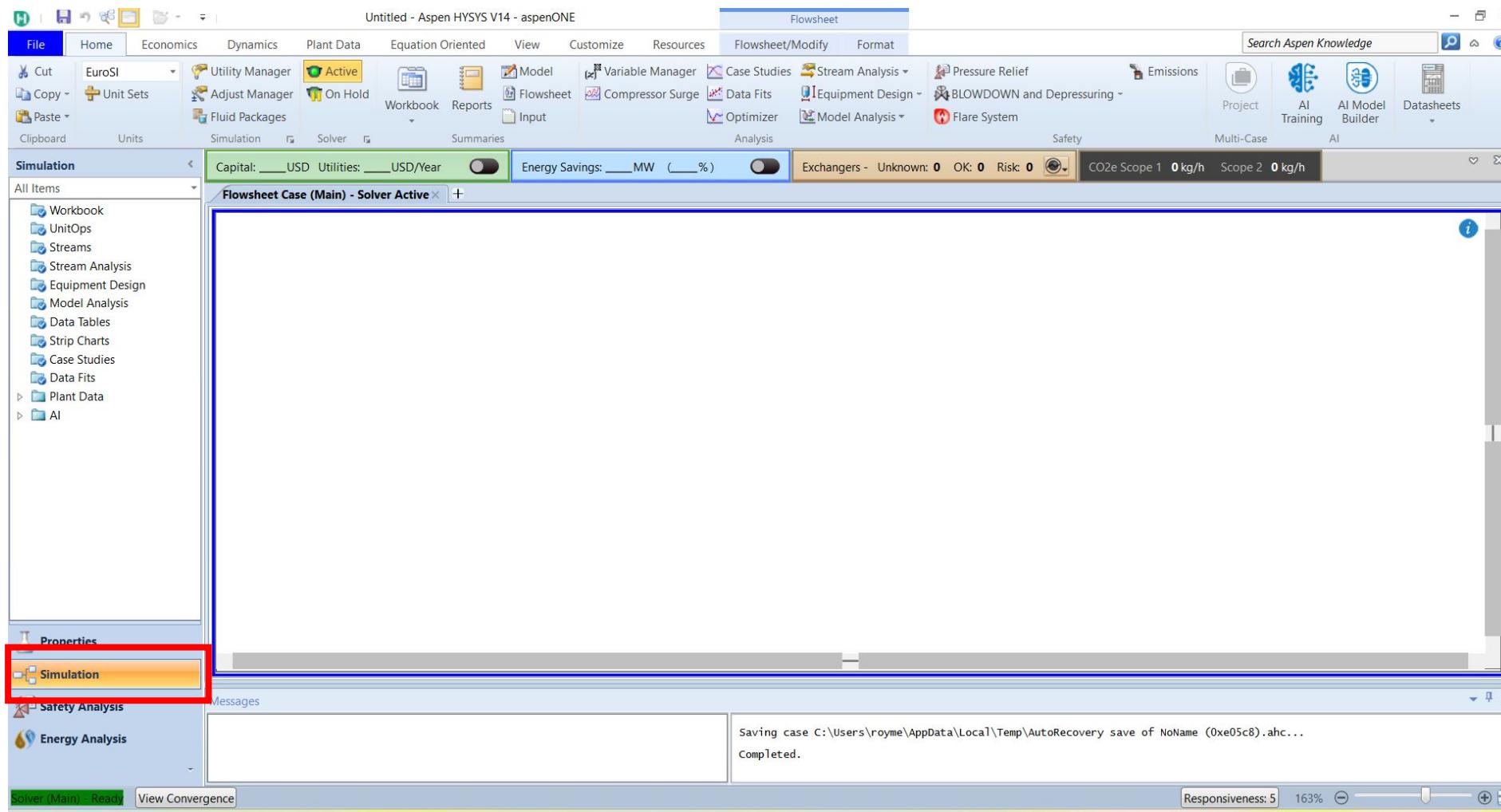
Dimensionamento em Hysys

Especificação do pacote termodinâmico



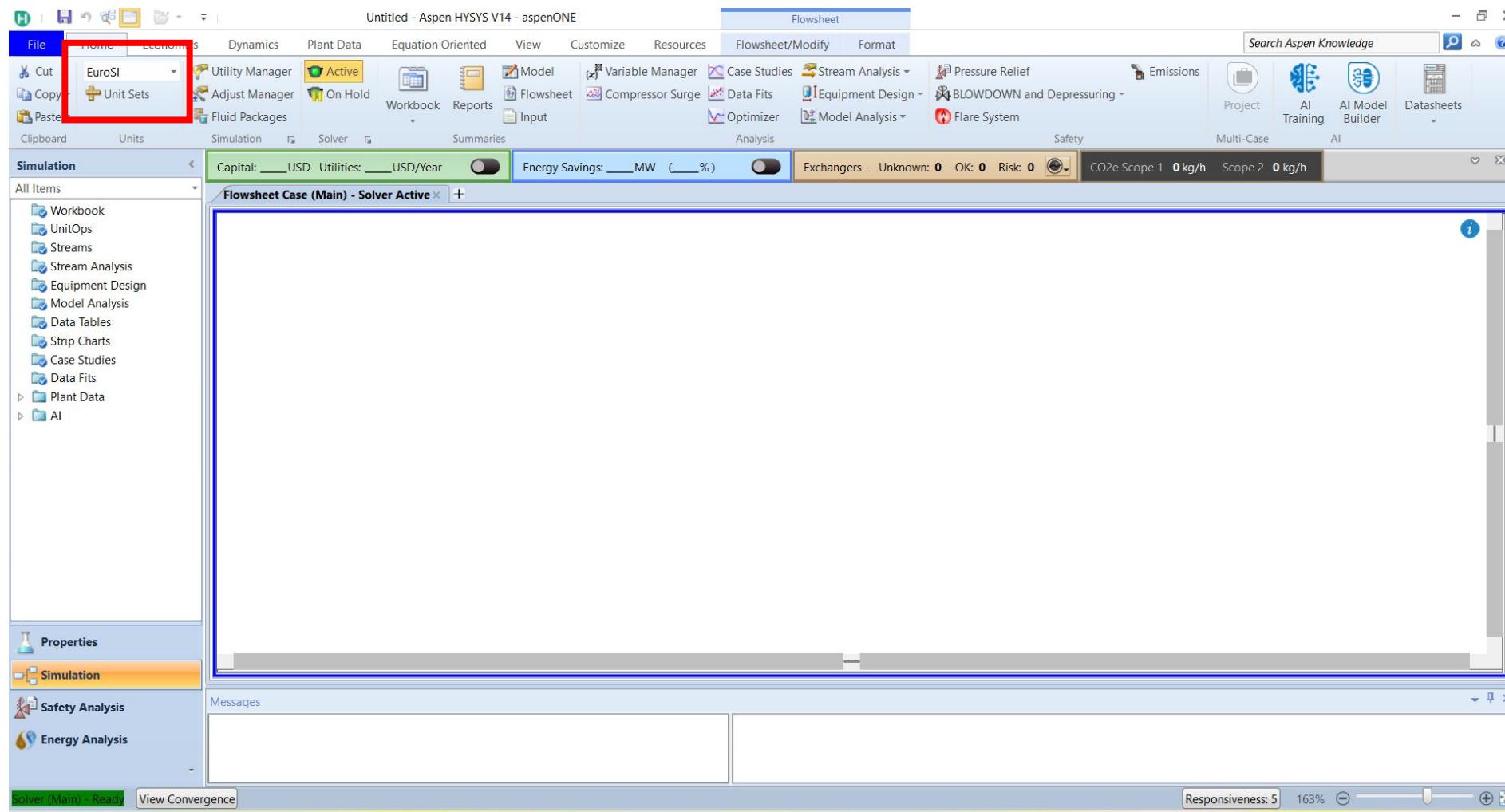
Dimensionamento em Hysys

Passando para o ambiente de simulação



Dimensionamento em Hysys

Especificação do sistema de unidades EusoSI



Dimensionamento em Hysys

Corrente de alimentação

Material Stream: Feed

Worksheet Attachments Dynamics

Worksheet	
Conditions	Stream Name
Properties	Vapour / Phase Fraction
Composition	Temperature [C]
Oil & Gas Feed	Pressure [bar]
Petroleum Assay	Molar Flow [kgmole/h]
K Value	Mass Flow [kg/h]
User Variables	Std Ideal Liq Vol Flow [m ³ /h]
Notes	Molar Enthalpy [kcal/kgmole]
Cost Parameters	Molar Entropy [kJ/kgmole-C]
Normalized Yields	Heat Flow [kcal/h]
Emissions	Liq Vol Flow @Std Cond [m ³ /h]
	Fluid Package

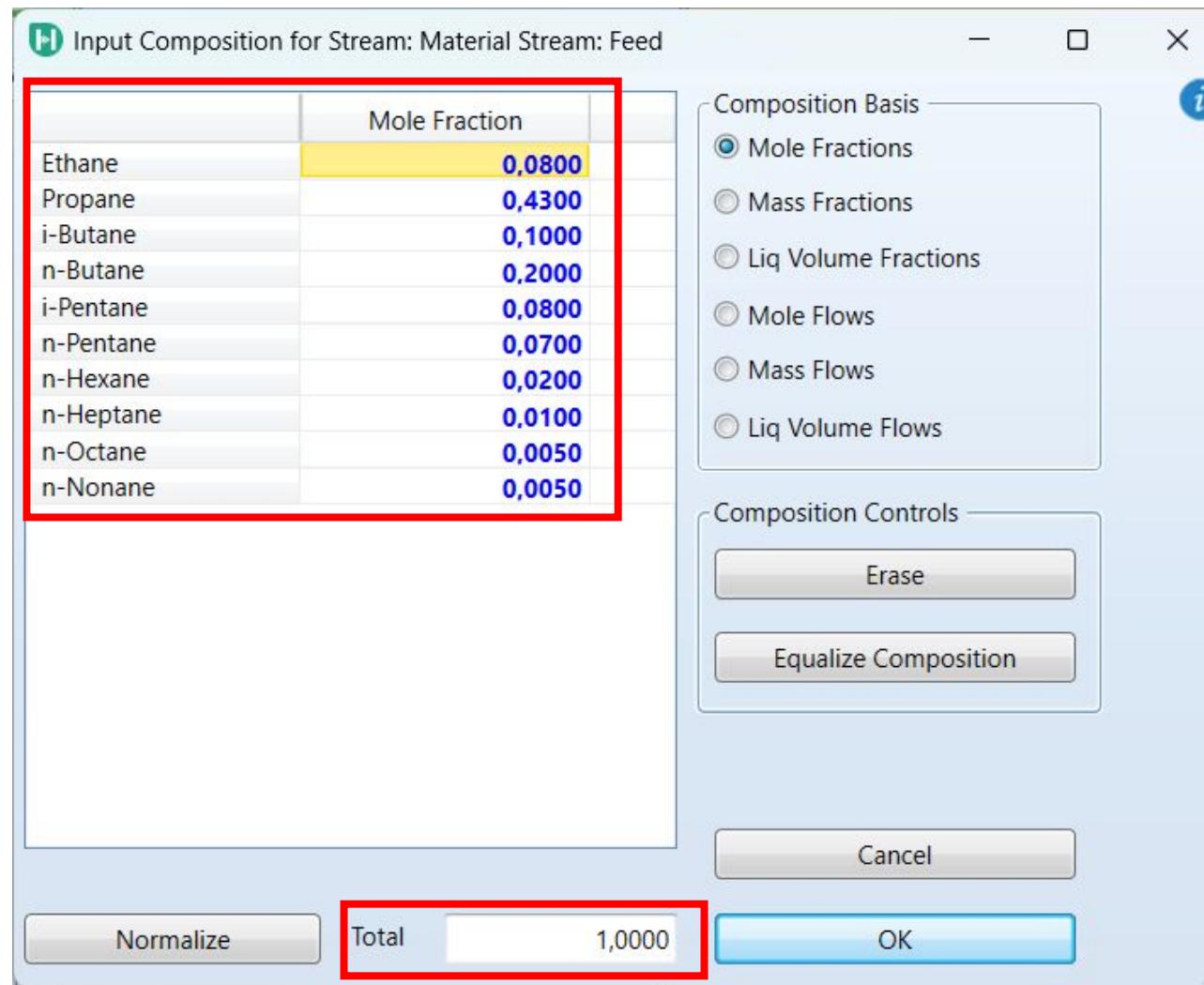
Unknown Compositions

Delete Define from Stream... View Assay ← →

The screenshot shows the 'Material Stream' dialog for a stream named 'Feed'. The 'Worksheet' tab is selected. The stream name is set to 'Feed'. The temperature is listed as '70,00' and the pressure as '15,00'. The mass flow is specified as '1,000e+004' kg/h. The fluid package is set to 'Basis-1'. The dialog also includes tabs for 'Attachments' and 'Dynamics', and a sidebar with various properties like Conditions, Properties, Composition, etc.

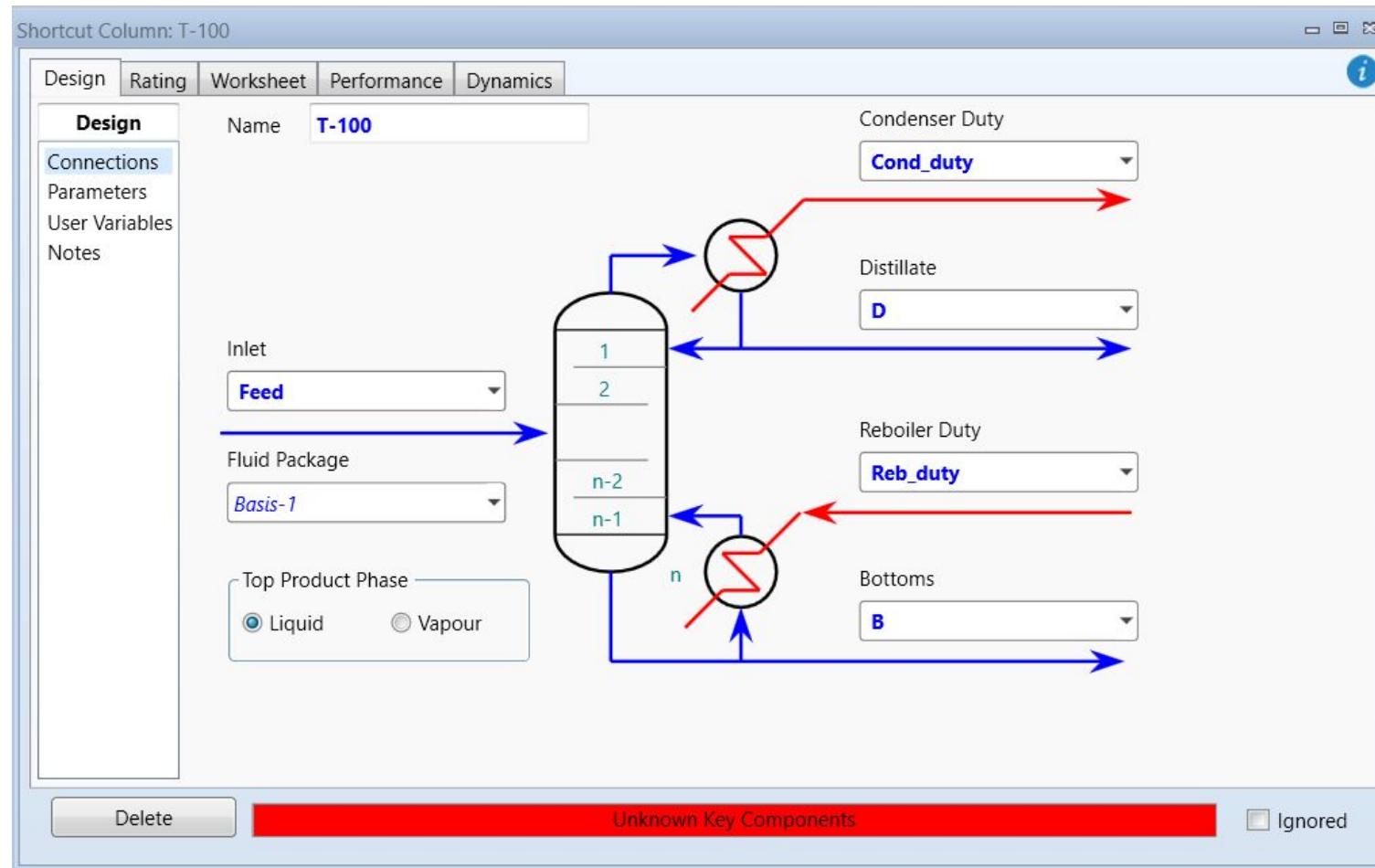
Dimensionamento em Hysys

Corrente de alimentação



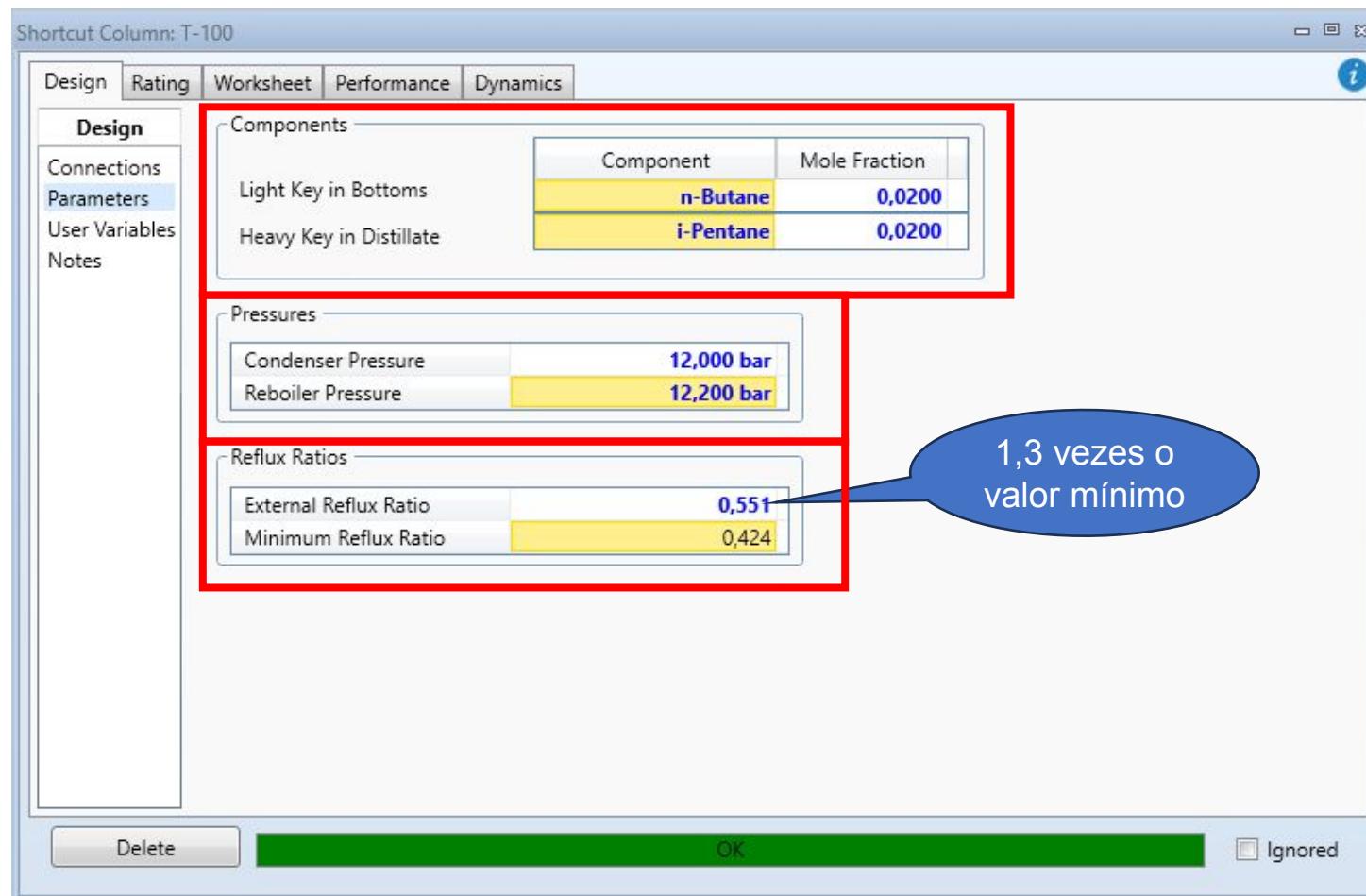
Dimensionamento em Hysys

Para um dimensionamento preliminar será utilizada uma coluna simplificada (“Shortcut Column”).



Dimensionamento em Hysys

Especificando os parâmetros



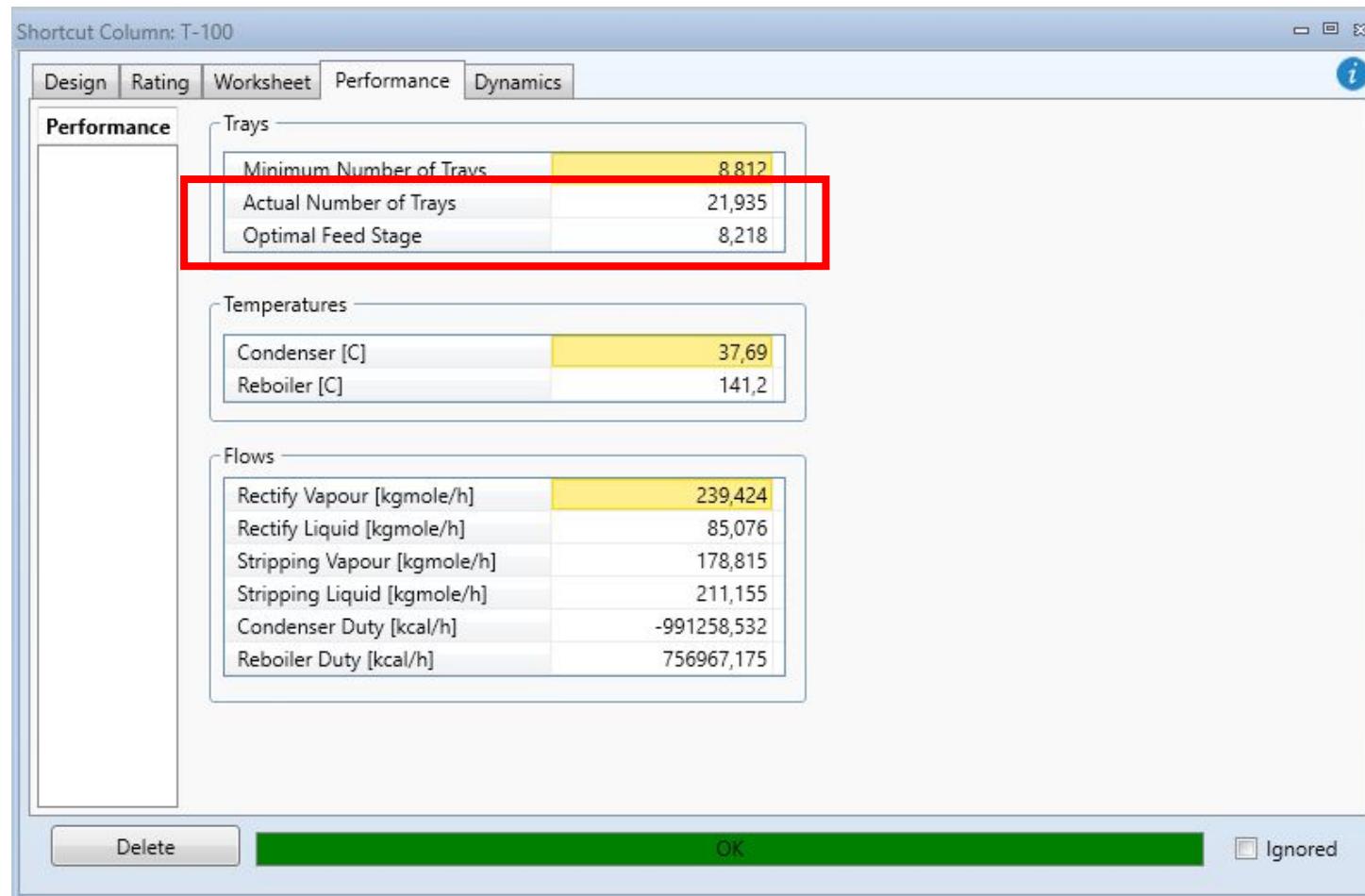
Dimensionamento em Hysys

Resultados do dimensionamento preliminar

Shortcut Column: T-100					
	Design	Rating	Worksheet	Performance	Dynamics
Worksheet	Name	Feed		D	B
	Vapour		0,3247	0,0000	0,0000
	Temperature [C]		70,00	37,69	141,2
	Pressure [bar]		15,00	12,00	12,20
	Molar Flow [kgmole/h]		186,7	154,3	32,34
	Mass Flow [kg/h]		1,000e+004	7480	2520
	Std Ideal Liq Vol Flow [m3/h]		18,20	14,27	3,929
	Molar Enthalpy [kcal/kgmole]		-3,080e+004	-3,064e+004	-3,880e+004
	Molar Entropy [kJ/kgmole-C]		125,7	98,44	141,3
	Heat Flow [kcal/h]		-5,750e+006	-4,730e+006	-1,255e+006
Conditions	Name	Cond_duty		D	B
	Vapour		<empty>		
	Temperature [C]		<empty>		
	Pressure [bar]		<empty>		
	Molar Flow [kgmole/h]		<empty>		
	Mass Flow [kg/h]		<empty>		
	Std Ideal Liq Vol Flow [m3/h]		<empty>		
	Molar Enthalpy [kcal/kgmole]		<empty>		
	Molar Entropy [kJ/kgmole-C]		<empty>		
	Heat Flow [kcal/h]		-9,913e+005		
Properties	Name	Feed		D	B
	Vapour		0,3247	0,0000	0,0000
	Temperature [C]		70,00	37,69	141,2
	Pressure [bar]		15,00	12,00	12,20
	Molar Flow [kgmole/h]		186,7	154,3	32,34
	Mass Flow [kg/h]		1,000e+004	7480	2520
	Std Ideal Liq Vol Flow [m3/h]		18,20	14,27	3,929
	Molar Enthalpy [kcal/kgmole]		-3,080e+004	-3,064e+004	-3,880e+004
	Molar Entropy [kJ/kgmole-C]		125,7	98,44	141,3
	Heat Flow [kcal/h]		-5,750e+006	-4,730e+006	-1,255e+006
Composition	Name	Cond_duty		D	B
	Vapour		<empty>		
	Temperature [C]		<empty>		
	Pressure [bar]		<empty>		
	Molar Flow [kgmole/h]		<empty>		
	Mass Flow [kg/h]		<empty>		
	Std Ideal Liq Vol Flow [m3/h]		<empty>		
	Molar Enthalpy [kcal/kgmole]		<empty>		
	Molar Entropy [kJ/kgmole-C]		<empty>		
	Heat Flow [kcal/h]		-9,913e+005		

Dimensionamento em Hysys

Resultados do dimensionamento preliminar



Dimensionamento em Hysys

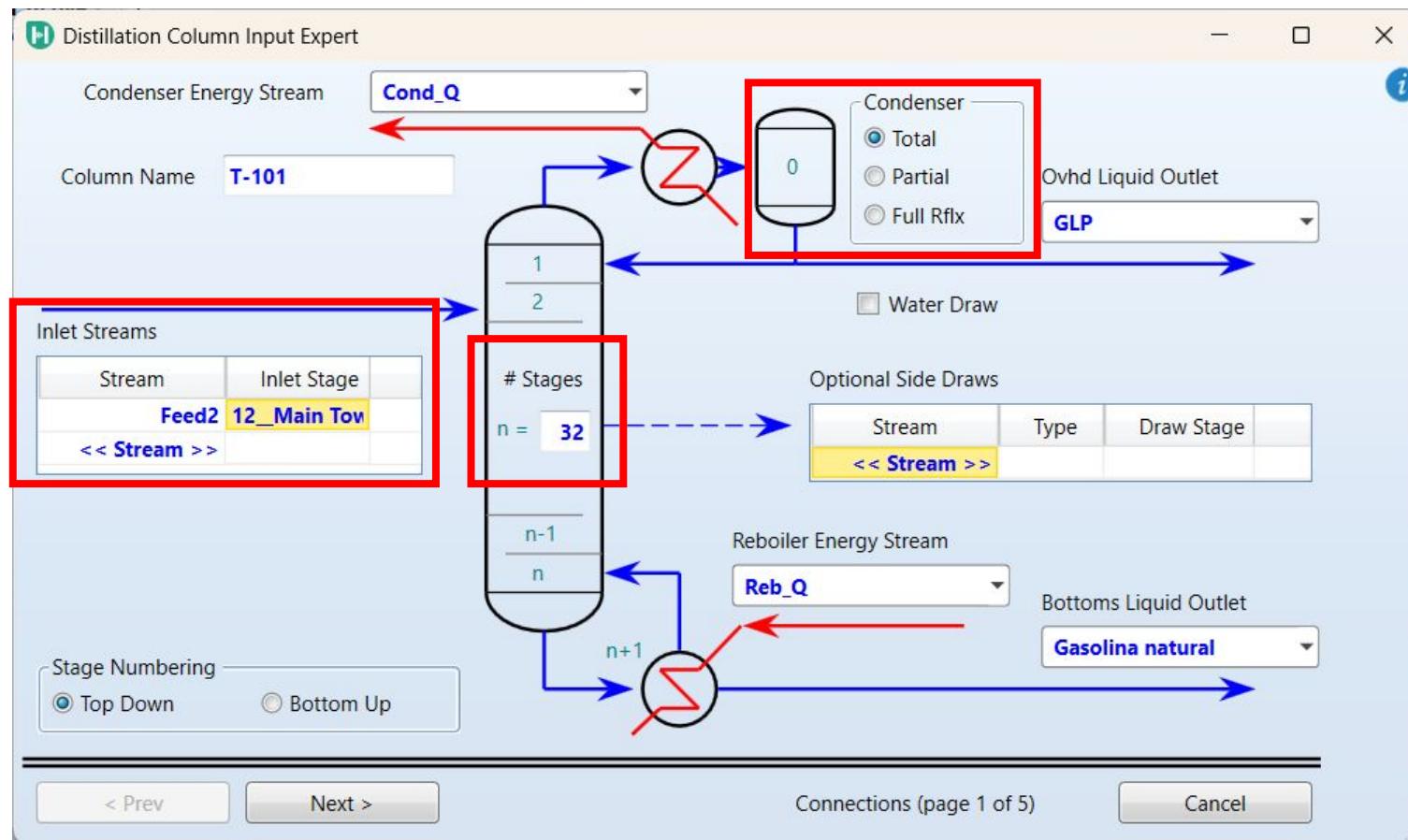
Levando a pratos reais usando a eficiência

$$NumEstagios_{reais} = \frac{NumEstagios_{teoricos}}{ef} = \frac{21,935}{0,7} = 31,33 \approx 32$$

$$PratoAlim_{real} = \frac{PratoAlim_{teorico}}{ef} = \frac{8,218}{0,7} = 11,74 \approx 12$$

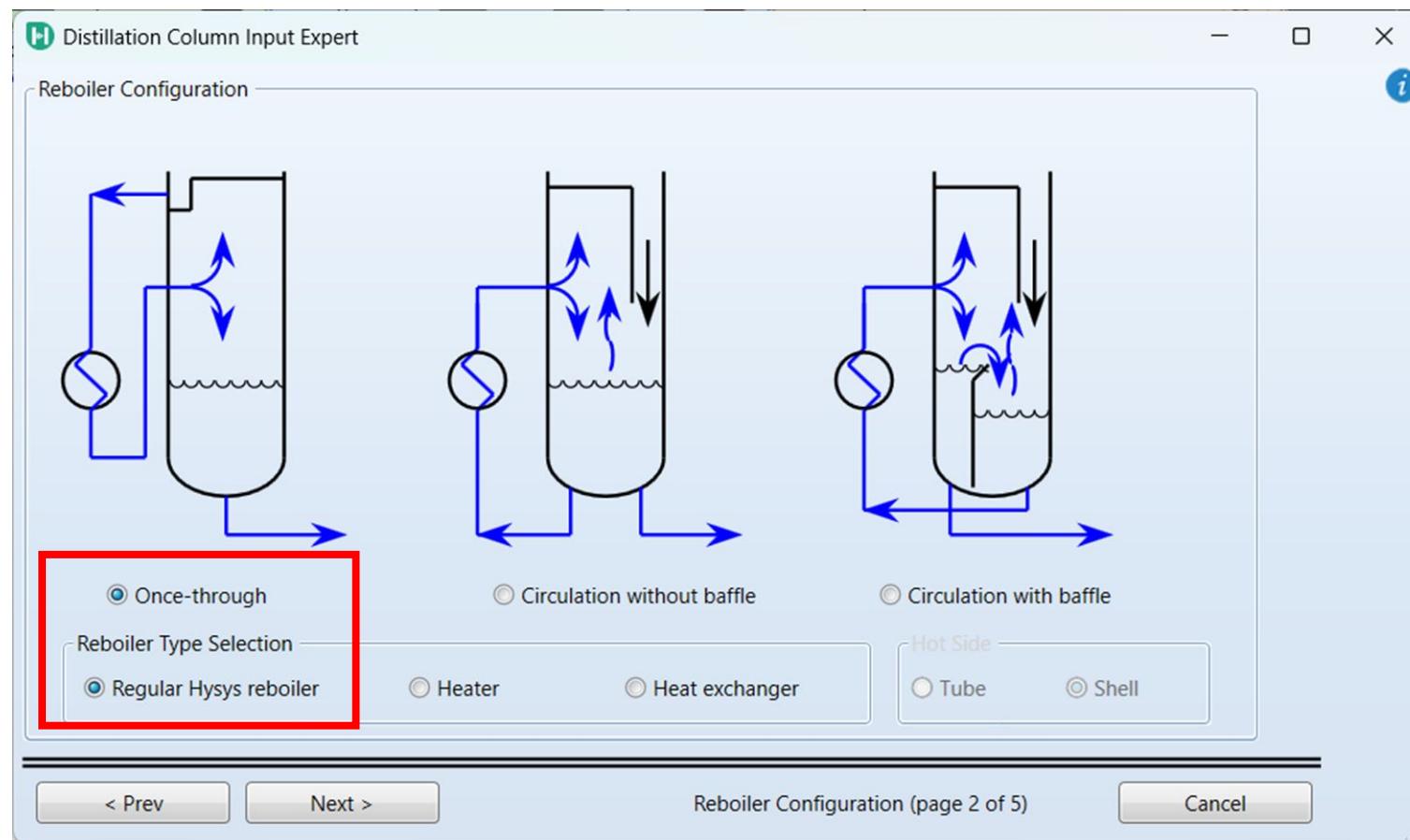
Dimensionamento em Hysys

Utilizando agora a coluna rigorosa (Distillation Column)



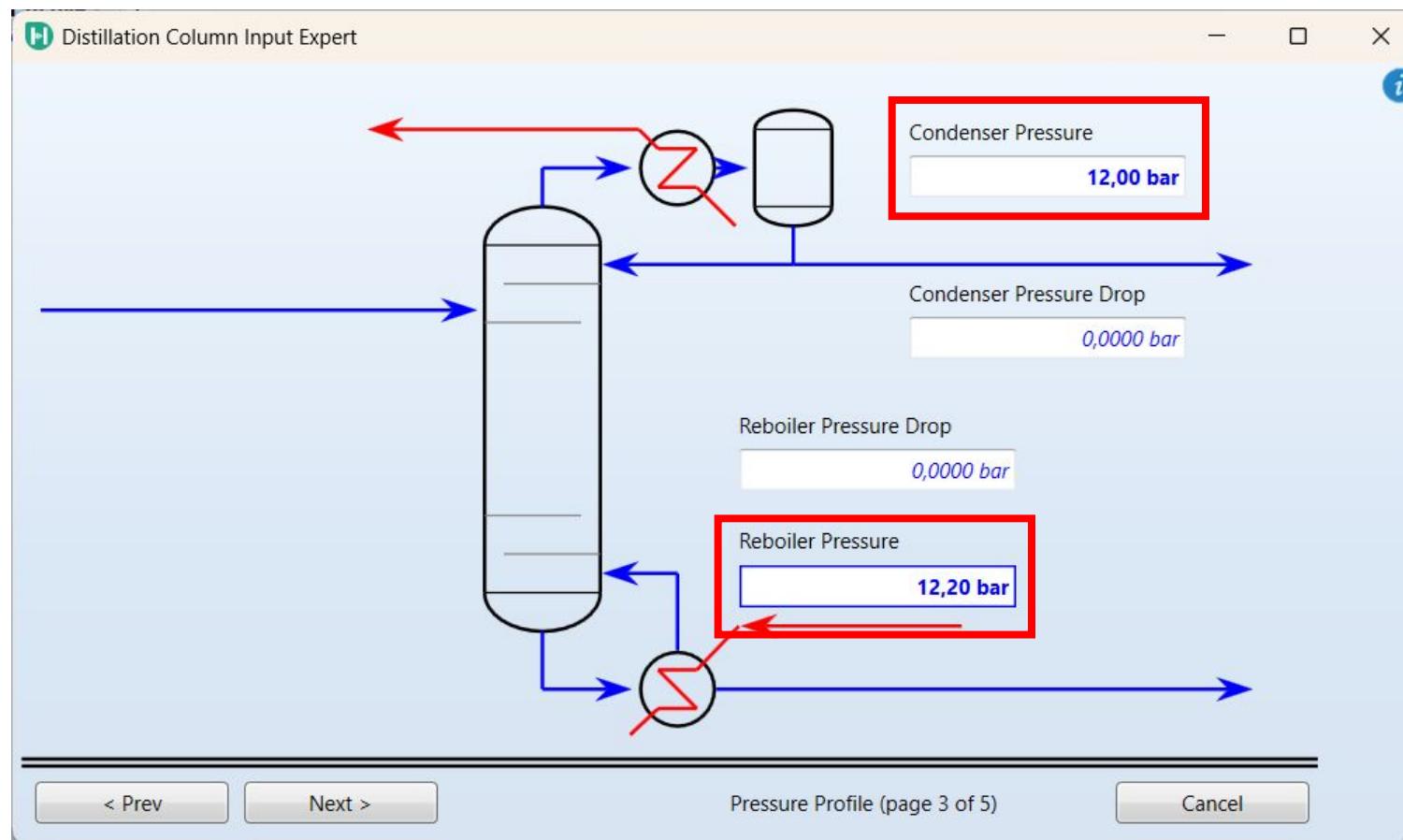
Dimensionamento em Hysys

Especificando a configuração do revedor



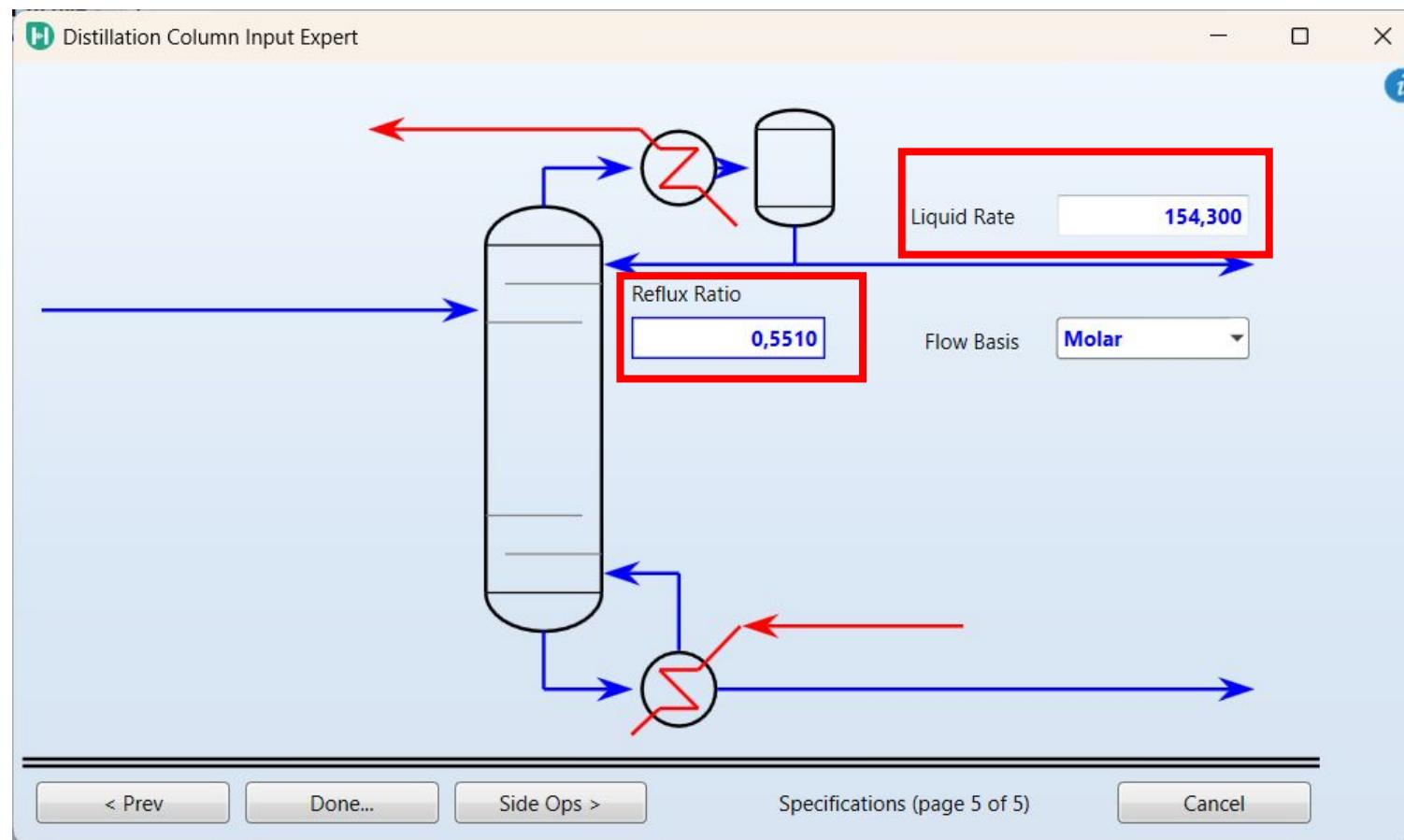
Dimensionamento em Hysys

Especificando as pressões



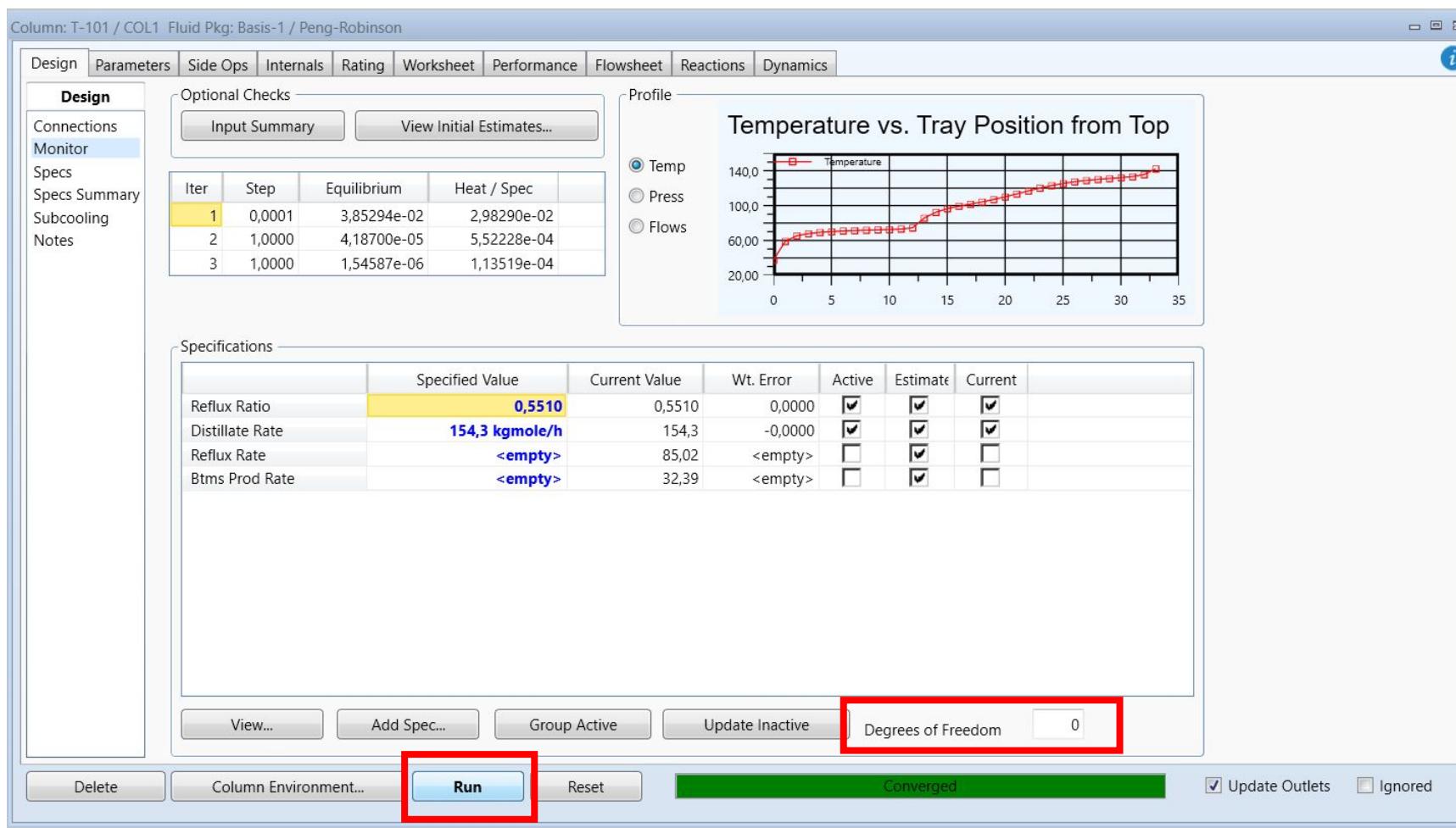
Dimensionamento em Hysys

Especificando a razão de refluxo e a vazão de destilado (valores tomados do dimensionamento preliminar)



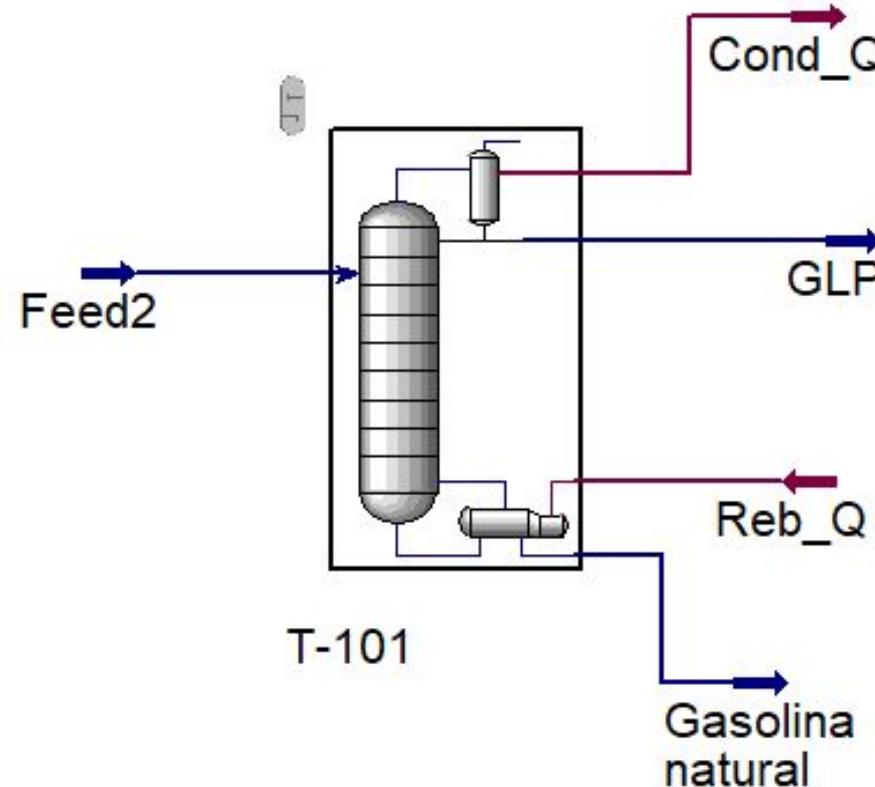
Dimensionamento em Hysys

Conferir que os graus de liberdade estão zerados e clicar em “Run” para convergir a coluna.



Dimensionamento em Hysys

Coluna convergida



Dimensionamento em Hysys

Colocando a eficiência dos pratos

Column: T-101 / COL1 Fluid Pkg: Basis-1 / Peng-Robinson

Design Parameters Side Ops Internals Rating Worksheet Performance Flowsheet Reactions Dynamics

Parameters

Profiles Estimates Efficiencies Solver 2/3 Phase Fluid Pkgs

Stage Efficiencies

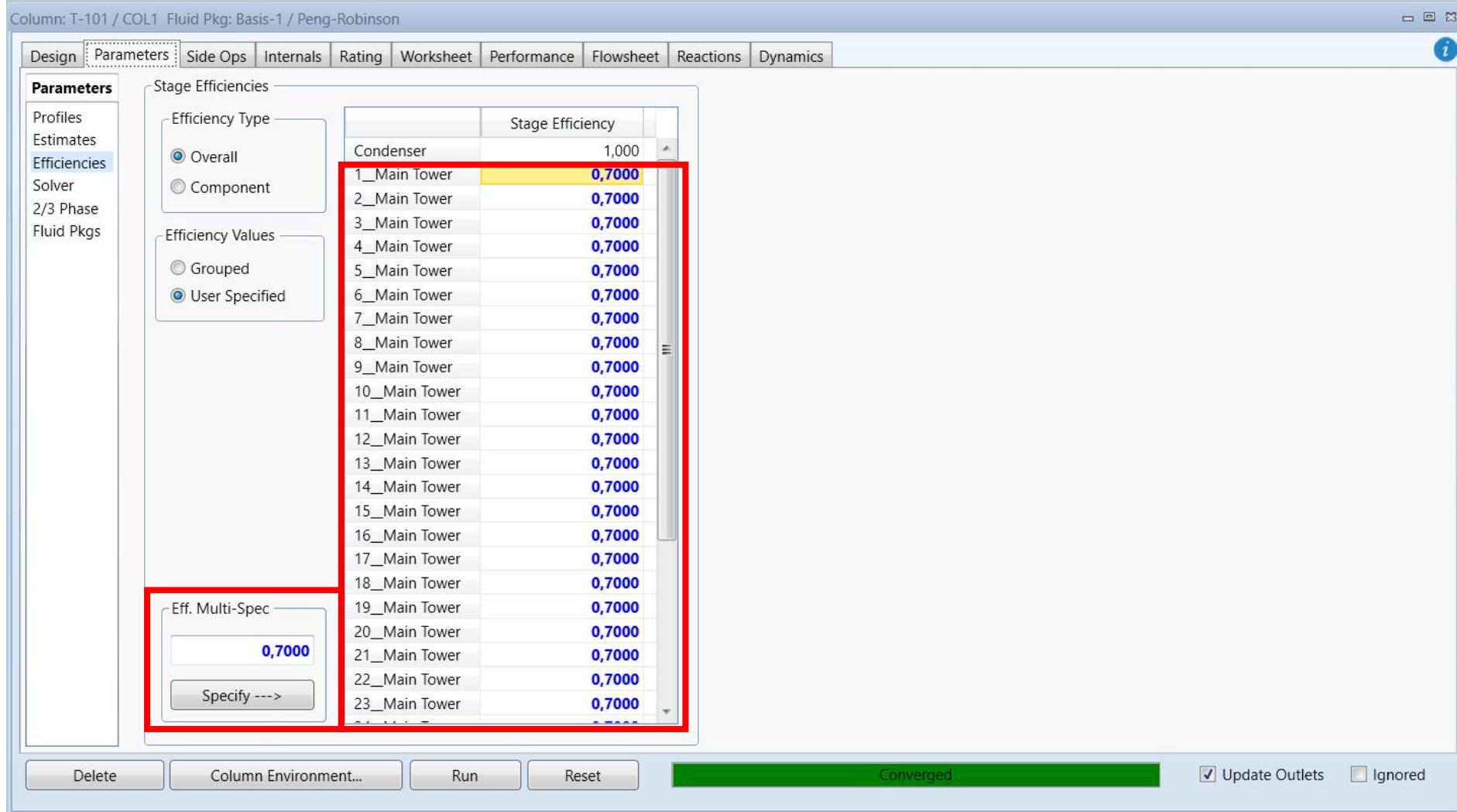
Efficiency Type
 Overall
 Component

Efficiency Values
 Grouped
 User Specified

Eff. Multi-Spec
0,7000
Specify -->

	Stage Efficiency
Condenser	1,000
1_Main Tower	0,7000
2_Main Tower	0,7000
3_Main Tower	0,7000
4_Main Tower	0,7000
5_Main Tower	0,7000
6_Main Tower	0,7000
7_Main Tower	0,7000
8_Main Tower	0,7000
9_Main Tower	0,7000
10_Main Tower	0,7000
11_Main Tower	0,7000
12_Main Tower	0,7000
13_Main Tower	0,7000
14_Main Tower	0,7000
15_Main Tower	0,7000
16_Main Tower	0,7000
17_Main Tower	0,7000
18_Main Tower	0,7000
19_Main Tower	0,7000
20_Main Tower	0,7000
21_Main Tower	0,7000
22_Main Tower	0,7000
23_Main Tower	0,7000

Delete Column Environment... Run Reset Converged Update Outlets Ignored



Dimensionamento em Hysys

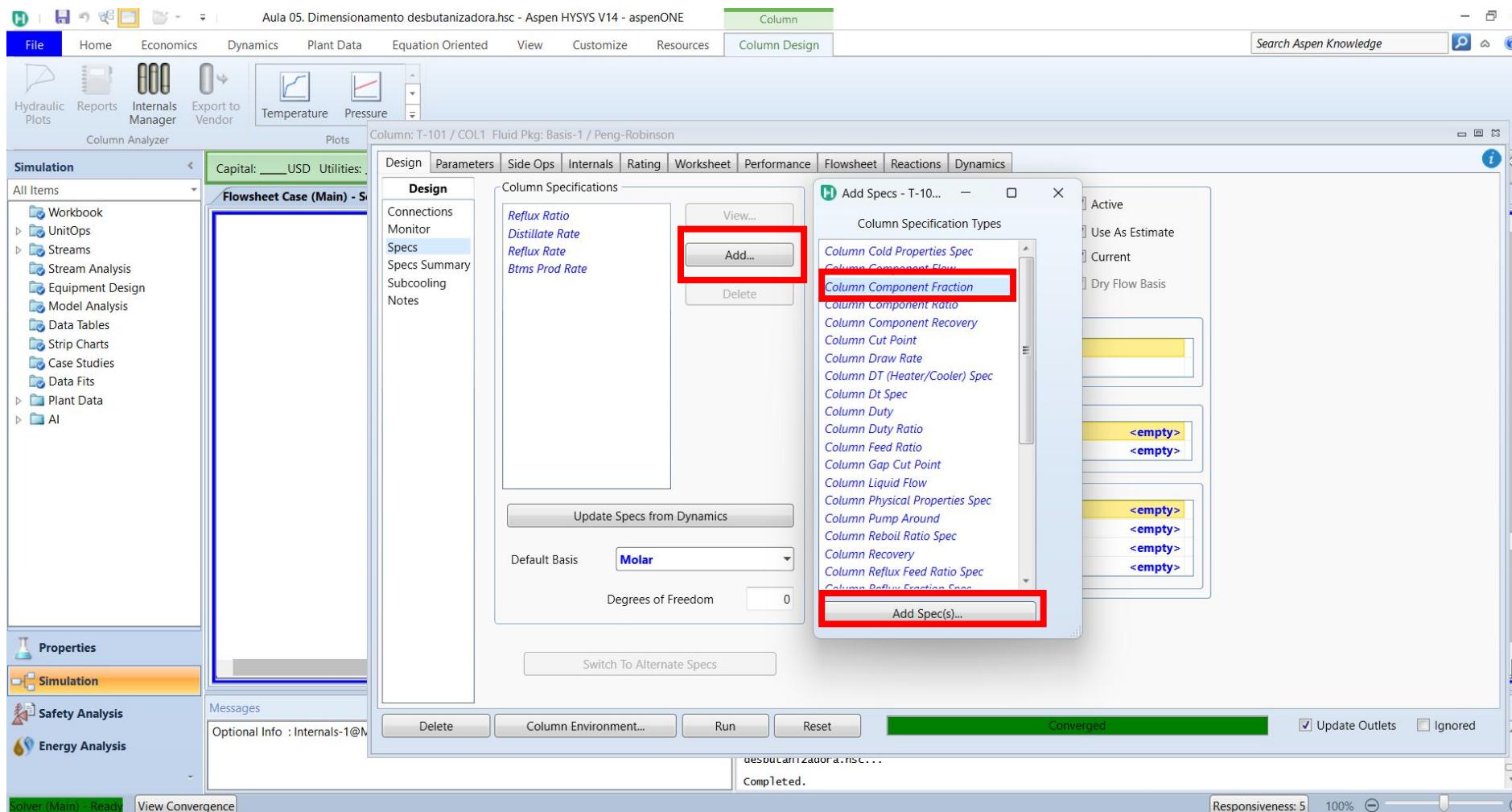
Conferindo se as purezas desejadas são atingidas

Column: T-101 / COL1 Fluid Pkg: Basis-1 / Peng-Robinson

		Feed2	GLP	Gasolina natural
Conditions	Ethane	0,0800	0,0968	0,0000
Properties	Propane	0,4300	0,5203	0,0000
Compositions	i-Butane	0,1000	0,1209	0,0007
PF Specs	n-Butane	0,2000	0,2370	0,0237
	i-Pentane	0,0800	0,0181	0,3747
	n-Pentane	0,0700	0,0069	0,3705
	n-Hexane	0,0200	0,0000	0,1152
	n-Heptane	0,0100	0,0000	0,0576
	n-Octane	0,0050	0,0000	0,0288
	n-Nonane	0,0050	0,0000	0,0288

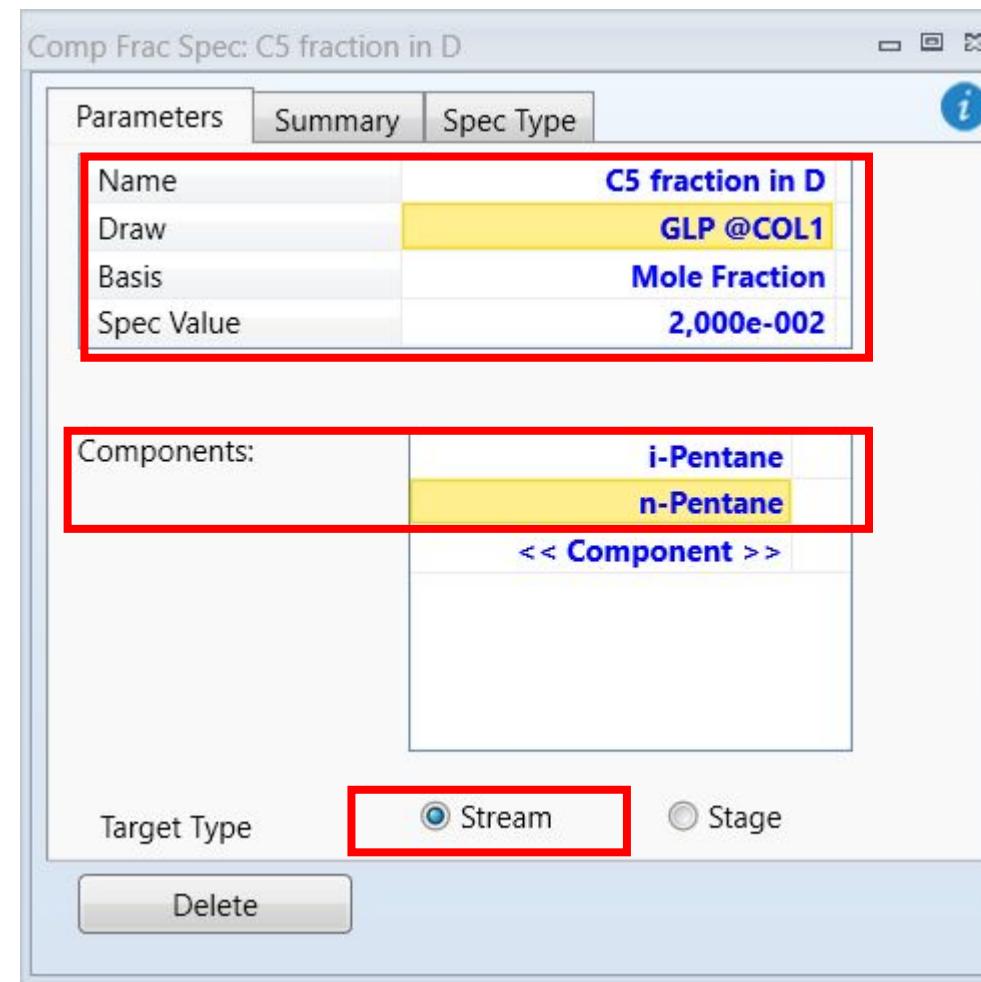
Dimensionamento em Hysys

Mudando as especificações para garantir as purezas desejadas



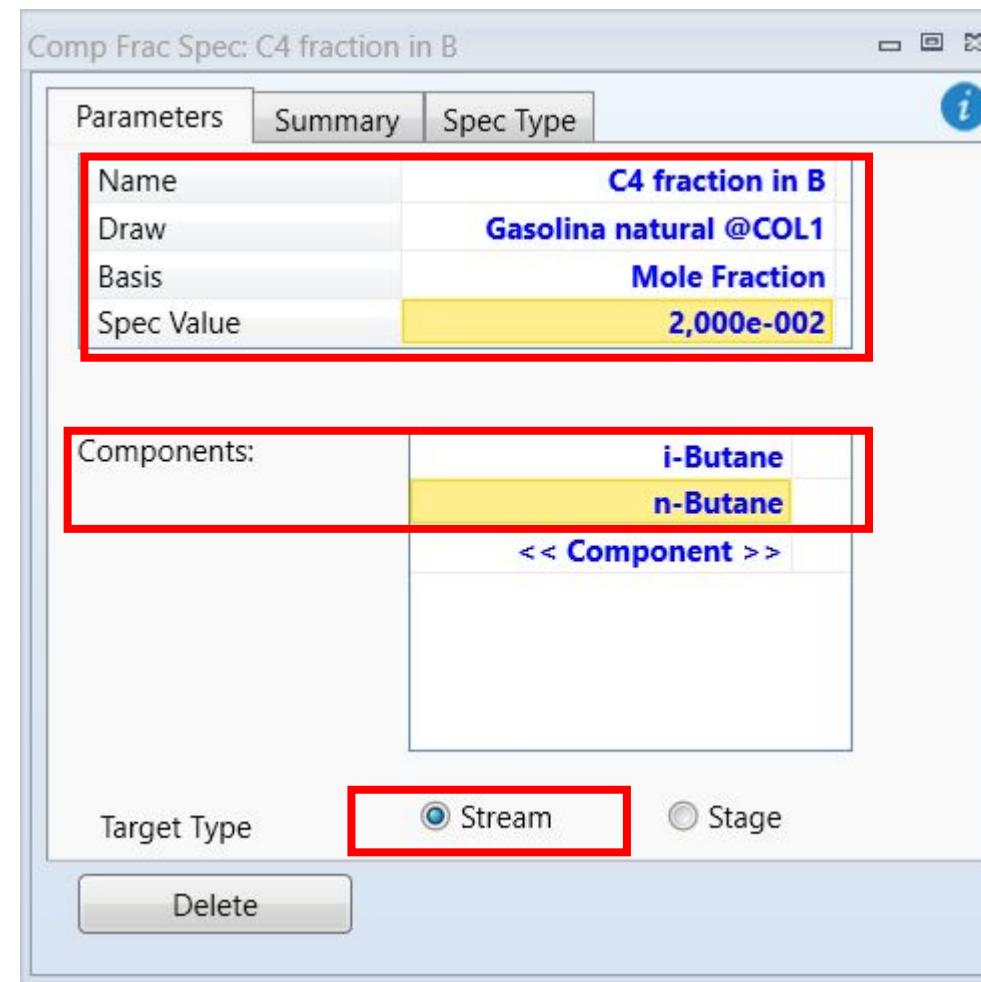
Dimensionamento em Hysys

Especificação de C5 no destilado



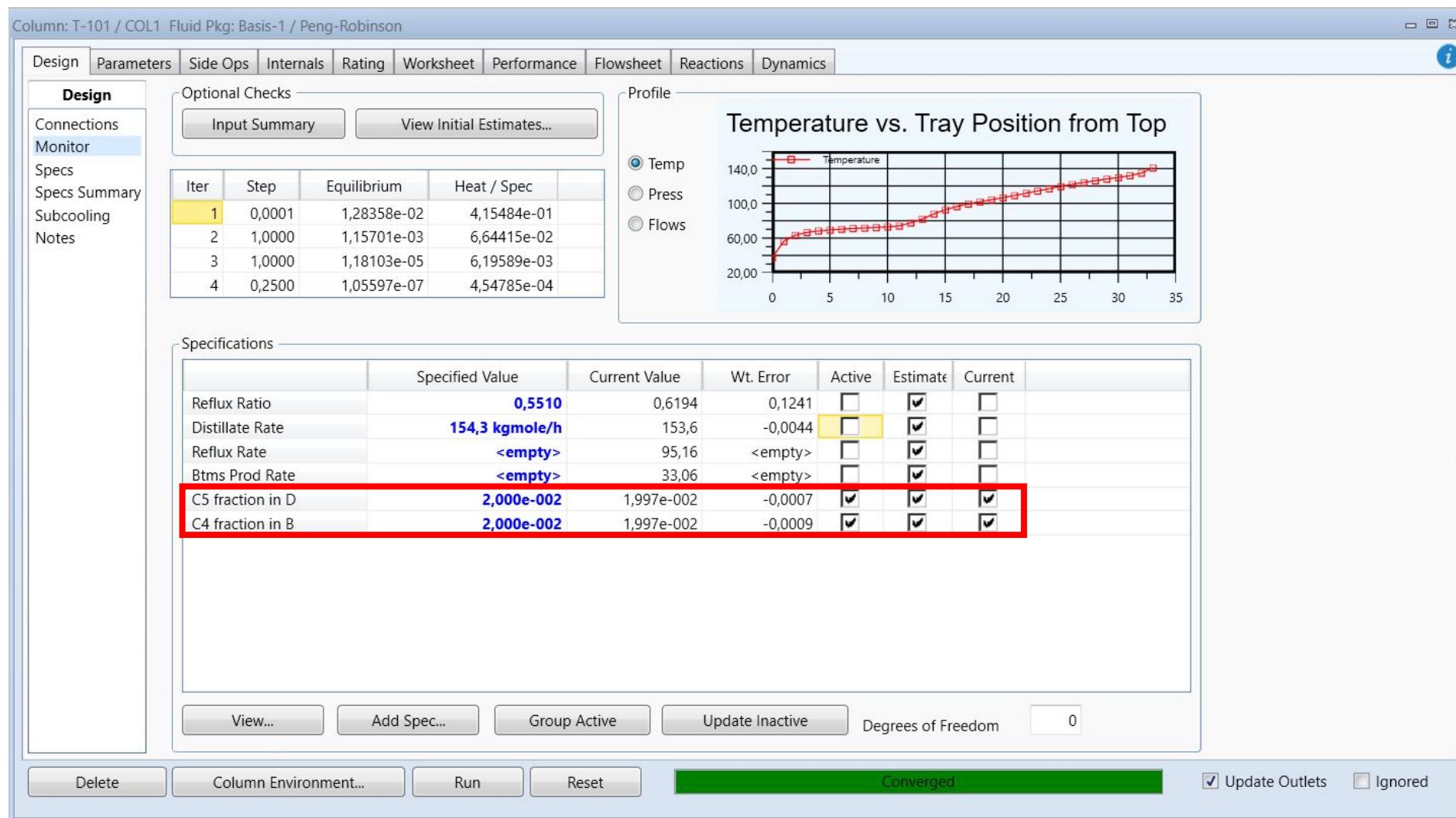
Dimensionamento em Hysys

Especificação de C4 no fundo



Dimensionamento em Hysys

Coluna convergida com as especificações de separação desejadas



Dimensionamento em Hysys

Trabalhando agora com a parte hidráulica

Column: T-101 / COL1 Fluid Pkg: Basis-1 / Peng-Robinson

Design Parameters Side Ops Internals Rating Worksheet Performance Flowsheet Reactions Dynamics

Design/Rating Active Internals-1 Column Description Auto Section Duplicate Import Template Export Template View Internals Summary

The column has gaps 1-32 Internals Input Incomplete

Main Tower

1 12 32

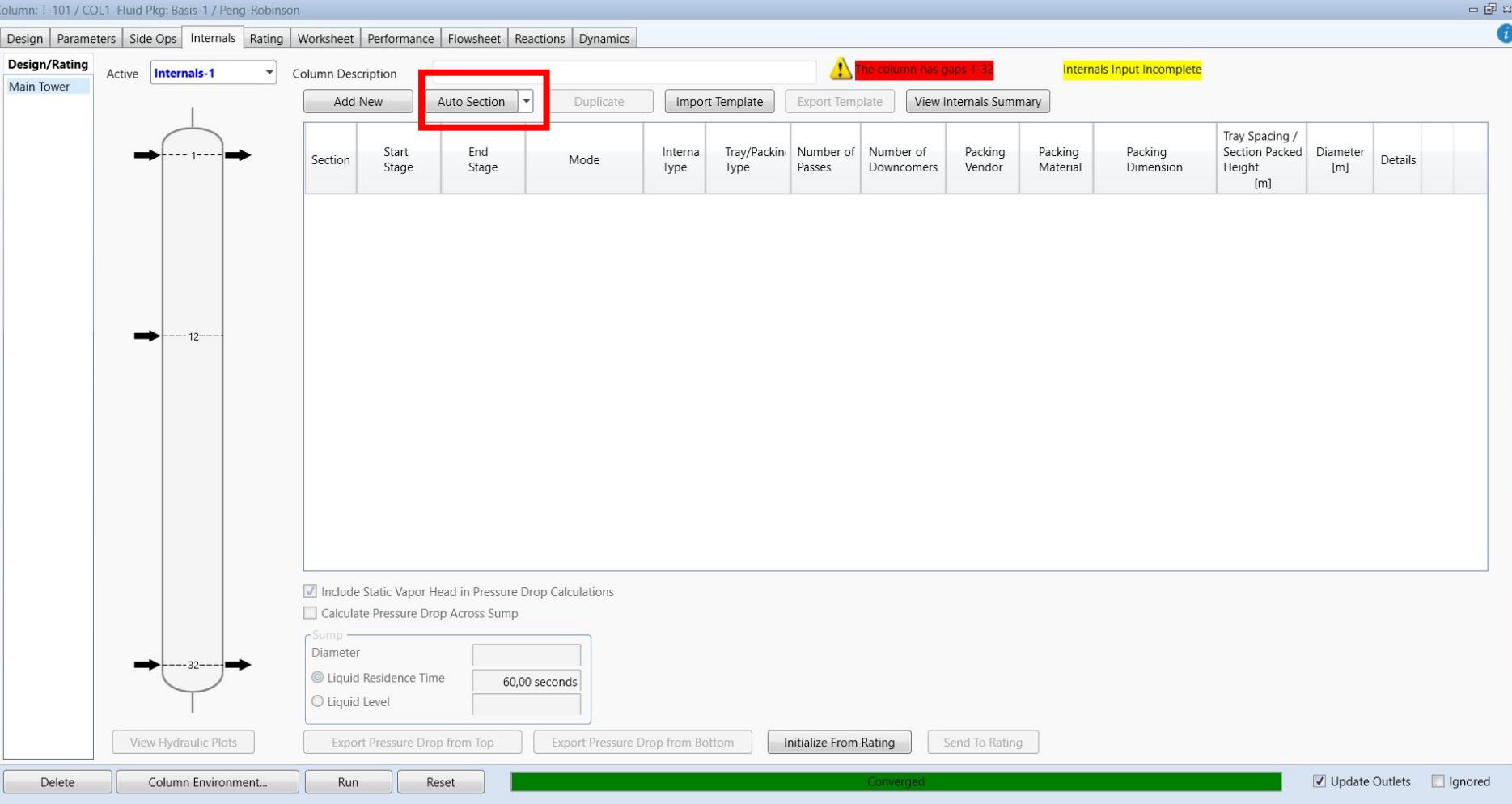
Section	Start Stage	End Stage	Mode	Internal Type	Tray/Packing Type	Number of Passes	Number of Downcomers	Packing Vendor	Packing Material	Packing Dimension	Tray Spacing / Section Packed Height [m]	Diameter [m]	Details

Include Static Vapor Head in Pressure Drop Calculations
 Calculate Pressure Drop Across Sump

Sump
Diameter:
 Liquid Residence Time:
 Liquid Level:

View Hydraulic Plots Export Pressure Drop from Top Export Pressure Drop from Bottom Initialize From Rating Send To Rating

Delete Column Environment... Run Reset Converged Update Outlets Ignored



Dimensionamento em Hysys

Duas seções criadas automaticamente.

Column: T-101 / COL1 Fluid Pkg: Basis-1 / Peng-Robinson

Design Parameters Side Ops Internals Rating Worksheet Performance Flowsheet Reactions Dynamics

Design/Rating Active Internals-1 Main Tower

Column Description

Add New Auto Section Duplicate Import Template Export Template View Internals Summary

Internals calculations completed with warnings.
Please see hydraulic plot for details.

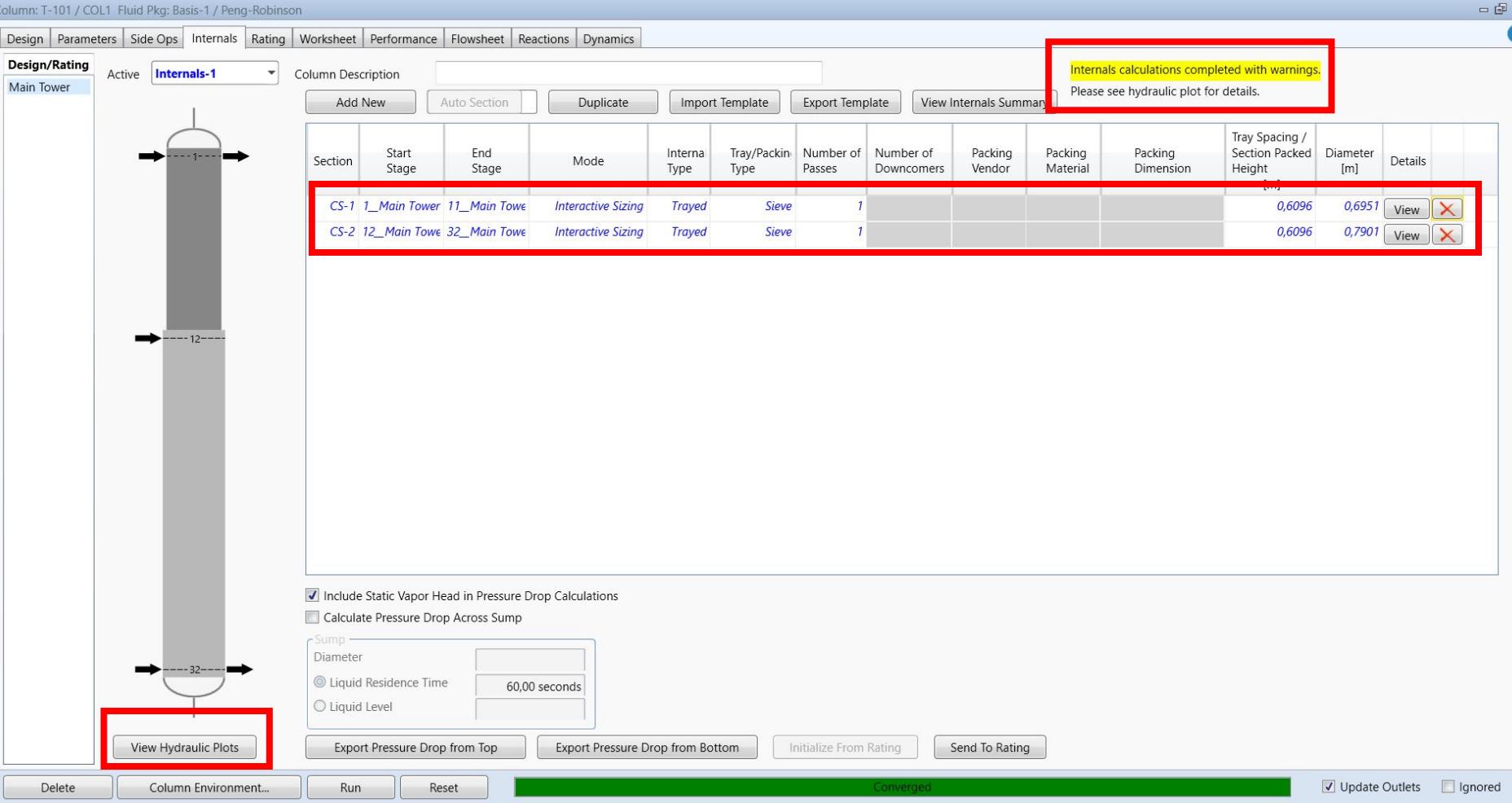
Section	Start Stage	End Stage	Mode	Internal Type	Tray/Packing Type	Number of Passes	Number of Downcomers	Packing Vendor	Packing Material	Packing Dimension	Tray Spacing / Section Packed Height	Diameter [m]	Details
CS-1_1_Main Tower	11_Main Tower	Interactive Sizing	Trayed	Sieve	1						0,6096	0,6951	View X
CS-2_12_Main Tower	32_Main Tower	Interactive Sizing	Trayed	Sieve	1						0,6096	0,7901	View X

Include Static Vapor Head in Pressure Drop Calculations
 Calculate Pressure Drop Across Sump

Sump
Diameter
 Liquid Residence Time
 Liquid Level

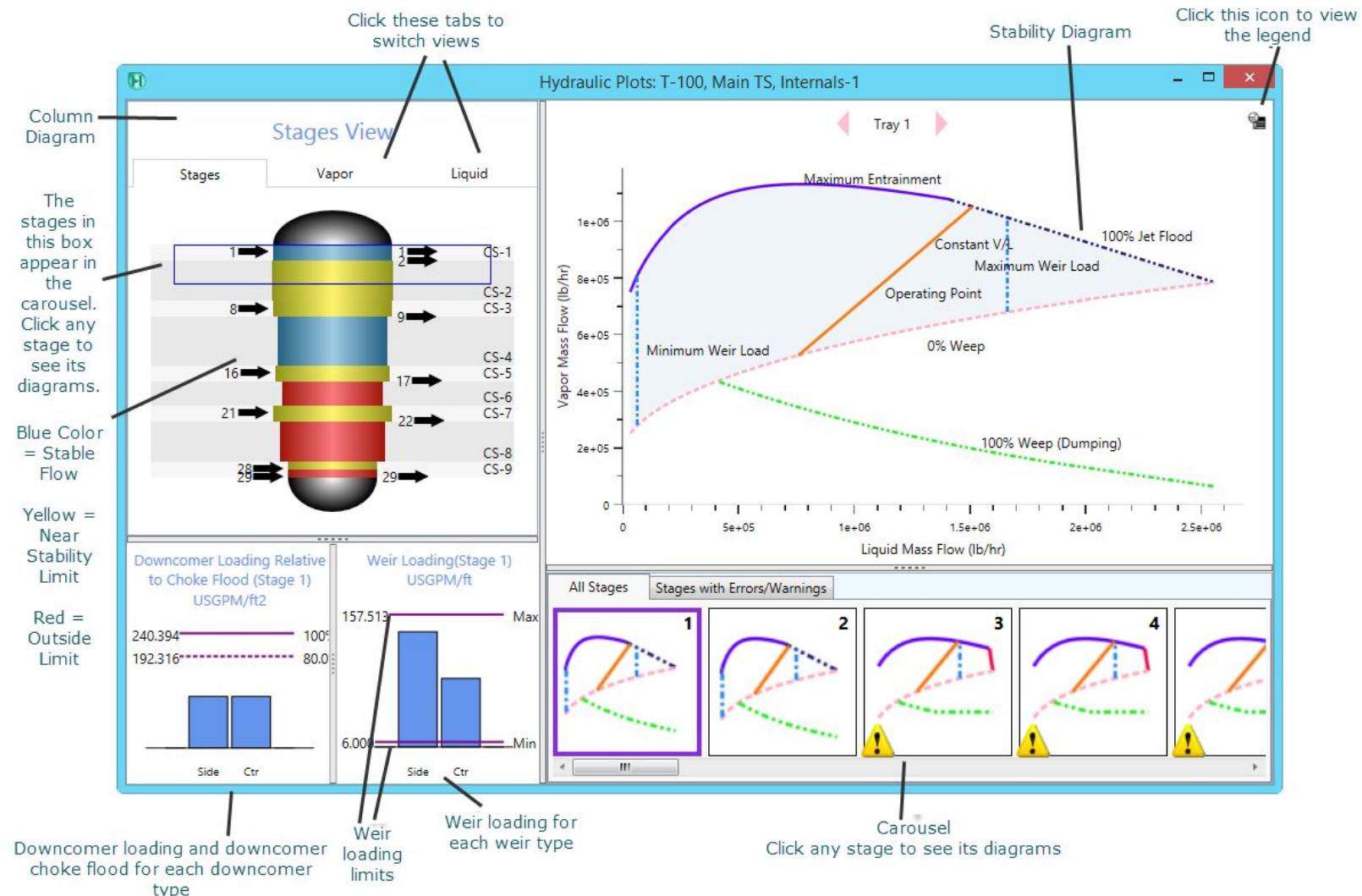
[View Hydraulic Plots](#) [Export Pressure Drop from Top](#) [Export Pressure Drop from Bottom](#) [Initialize From Rating](#) [Send To Rating](#)

Delete Column Environment... Run Reset Converged Update Outlets Ignored



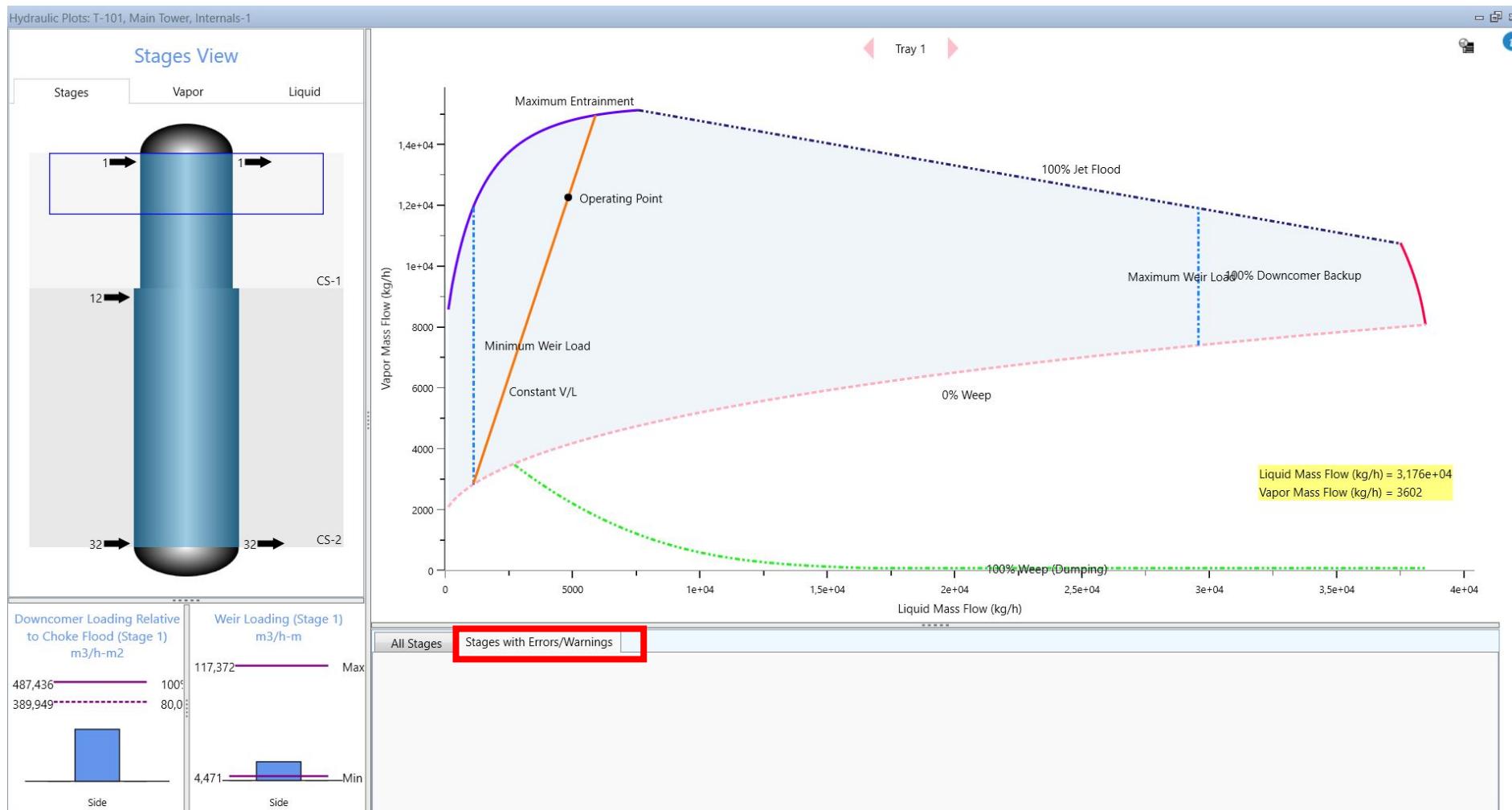
Dimensionamento em Hysys

Gráfico da hidráulica



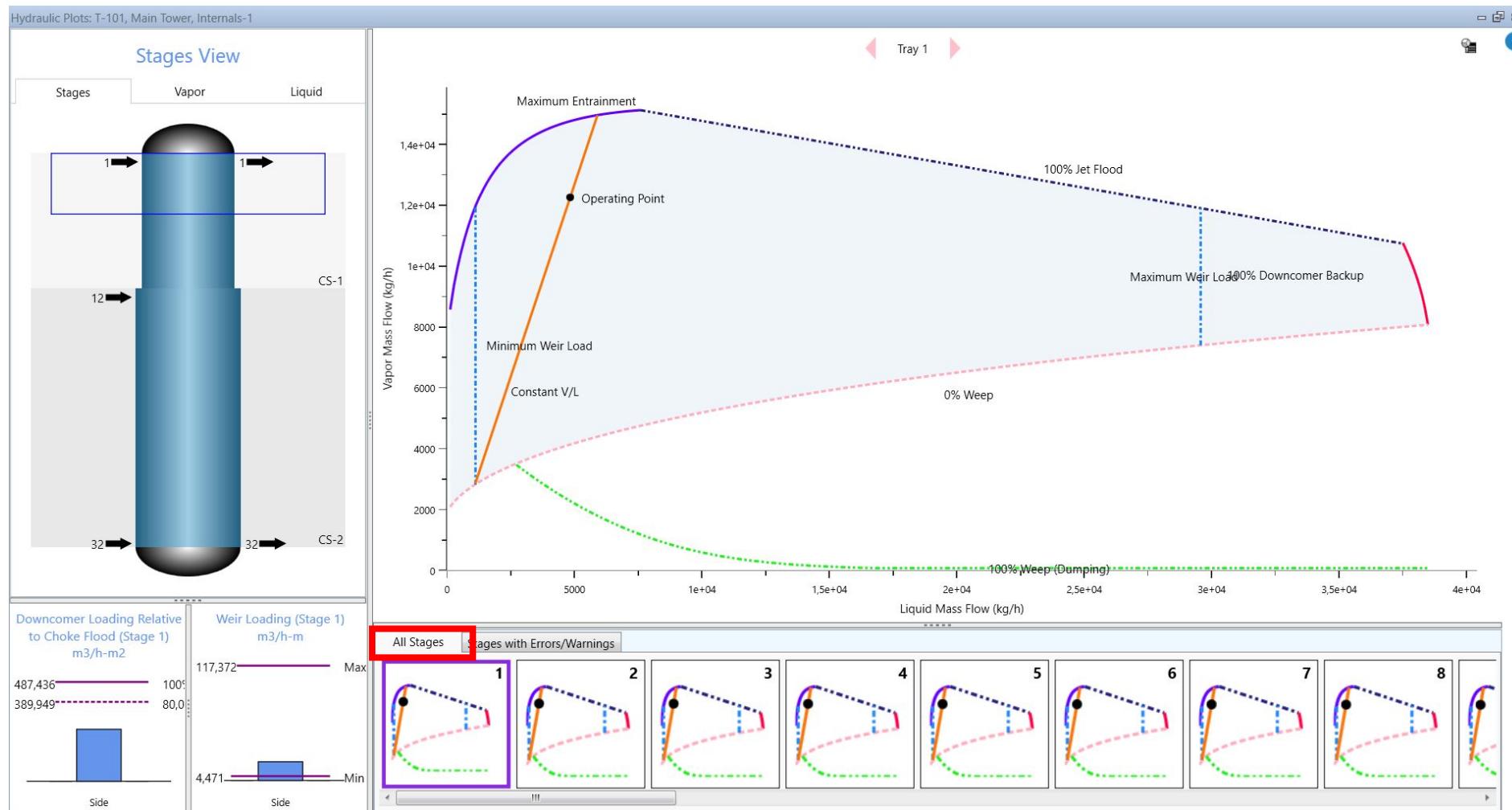
Dimensionamento em Hysys

Nenhum estágio tem Advertência (cor amarela) ou Erro (cor vermelha)



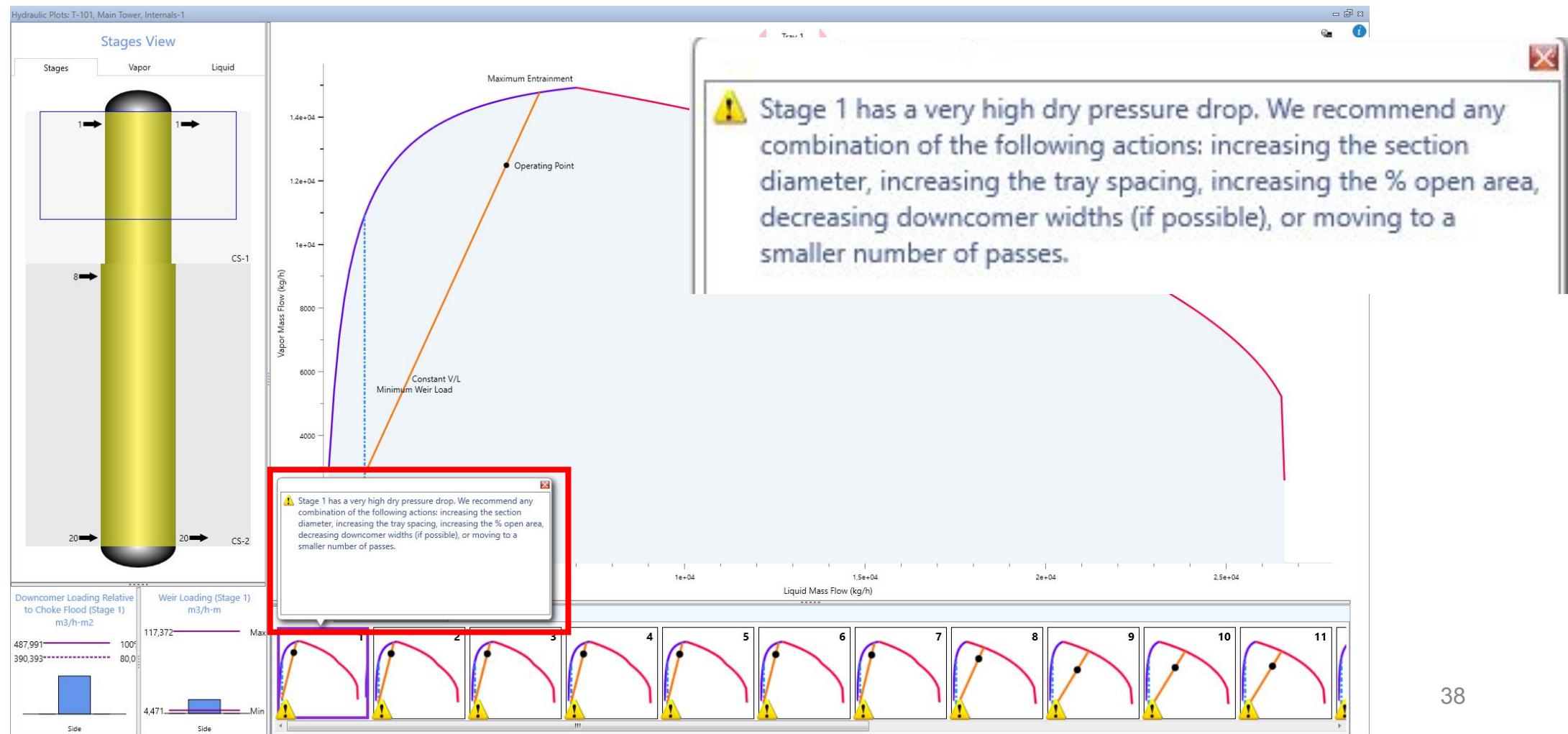
Dimensionamento em Hysys

Se tiver erro ou advertência em algum prato seguir as recomendações



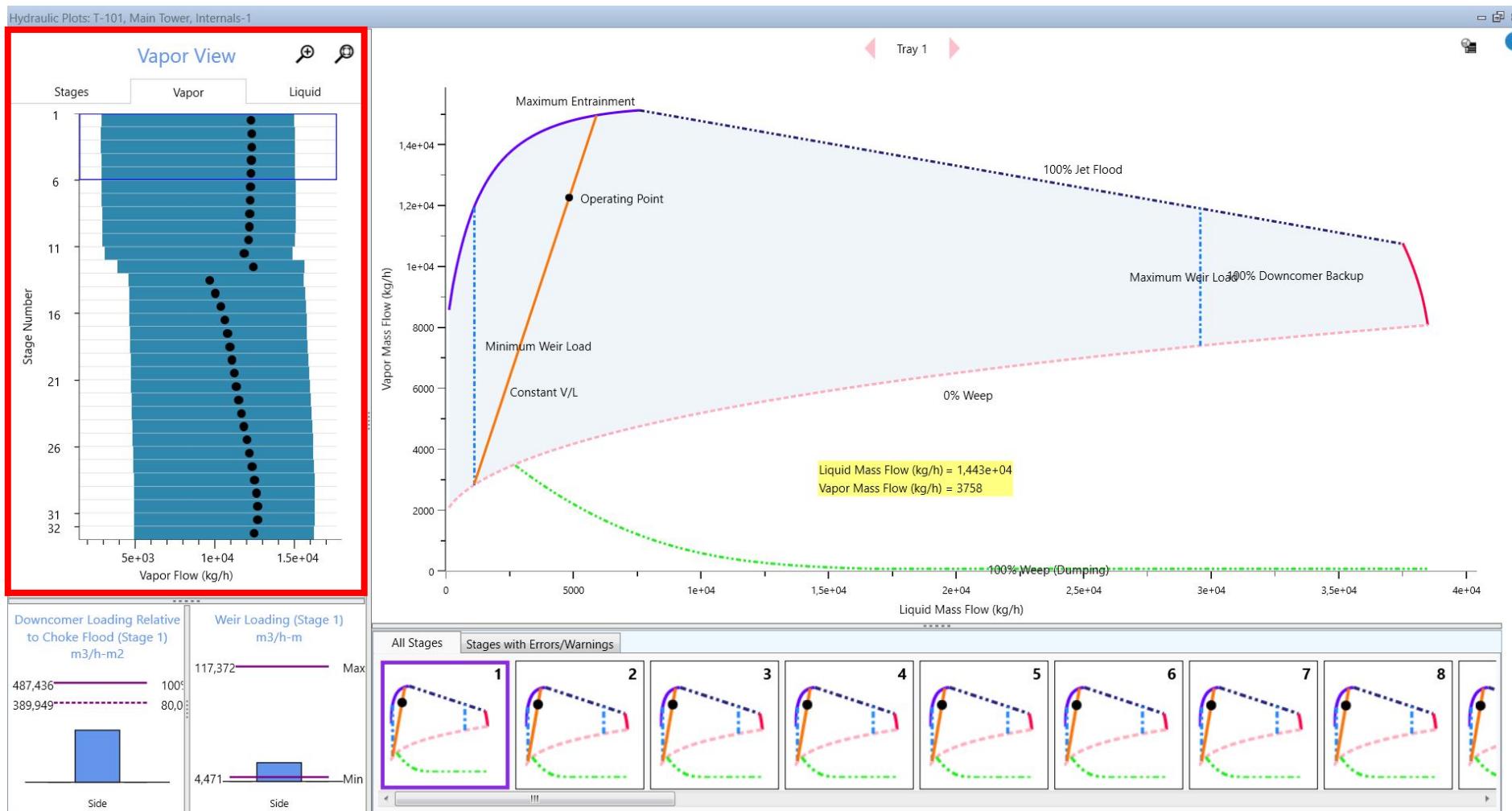
Dimensionamento em Hysys

Imagen de exemplo com Advertência e Recomendações



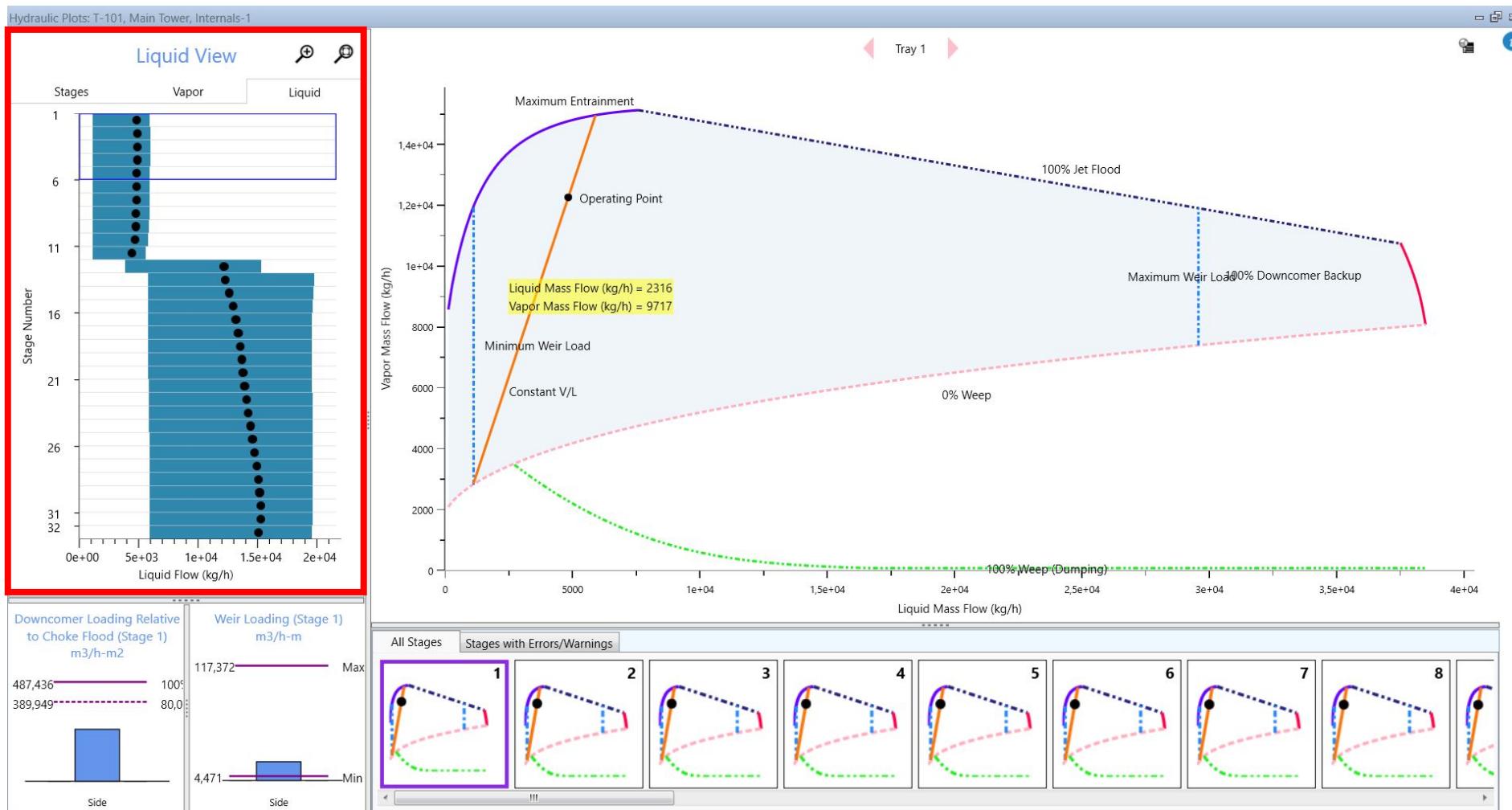
Dimensionamento em Hysys

Limites das vazões de vapor e ponto de operação



Dimensionamento em Hysys

Limites das vazões de líquido e ponto de operação



Dimensionamento em Hysys

Resultados: Resumo das correntes

Column: T-101 / COL1 Fluid Pkg: Basis-1 / Peng-Robinson

Design Parameters Side Ops Internals Rating Worksheet Performance Flowsheet Reactions Dynamics

Performance

Summary Column Profiles Feeds / Products Plots Cond./Reboiler Internals Results

Feeds

	Feed2
Flow Rate (kgmole/h)	186,6883
Ethane	0,0800
Propane	0,4300
i-Butane	0,1000
n-Butane	0,2000
i-Pentane	0,0800
n-Pentane	0,0700
n-Hexane	0,0200
n-Heptane	0,0100
n-Octane	0,0050
n-Nonane	0,0050

Products

	GLP	Gasolina natural
Flow Rate (kgmole/h)	153,6271	33,0612
Ethane	0,0972	0,0000
Propane	0,5225	0,0000
i-Butane	0,1214	0,0005
n-Butane	0,2389	0,0194
i-Pentane	0,0150	0,3822
n-Pentane	0,0050	0,3720
n-Hexane	0,0000	0,1129
n-Heptane	0,0000	0,0565
n-Octane	0,0000	0,0282
n-Nonane	0,0000	0,0282

Delete Column Environment... Run Reset Converged Update Outlets Ignored

Dimensionamento em Hysys

Resultados: Condensador e revedor

Column: T-101 / COL1 Fluid Pkg: Basis-1 / Peng-Robinson

Design Parameters Side Ops Internals Rating Worksheet Performance Flowsheet Reactions Dynamics

Performance

Summary Column Profiles Feeds / Products Plots Cond./Reboiler Internals Results

Condenser

Type	Total
Temperature	37,46 C
Pressure	12,00 bar
Duty	1,013e+006 kcal/h
Reflux Flowrate	95,16 kgmole/h

Reboiler

Type	Regular
Temperature	140,9 C
Pressure	12,20 bar
Duty	7,804e+005 kcal/h
Outlet Flowrate	33,06 kgmole/h

Delete Column Environment... Run Reset Converged Update Outlets Ignored

Dimensionamento em Hysys

Resultados: Resumo dos internos

Column: T-101 / COL1 Fluid Pkg: Basis-1 / Peng-Robinson

Design Parameters Side Ops Internals Rating Worksheet Performance Flowsheet Reactions Dynamics

Tower Main Tower Selected Internals Internals-1 Transport Properties Flows

Performance

Summary Column Profiles Feeds / Products Plots Cond./Reboiler Internals Results

Column Internals Summary

Number Of Stages	32
Total Height [m]	19,51
Total Head Loss [mm]	4291
Total Pressure Drop [mbar]	209,5
Number Of Sections	2
Number Of Diameters	2
Pressure Drop Across Sump [bar]	<empty>

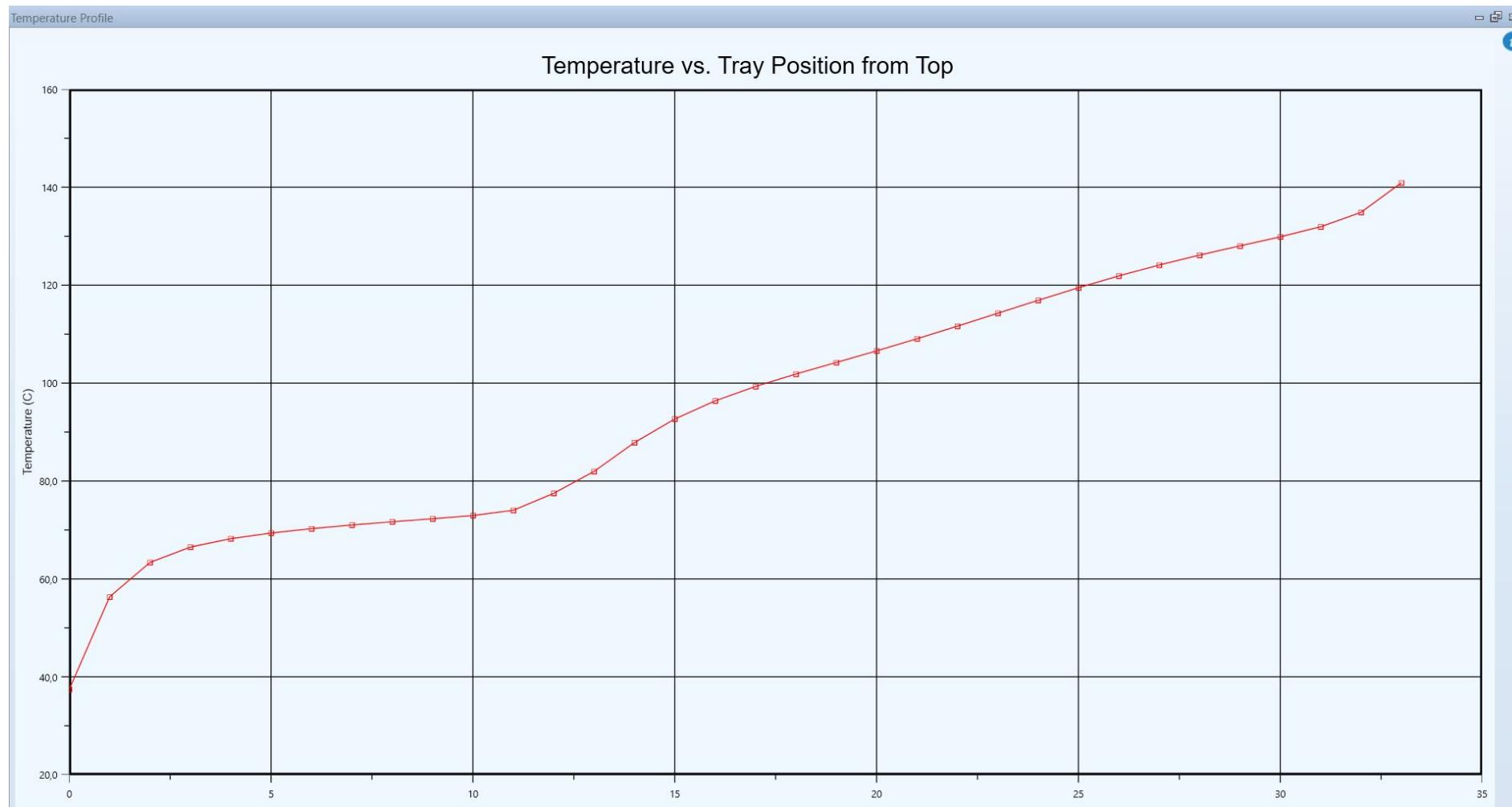
Sections Summary

Section	Start	End	Diameter [m]	Height [m]	Internal Type	Tray or Packin Type	Section Pressure Drop [mbar]	Approach To Flood [%]	Limiting Stage	
CS-1	1_Main Tower	11_Main Tower	0,6951	6,706	Trayed	Sieve	76,75	80,00	2_Main Tower	<button>View</button>
CS-2	12_Main Tower	32_Main Tower	0,7901	12,80	Trayed	Sieve	132,7	79,50	12_Main Tower	<button>View</button>

Delete Column Environment... Run Reset Converged Update Outlets Ignored

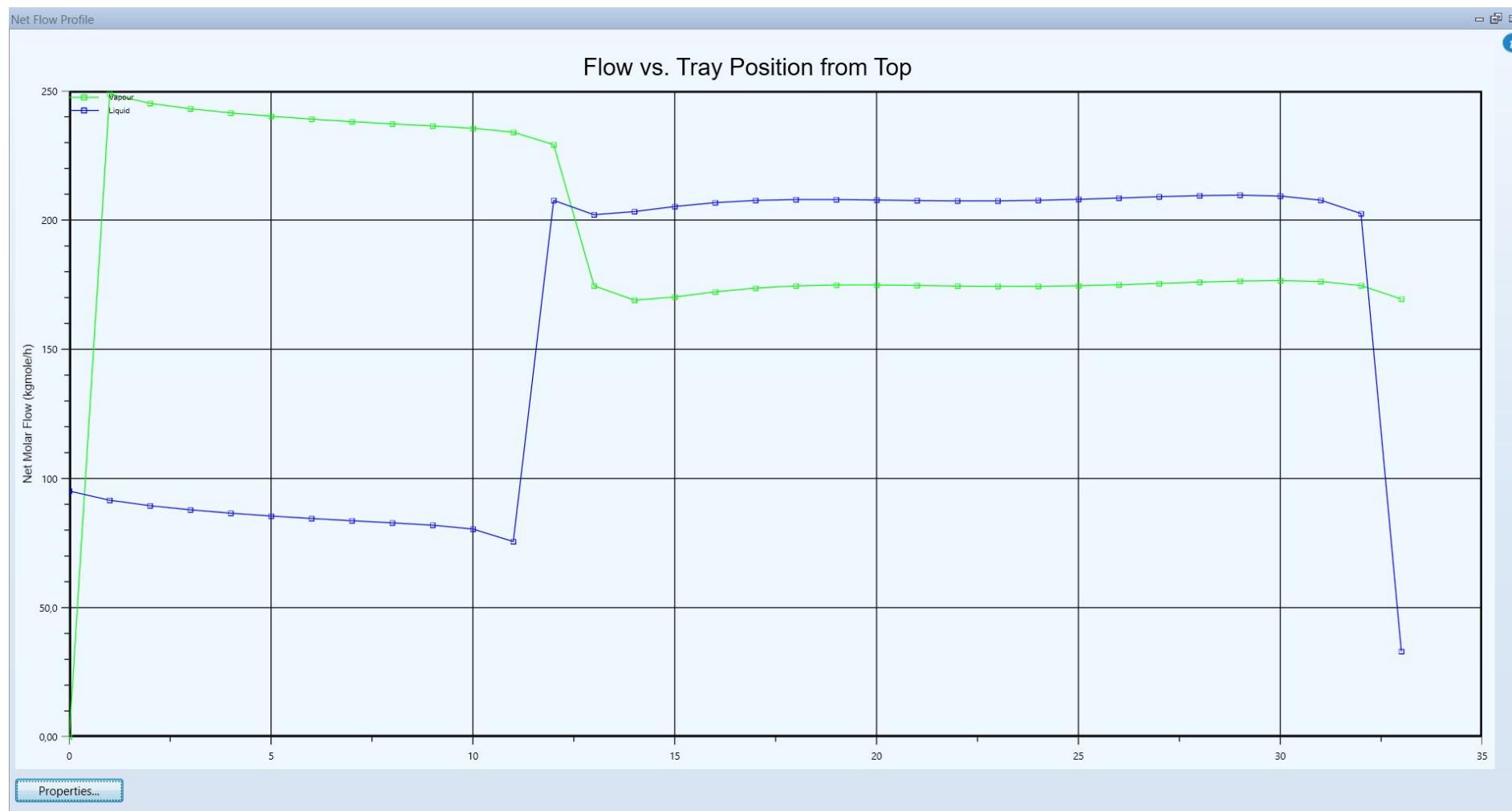
Dimensionamento em Hysys

Resultados: Perfil de temperatura



Dimensionamento em Hysys

Resultados: Perfil de vazões



Dúvidas?



Recados importantes

- Próxima aula: Craqueamento a vapor do etano em DWSIM
- Os slides desta aula estarão disponíveis no Classroom da disciplina.

“Ensinar não é transferir conhecimento, mas criar as possibilidades para a sua própria produção ou a sua construção.”

Paulo Freire