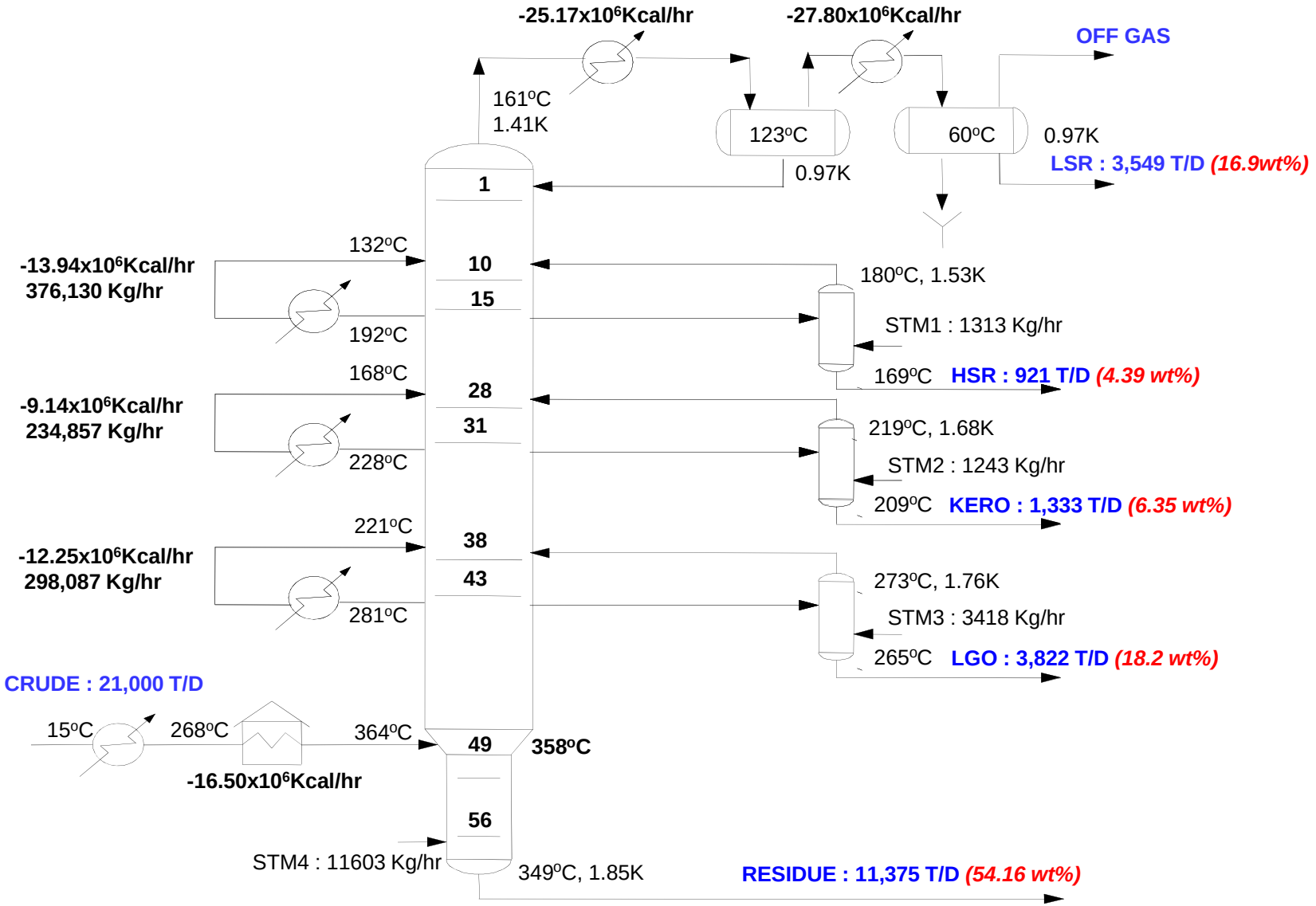
Modeling an Atmospheric Crude Tower



Problem Description:

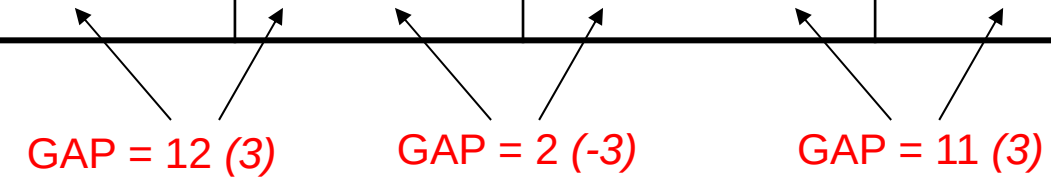
- A crude unit is designed to process 21,000 tons per day of 50% Arabian heavy crude and 50% Arabian light crude. The desired products are shown in the next slide, with specifications in Table 1.

- 250^{o}C steam (assumed to be saturated) is available for stripping. The condenser is to operate at 123^{o}C and 0.97 Kg/cm^{2}G.

- An initial simulation model was constructed as shown in the above slide. ASTM D86 95% temperatures were used for HSR, Kerosene and LGO. The overflash (0.03) was set as a specification. A partial condenser was used to meet the desired temperature of 123^{o}C.

ASTM D86 Temperatures for Side Distillates Products

Table 1 : Product Specification of Each Side Distillates					
	NAPHTHA	HSR	KEROSENE	LGO	RESIDUE
IBP	69	137	168	218	
5 %	71	165 *(162)*	198 *(190)*	246 *(238)*	
10 %	74	172 *(171)*	203 *(199)*	254 *(246)*	
30 %	88	179 *(175)*	210 *(205)*	268 *(265)*	
50 %	104 *(104)*	183 *(176)*	215 *(209)*	283 *(282)*	
70 %	122 *(129)*	187 *(180)*	221 *(215)*	301 *(301)*	
90 %	146 *(149)*	193 *(186)*	229 *(226)*	328 *(328)*	
95 %	153 *(159)*	196 *(193)*	235 *(234)*	337 *(339)*	
EP	162	204	251	378	



Feedstock Characterization for Crude Oils

Table 2 : Oil 1 (Arabian Heavy Crude Oil : TBP)					
Liq. vol. %	Temp (C)	Liq. Vol. %	Temp (C)	Liq. vol. %	Temp (C)
4.9675	50	29.5540	230	57.3875	410
6.3165	60	31.0779	240	58.7564	420
7.8273	70	32.6249	250	60.0973	430
8.0584	80	34.1912	260	61.4113	440
9.4522	90	35.7731	270	62.6993	450
11.0033	100	37.3668	280	63.9624	460
11.8134	110	38.9686	290	66.4180	480
13.2141	120	40.5747	300	68.7861	500
14.1386	130	42.1813	310	71.0740	520
15.7578	140	43.7847	320	73.2721	540
17.3845	150	45.3812	330	75.3642	560
18.9837	160	46.9669	340	77.3657	580
20.5502	170	48.5379	350	79.2783	600
22.0844	180	50.0883	360	83.6724	650
23.5917	190	51.6115	370	87.5258	700
25.0820	200	53.1026	380	100.0000	850
26.5657	210	54.5616	390		
28.0529	220	55.9896	400		

Feedstock Characterization for Crude Oils

Table 3 : Oil 1 (Arabian Heavy Crude Oil : Specific Gravity)					
Liq. vol. %	Sp. Gr.	Liq. Vol. %	Sp. Gr.	Liq. vol. %	Sp. Gr.
4.9675	0.6348	29.5540	0.8015	57.3875	0.9101
6.3165	0.7603	31.0779	0.8080	58.7564	0.9140
7.8273	0.6643	32.6249	0.8143	60.0973	0.9187
8.0584	0.6733	34.1912	0.8178	61.4113	0.9231
9.4522	0.7736	35.7731	0.8240	62.6993	0.9275
11.0033	0.6953	37.3668	0.8302	63.9624	0.9317
11.8134	0.7128	38.9686	0.8366	66.4180	0.9358
13.2141	0.7342	40.5747	0.8429	68.7861	0.9474
14.1386	0.7258	42.1813	0.8493	71.0740	0.9548
15.7578	0.7349	43.7847	0.8558	73.2721	0.9623
17.3845	0.7427	45.3812	0.9623	75.3642	0.9699
18.9837	0.7512	46.9669	0..8705	77.3657	0.9777
20.5502	0.7592	48.5379	0.8769	79.2783	0.9855
22.0844	0.7662	50.0883	0.8630	83.6724	0.9987
23.5917	0.7736	51.6115	0.8889	87.5258	1.0169
25.0820	0.7809	53.1026	0.8945	100.0000	1.1116
26.5657	0.7879	54.5616	0.9000		
28.0529	0.7948	55.9896	0.9052		

Lightend Analysis for Arabian Heavy Crude

Table 4: Lightends Analysis	
Component	**LV fraction**
C2	**0.0005**
C3	**0.0069**
IC4	**0.0031**
NC4	**0.0130**
Total	***0.0235***

Feedstock Characterization for Crude Oils

Table 5 : Oil 2 (Arabian Light Crude Oil : TBP)					
Liq. vol. %	Temp (C)	Liq. Vol. %	Temp (C)	Liq. vol. %	Temp (C)
3.7904	40	32.4055	220	64.4796	400
4.5061	50	34.2644	230	66.0120	410
5.1447	60	36.1177	240	67.4992	420
7.0606	70	37.9654	250	68.9412	430
7.9677	80	39.8075	260	69.9615	440
8.7810	90	41.6440	270	71.3225	450
10.8900	100	43.4749	280	72.6537	460
11.8191	110	45.3662	290	75.2268	480
12.7902	120	47.1824	300	77.6808	500
15.3348	130	48.9886	310	80.0157	520
17.1090	140	50.7849	320	82.2399	540
18.8832	150	52.5712	330	84.1859	560
21.1010	160	54.3475	340	85.8773	580
23.1071	170	56.1138	350	87.4502	600
25.1326	180	57.8986	360	90.8971	650
26.9911	190	59.6116	370	93.7166	700
28.8573	200	61.2794	380	100.0000	850
30.5410	210	62.9021	390		

Feedstock Characterization for Crude Oils

Table 6 : Oil 2 (Arabian Light Crude Oil : Specific Gravity)					
Liq. vol. %	Sp. Gr.	Liq. Vol. %	Sp. Gr.	Liq. vol. %	Sp. Gr.
3.7904	0.6341	32.4055	0.8023	64.4796	0.9075
4.5061	0.6541	34.2644	0.8083	66.0120	0.9104
5.1447	0.6527	36.1177	0.8142	67.4992	0.9147
7.0606	0.6627	37.9654	0.8163	68.9412	0.9188
7.9677	0.7156	39.8075	0.8221	69.9615	0.9228
8.7810	0.7044	41.6440	0.8281	71.3225	0.9267
10.8900	0.7018	43.4749	0.8342	72.6537	0.9304
11.8191	0.7242	45.3662	0.8404	75.2268	0.9358
12.7902	0.7664	47.1824	0.8467	77.6808	0.9406
15.3348	0.7326	48.9886	0.8532	80.0157	0.9476
17.1090	0.7594	50.7849	0.8598	82.2399	0.9549
18.8832	0.7647	52.5712	0.8690	84.1859	0.9624
21.1010	0.7634	54.3475	0.8754	85.8773	0.9702
23.1071	0.7707	56.1138	0.8815	87.4502	0.9784
25.1326	0.7770	57.8986	0.8873	90.8971	0.9914
26.9911	0.7852	59.6116	0.8928	93.7166	1.0095
28.8573	0.7919	61.2794	0.8980	100.0000	1.0982
30.5410	0.7961	62.9021	0.9029		

Lightend Analysis for Arabian Light Crude

Table 7: Lightends Analysis	
Component	**LV %**
C2	**0.0001**
C3	**0.0017**
IC4	**0.0018**
NC4	**0.0099**
Total	***0.0235***

Crude Distillation Column: Tray Efficiencies

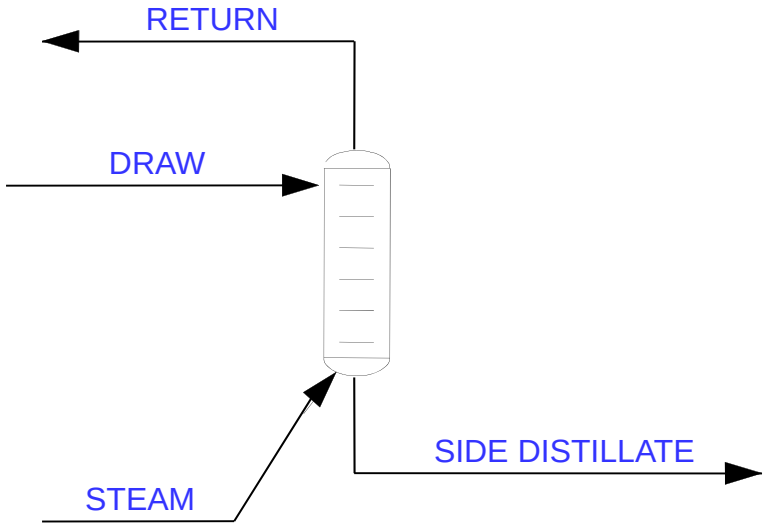
Typical Tray Efficiencies for Each Section:

Crude Distillation Column Section	Overall Tray Efficiency %	Typical Theoretical Trays
STRIPPING ZONE	20 – 30	(1 – 2)
FLASH ZONE – GAS OIL	30 – 40	(3 – 4)
GAS OIL – DIESEL	40 – 50	(4 – 5)
DIESEL – KEROSENE	50 – 55	(3 – 4)
KEROSENE – NAPHTHA	55 – 60	(4 – 5)
NAPHTHA – TOP OF COLUMN	60 – 65	(6 – 8)
Overall Tray Efficiency for Crude Column : About 50 %		

Crude Oil Distillation : *SIMULATION BASICS*

SIDE STRIPPING OF PRODUCTS :

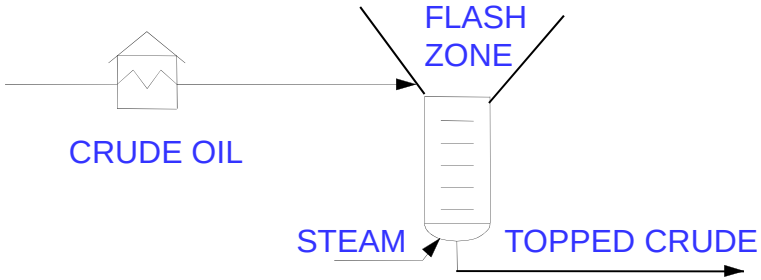
- STEAM:
  4 – 6 TRAYS
- REBOILED:
  6 – 10 TRAYS
- IMPROVES D86 5% POINTS BY STRIPPING TO REMOVE LIGHT ENDS
- TYPICAL STEAM:
  0.1 – 0.25 LBS/GALLON
  [12 – 30 KG/M3] OF PRODUCT



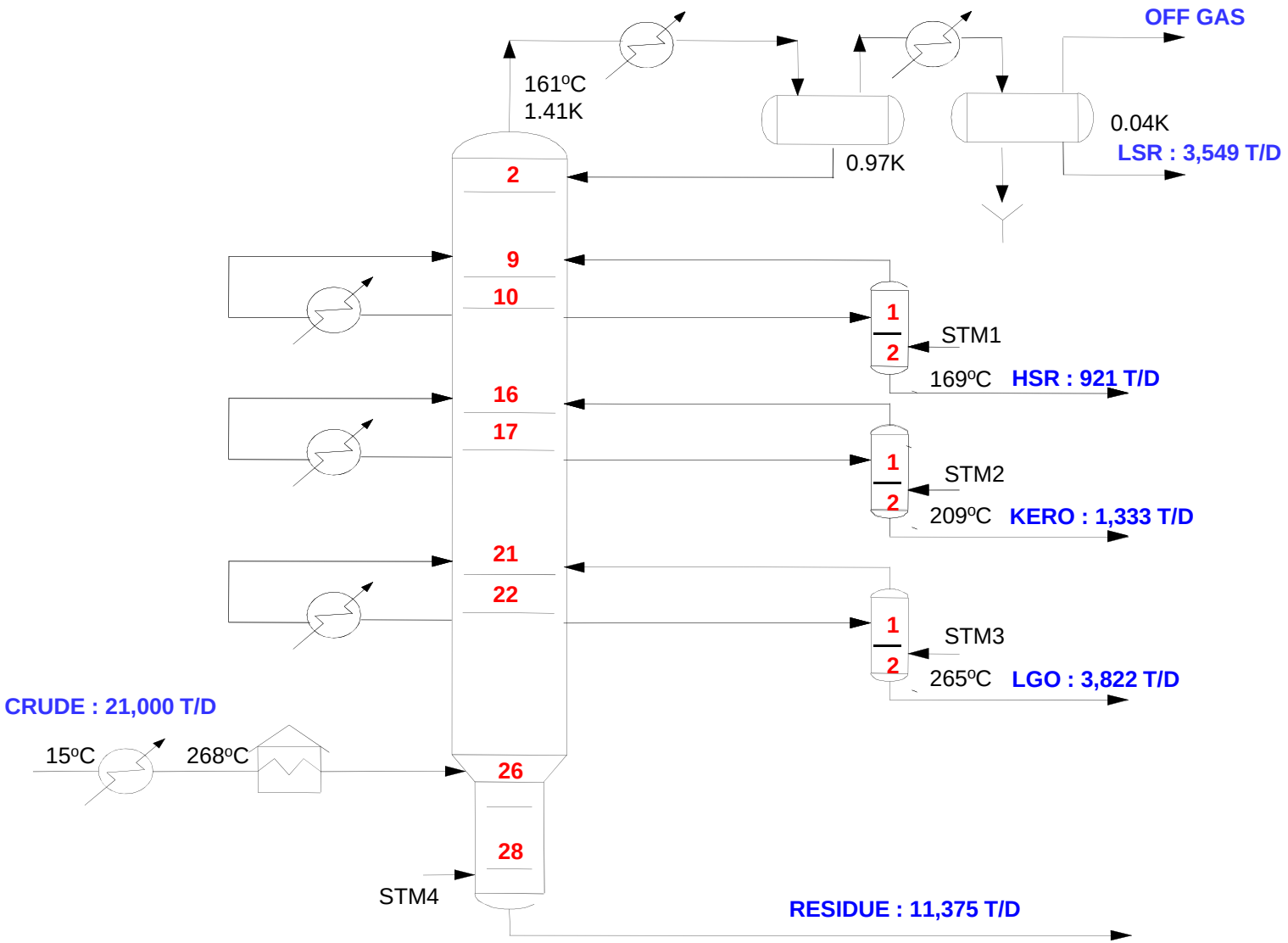
Crude Oil Distillation : *CONTINUED*

BOTTOM STRIPPING STEAM :

- STRIP GAS OIL FROM BOTTOMS TO RAISE D86 5% OF BOTTOMS
- LOWER HYDROCARBON PARTIAL PRESSURE IN THE FLASH ZONE
- USE 2 THEORETICAL TRAYS EXCLUDING FLASH ZONE



CDU: Simulation Flowsheet



CDU: Problem Solution

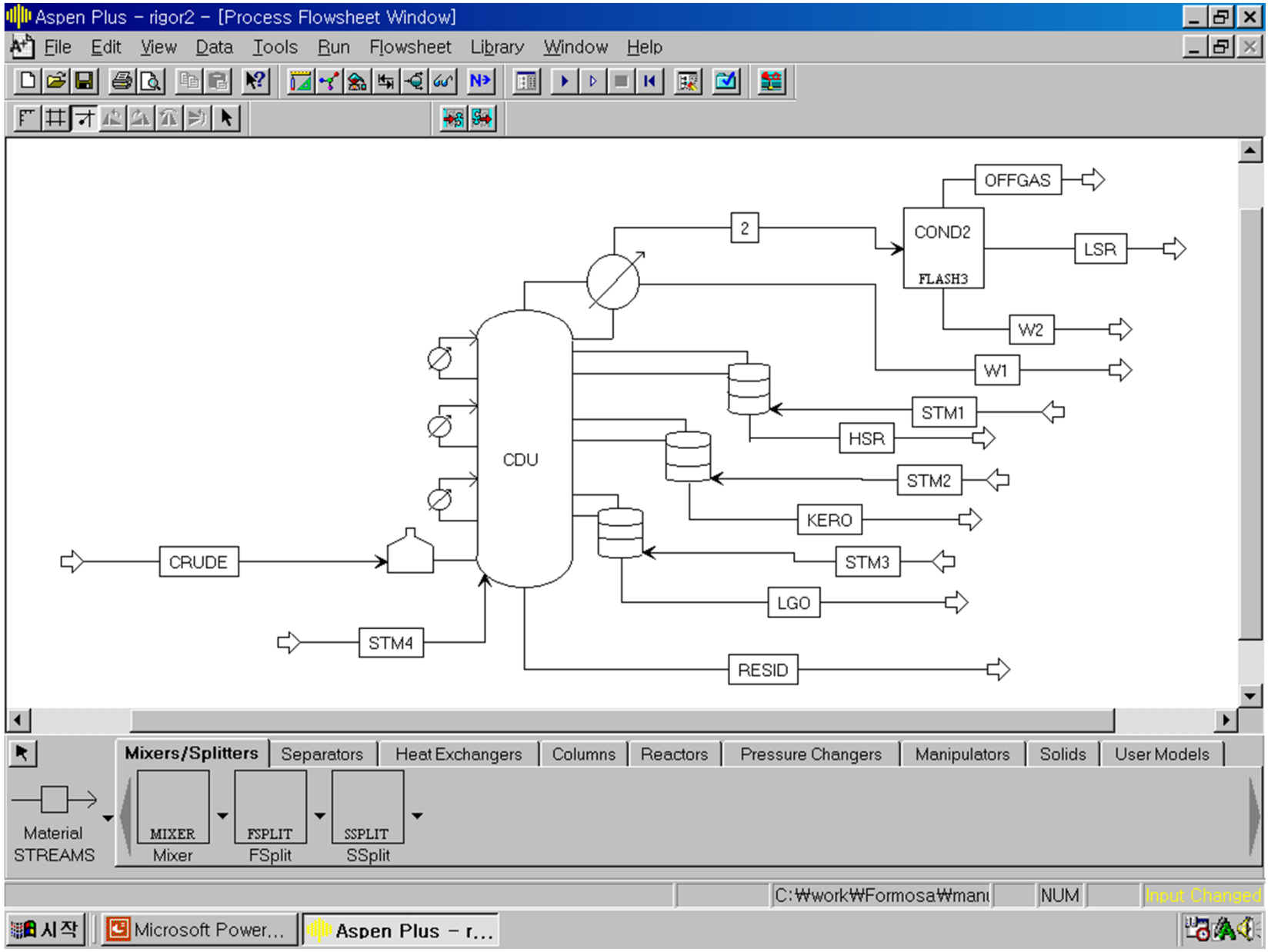
- LSR D86(95) controlled by Distillate (Residue) rate
- HSR D86(95) controlled by HSR flowrate
- Kerosene D86(95) controlled by Kerosene flowrate
- LGO D86(95) controlled by LGO flowrate
- Runback to Flash zone (overflash) controlled by furnace duty

Modeling a U-type Tower:

The Tower has:

- **A partial condenser**
- **Three coupled side strippers**
- **U-type tower has no pump around side coolers.**

File name : U-type.bkp



Process Flowsheet for a U-type Crude Distillation Column

Three side strippers

Stripper	Location	Specifications
HSR (S-1)	Liquid draw from stage 10 Vapor return to 9	Product rate: 921 Ton/day Steam stripping (STM1) 2 equilibrium stages
KERO (S-2)	Liquid draw from stage 17 Vapor return to 16	Product rate: 1,333 Ton/day Steam stripping (STM2) 2 equilibrium stages
LGO (S-3)	Liquid draw from stage 22 Vapor return to 21	Product rate: 3,822 Ton/day Steam stripping (STM3) 2 equilibrium stages

Steam Conditions for side strippers & main fractionator

Steam	Location	Conditions and Flow
STM1	HSR Stripper	250^{o}C (saturated), 1,313 Kg/hr
STM2	Kerosene Stripper	250^{o}C (saturated), 1,243 Kg/hr
STM3	LGO Stripper	250^{o}C (saturated), 3,418 Kg/hr
STM4	Main Tower	250^{o}C (saturated), 11,603 Kg/hr

Adding the CDU to the Flowsheet

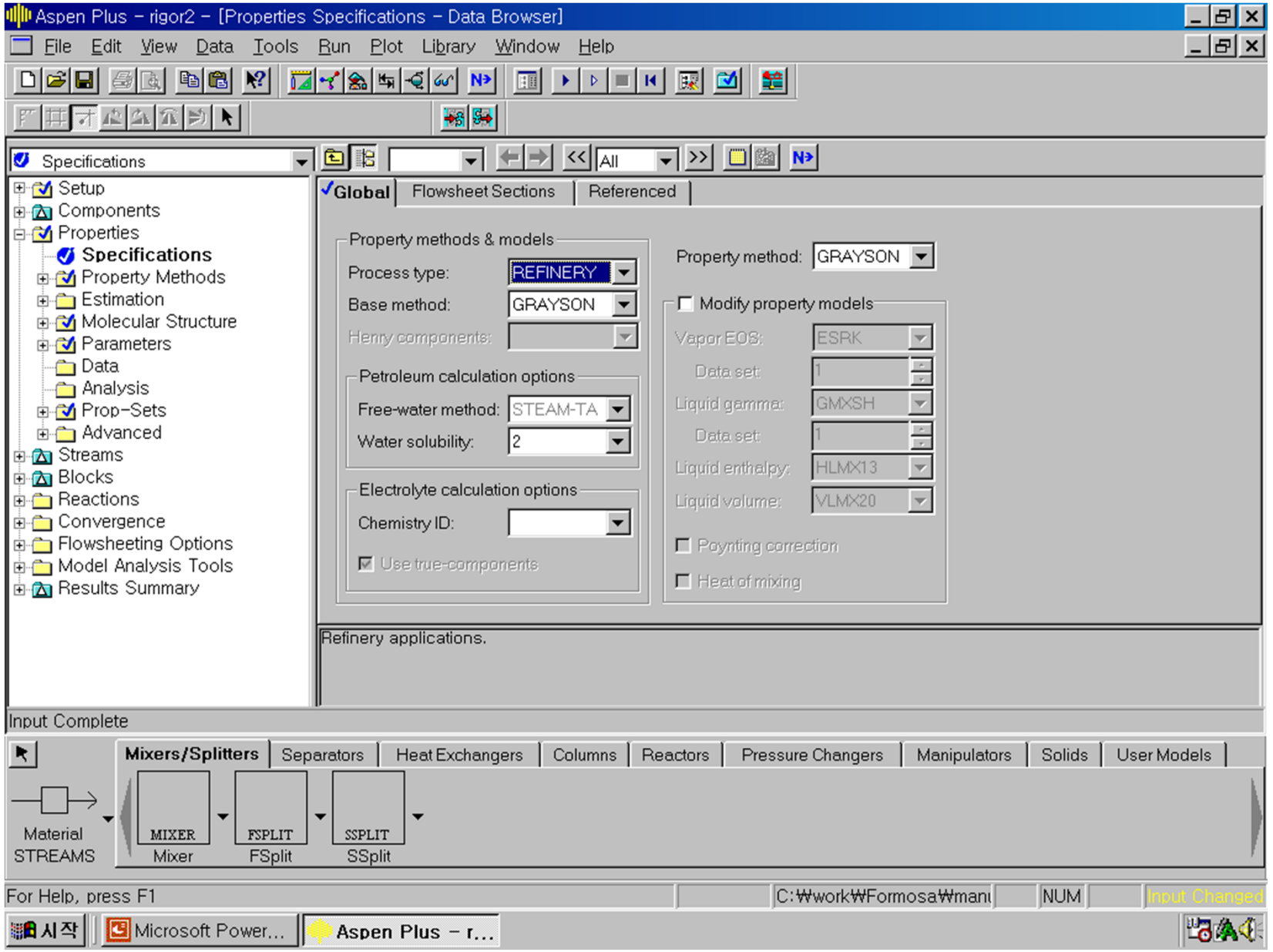
- In the Model Library, click the Column tab.
- Select the unit operation model, PetroFrac, to place in your process flowsheet.
- In this case, you should select the PetroFrac icon CDU10F.
- Place the CDU10F icon in the flowsheet. Name the block CRUDE.
- Click the Material Stream icon on the left side of the Model Library.
- Point a blank part of the process flowsheet window where you want the feed to originates and click once.

For the CRUDE stream, first connect it to the bottom of feed port and then Drag it to the desired location in front of the feed furnace.

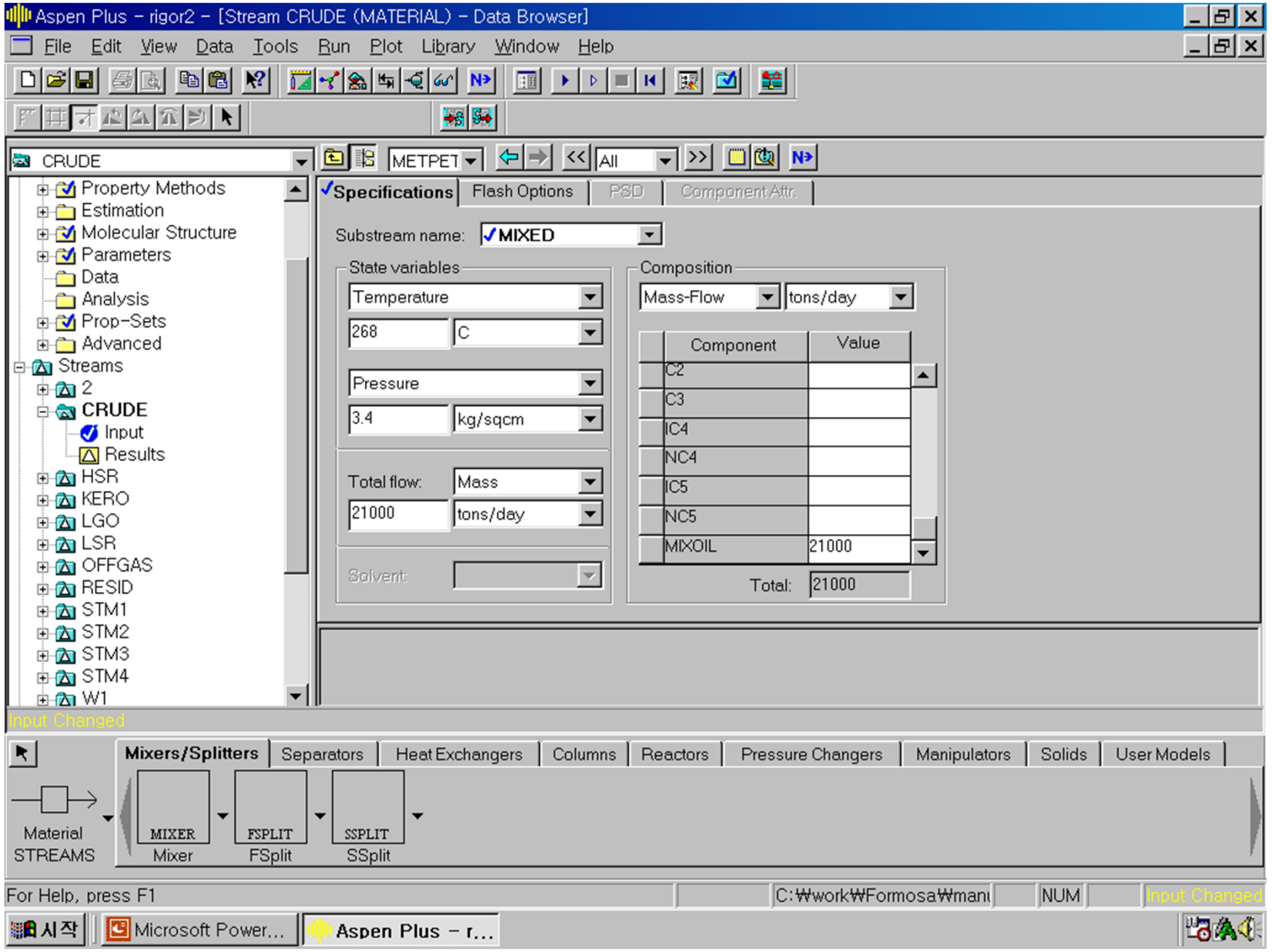
Streams and Corresponding Ports

Stream ID	Port Name
CRUDE	Main Column Feed
STM1	Stripping Steam for HSR Side Stripper
STM2	Stripping Steam for Kerosene Side Stripper
STM3	Stripping Steam for LGO Side Stripper
STM4	Stripping Steam for Main Column
WTR	Condenser Water Decant for Main Column
2	Vapor Flow from Main Column Overhead
LSR	Distillate Product from Main Column Overhead
HSR	Bottom Product from Upper Side Stripper
KERO	Bottom Product from Middle Side Stripper
LGO	Bottom Product from Lower Side Stripper
RESIDUE	Bottom Product from Main Column

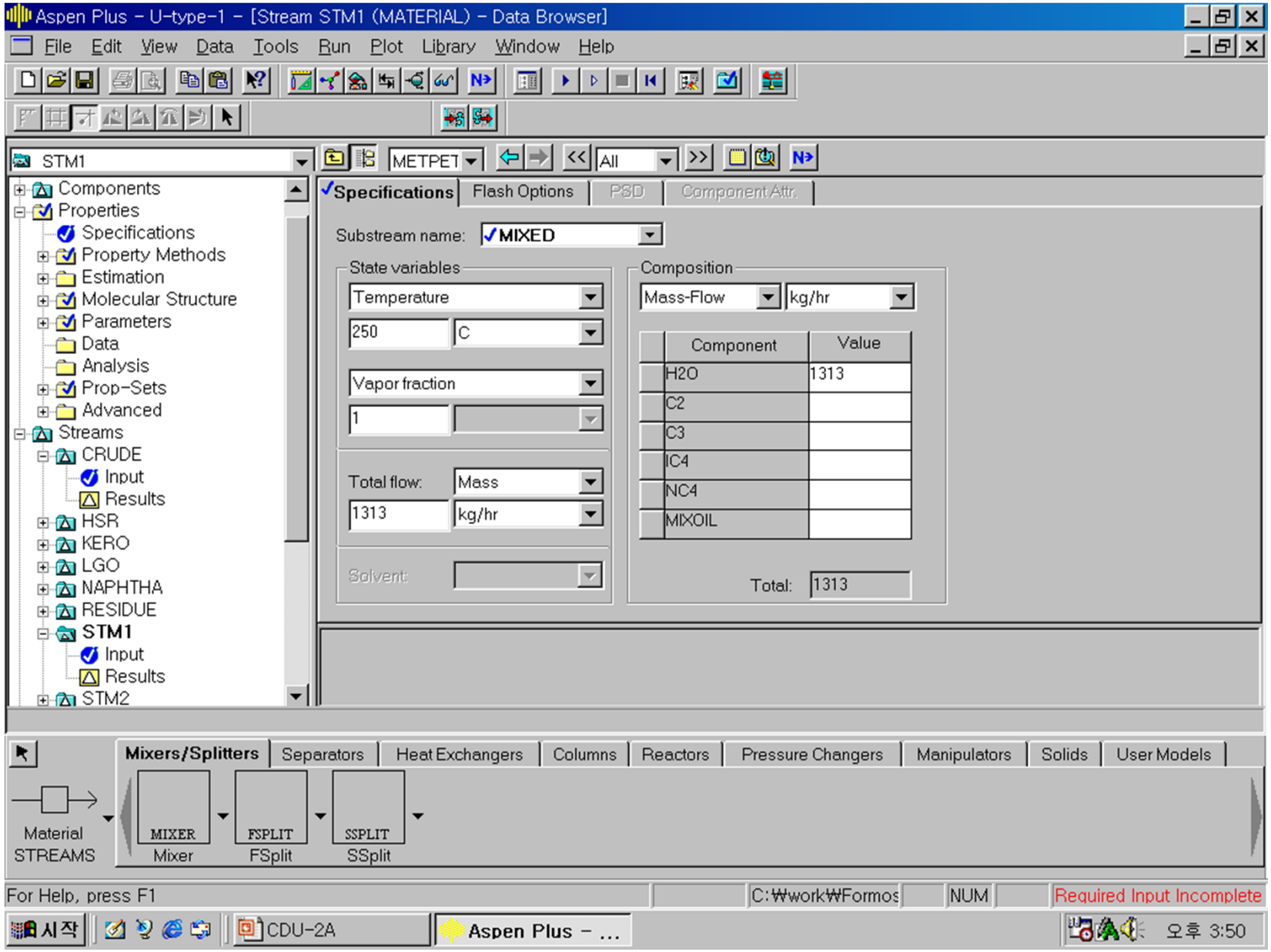
Specifying Properties



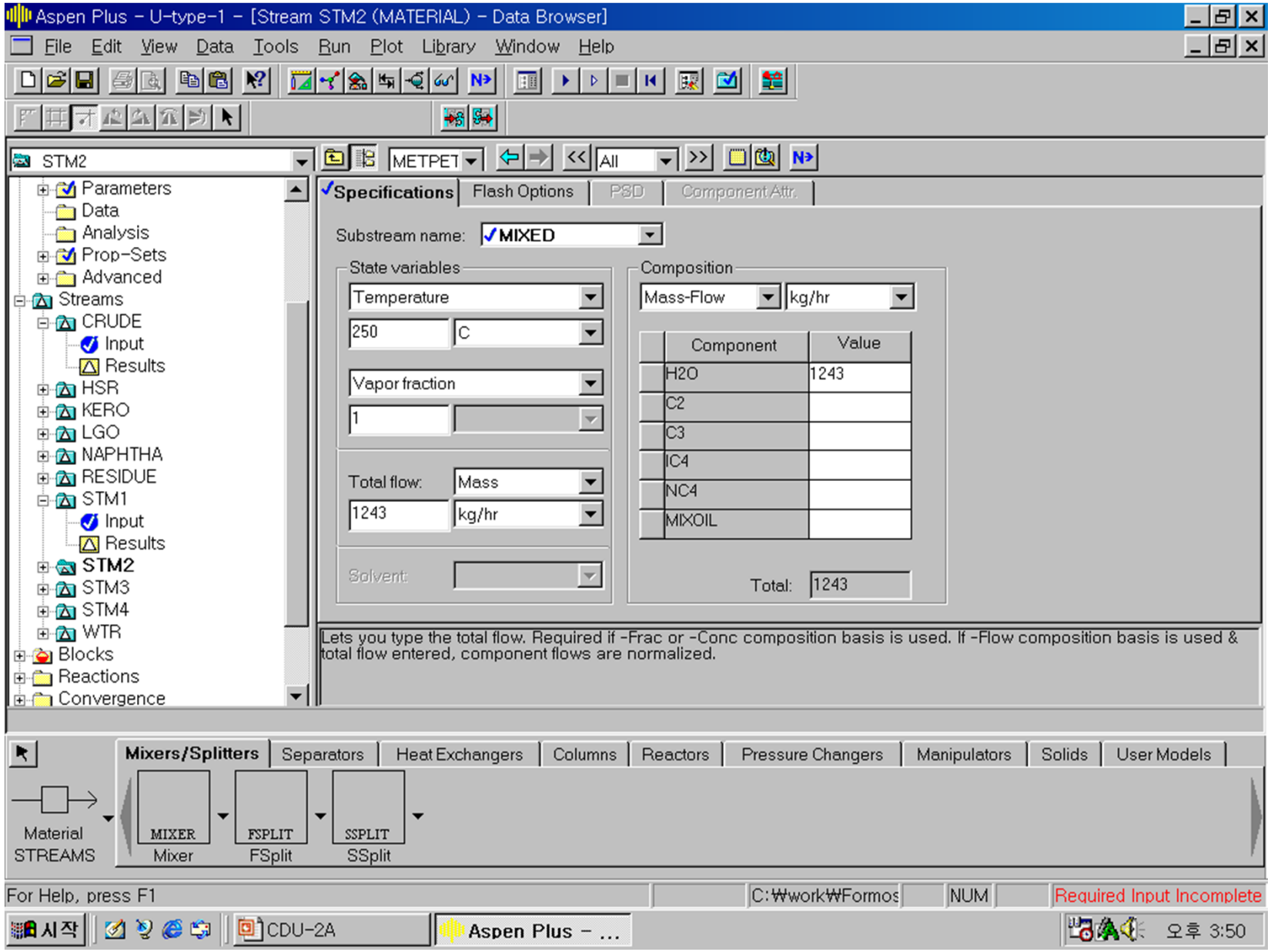
Entering Stream Data for CRUDE



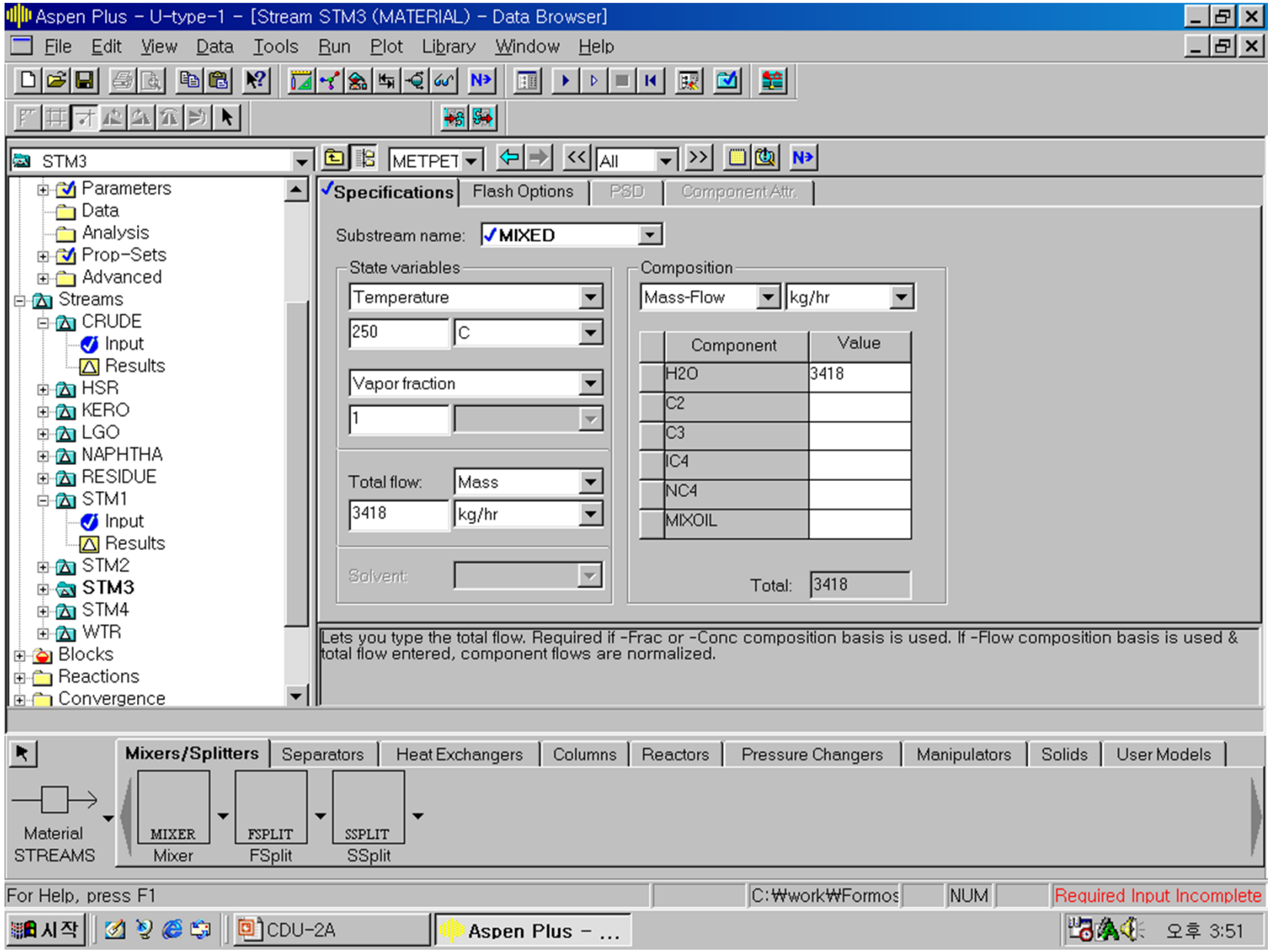
Specifying STM1 to the Upper Side Stripper



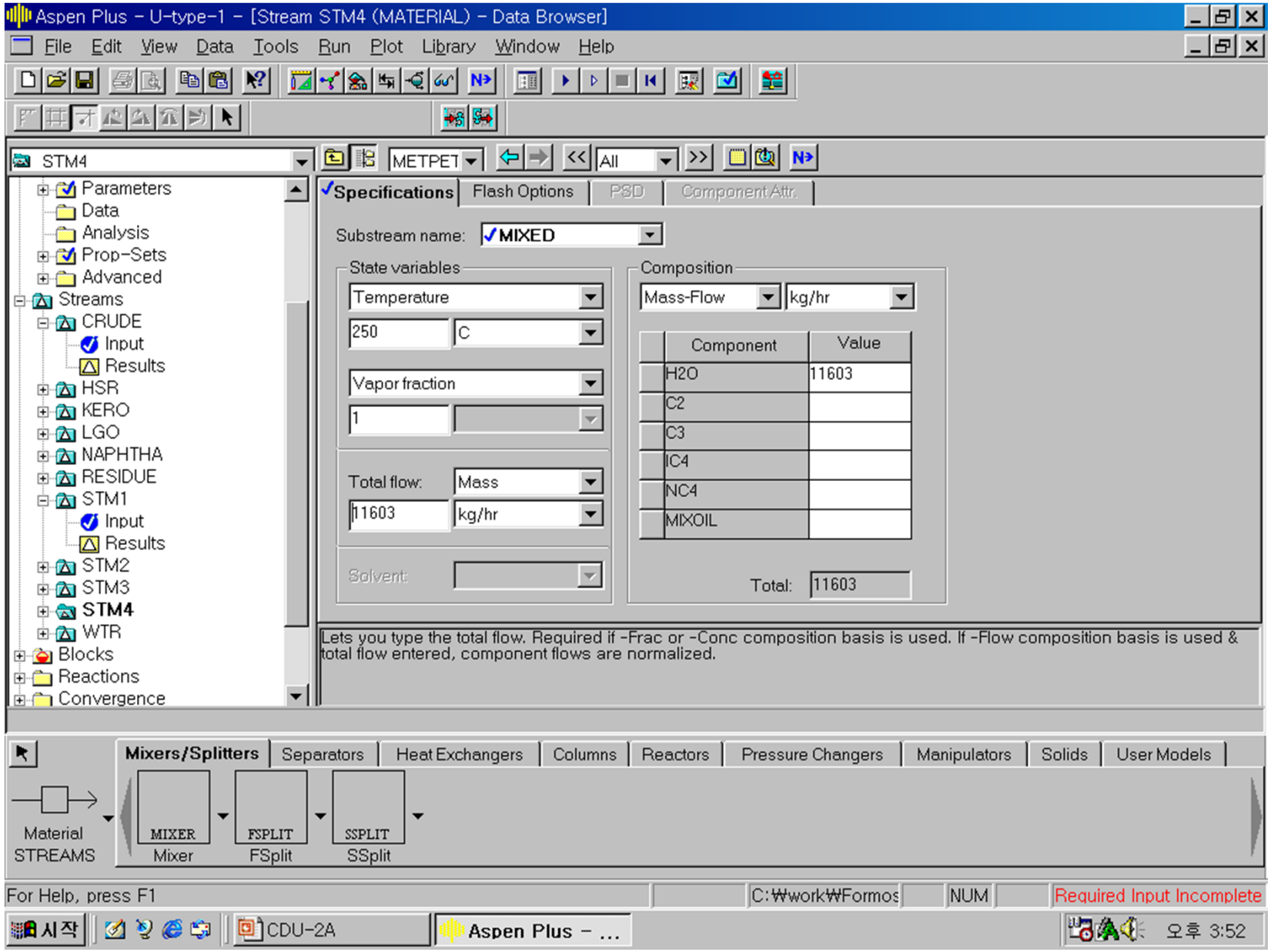
Specifying STM2 to the Middle Side Stripper



Specifying STM3 to the Lower Side Stripper



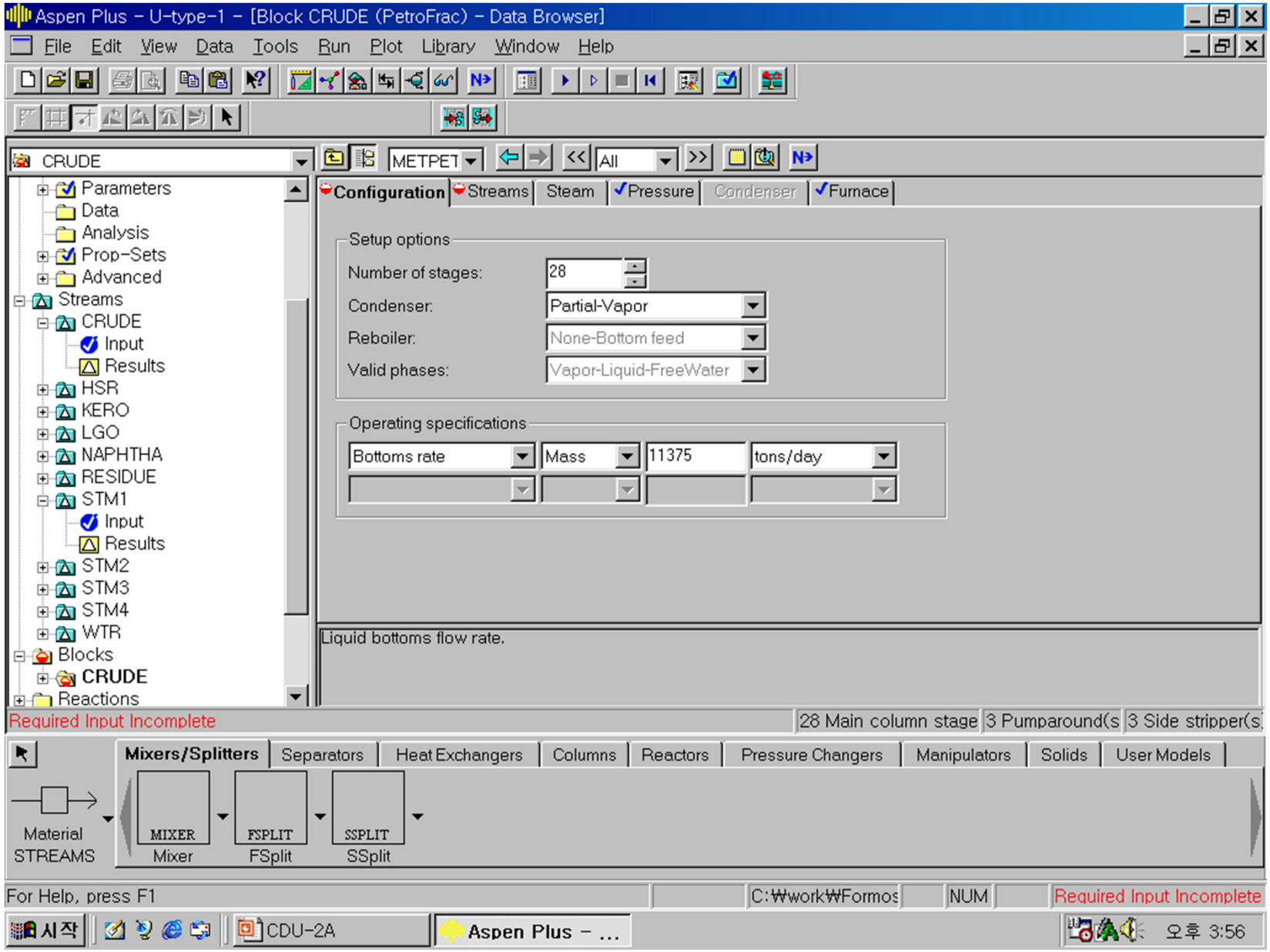
Specifying STM4 to the Main Column



Specifying the Atmospheric Column

On the Configuration Sheet, specify:	
Number of Stages	**28**
Condenser	**Partial**
Reboiler	**Non-Bottom Feed**
Bottoms (Residue) rate	***11,375 Ton/day***

- The bottoms (Atmospheric residue) flowrate is an estimate. This value will be manipulated to achieve the desired ASTM 95% temperature for LSR stream.


Aspen Plus – U-type-1 – [Block CRUDE (PetroFrac) – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
CRUDE
METPET
All
Parameters
Data
Analysis
Prop-Sets
Advanced
Streams
CRUDE
Input
Results
HSR
KERO
LGO
NAPHTHA
RESIDUE
STM1
Input
Results
STM2
STM3
STM4
WTR
Blocks
CRUDE
Reactions
Configuration
Streams
Steam
Pressure
Condenser
Furnace
Setup options
Number of stages: 28
Condenser: Partial-Vapor
Reboiler: None-Bottom feed
Valid phases: Vapor-Liquid-FreeWater
Operating specifications
Bottoms rate Mass 11375 tons/day
Liquid bottoms flow rate.
Required Input Incomplete
28 Main column stage
3 Pumparound(s
3 Side stripper(s
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
Solids
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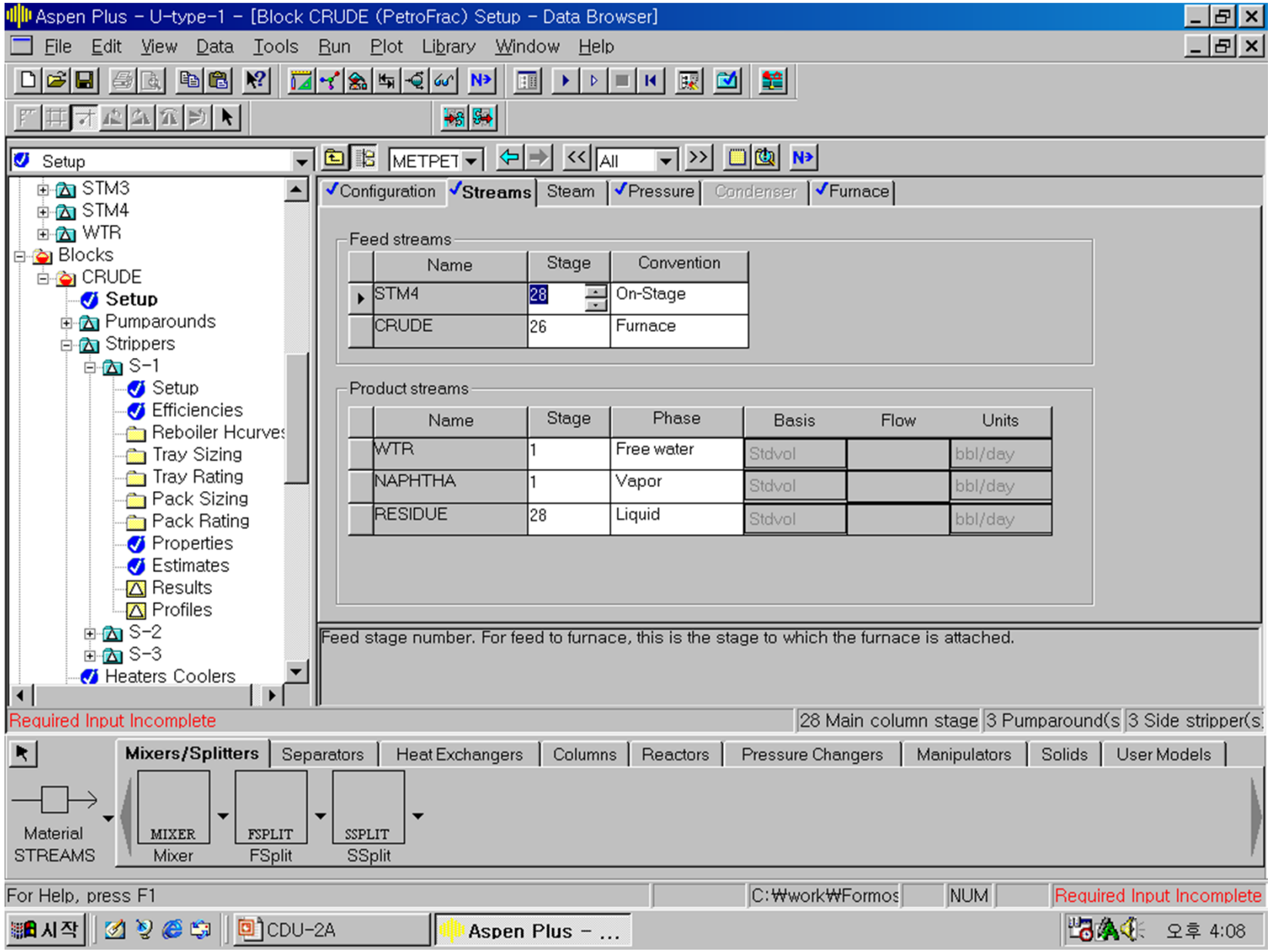
Specifying the Atmospheric Column (2)

	Stage	Conditions and Flow
CRUDE	**26**	**Furnace**
STM4	**28**	**On-Stage**

Specifying Furnace Feed Convention

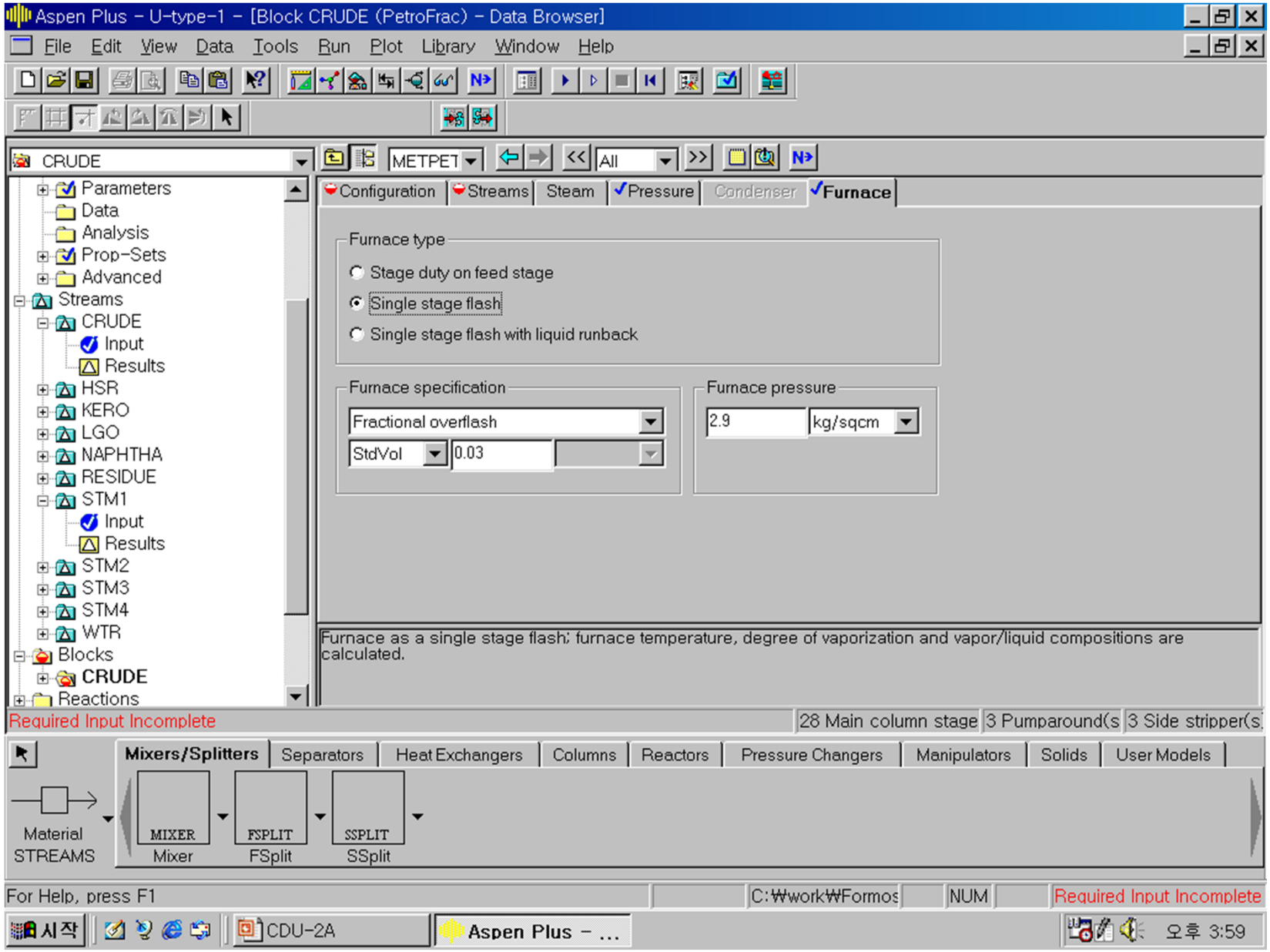


- Enter the following pressures using the Top/Bottom View:

Stage 1 / Condenser Pressure	**1.490 Kg/cm2**
Stage 2 Pressure	**2.330 Kg/cm2**
Bottom Stage Pressure	**2.770 Kg/cm2**

- Select the Single stage flash Furnace type in the Furnace sheet.

- Specify a StdVol Fractional *overflash* of 0.03 and a Furnace pressure of 2.9Kg/cm^2.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Analysis
Prop-Sets
Advanced
Streams
CRUDE
Input
Results
HSR
KERO
LGO
NAPHTHA
RESIDUE
STM1
Input
Results
STM2
STM3
STM4
WTR
Blocks
CRUDE
Reactions
Configuration
Streams
Steam
Pressure
Condenser
Furnace
Furnace type
Stage duty on feed stage
Single stage flash
Single stage flash with liquid runback
Furnace specification
Fractional overflash
StdVol
0.03
Furnace pressure
2.9
kg/sqcm
Furnace as a single stage flash; furnace temperature, degree of vaporization and vapor/liquid compositions are calculated.
Required Input Incomplete
28 Main column stage
3 Pumparound(s
3 Side stripper(s
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
Solids
User Models
Material
STREAMS
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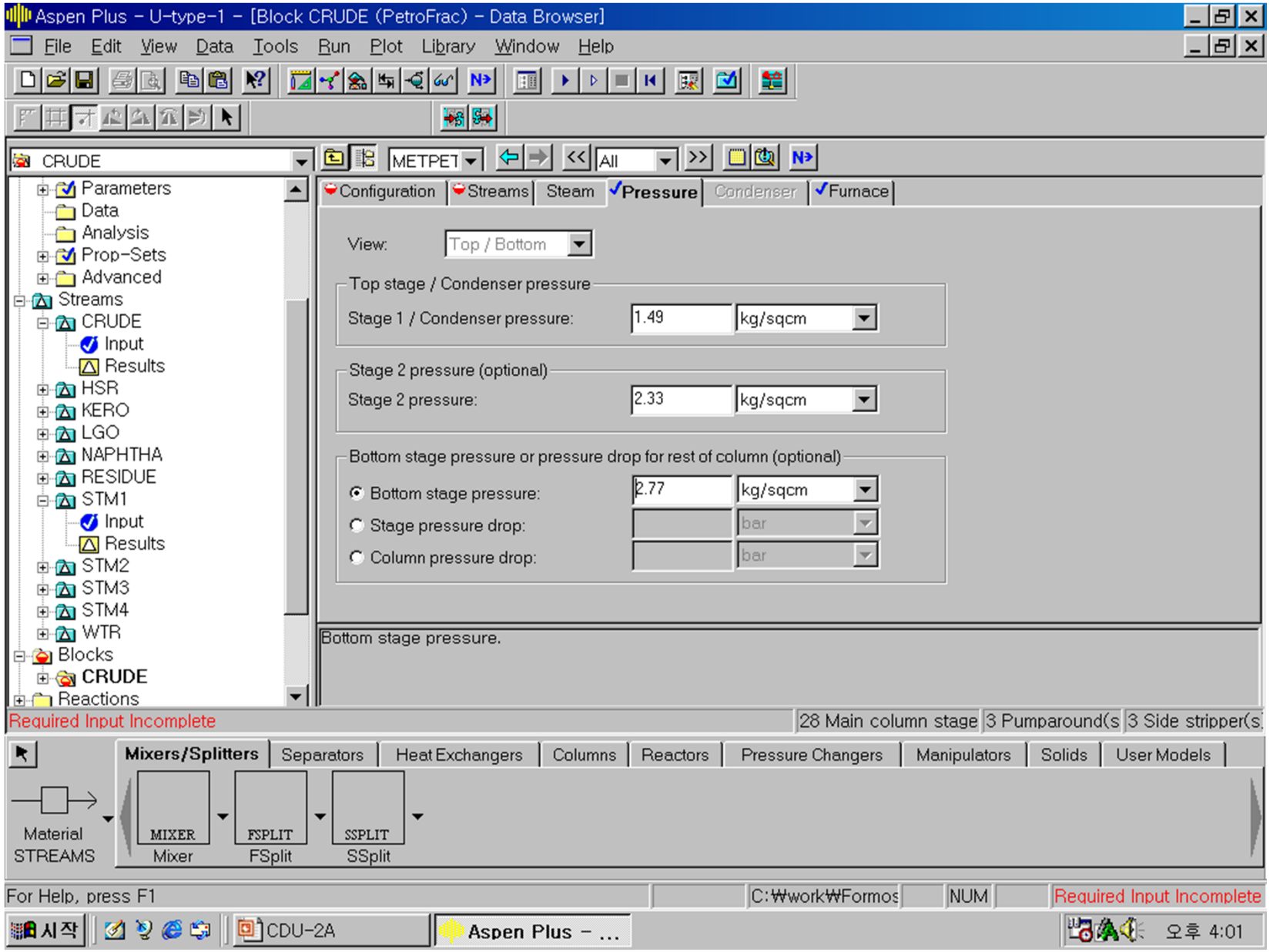
Aspen Plus – U-type-1 – [Block CRUDE (PetroFrac) – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
CRUDE
METPET
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Parameters
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Analysis
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Advanced
Streams
CRUDE
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Results
HSR
KERO
LGO
NAPHTHA
RESIDUE
STM1
Input
Results
STM2
STM3
STM4
WTR
Blocks
CRUDE
Reactions
Configuration
Streams
Steam
Pressure
Condenser
Furnace
View:
Top / Bottom
Top stage / Condenser pressure
Stage 1 / Condenser pressure:
1.49
kg/sqcm
Stage 2 pressure (optional)
Stage 2 pressure:
2.33
kg/sqcm
Bottom stage pressure or pressure drop for rest of column (optional)
Bottom stage pressure:
2.77
kg/sqcm
Stage pressure drop:
bar
Column pressure drop:
bar
Bottom stage pressure.
Required Input Incomplete
28 Main column stage
3 Pumparound(s
3 Side stripper(s
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
Solids
User Models
Material
STREAMS
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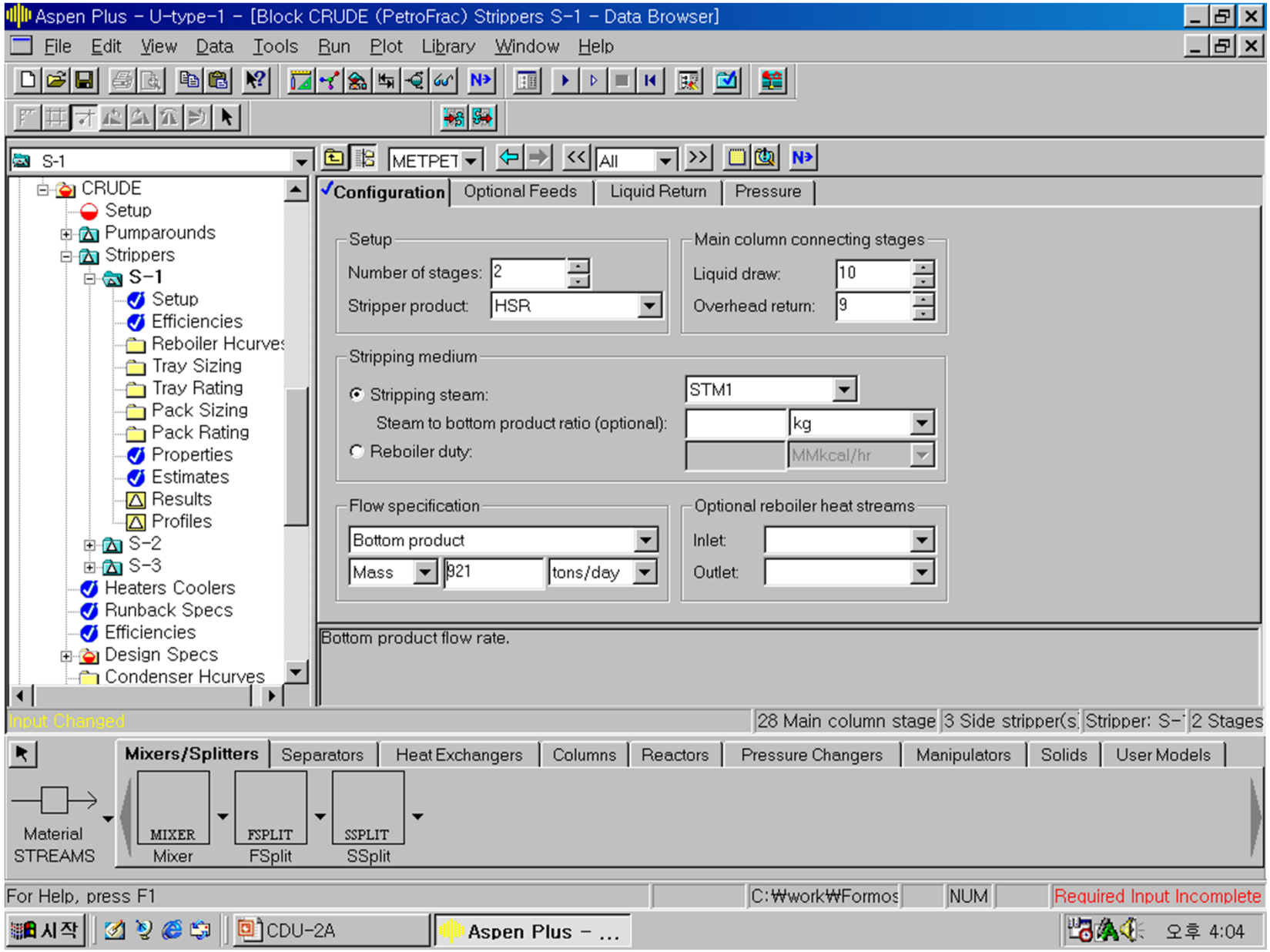
Specifying for Stripper S-1

Enter the following specifications:	
Number of stages	2
Liquid draw stage	10
Overhead return stage	9
Stripper product	HSR
Stripping steam	STM1
Bottom product flow	921 Ton/day


Aspen Plus – U-type-1 – [Block CRUDE (PetroFrac) Strippers S-1 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
S-1
METPET
All
CRUDE
Setup
Pumparounds
Strippers
S-1
Setup
Efficiencies
Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
Pack Rating
Properties
Estimates
Results
Profiles
S-2
S-3
Heaters Coolers
Runback Specs
Efficiencies
Design Specs
Condenser Hcurves
Configuration
Optional Feeds
Liquid Return
Pressure
Setup
Number of stages: 2
Stripper product: HSR
Main column connecting stages
Liquid draw: 10
Overhead return: 9
Stripping medium
Stripping steam: STM1
Steam to bottom product ratio (optional): kg
Reboiler duty: MMkcal/hr
Flow specification
Bottom product
Mass 921 tons/day
Optional reboiler heat streams
Inlet:
Outlet:
Bottom product flow rate.
Input Changed
28 Main column stage
3 Side stripper(s
Stripper: S-
2 Stages
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
Solids
User Models
Material
STREAMS
MIXER
Mixer
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FSplit
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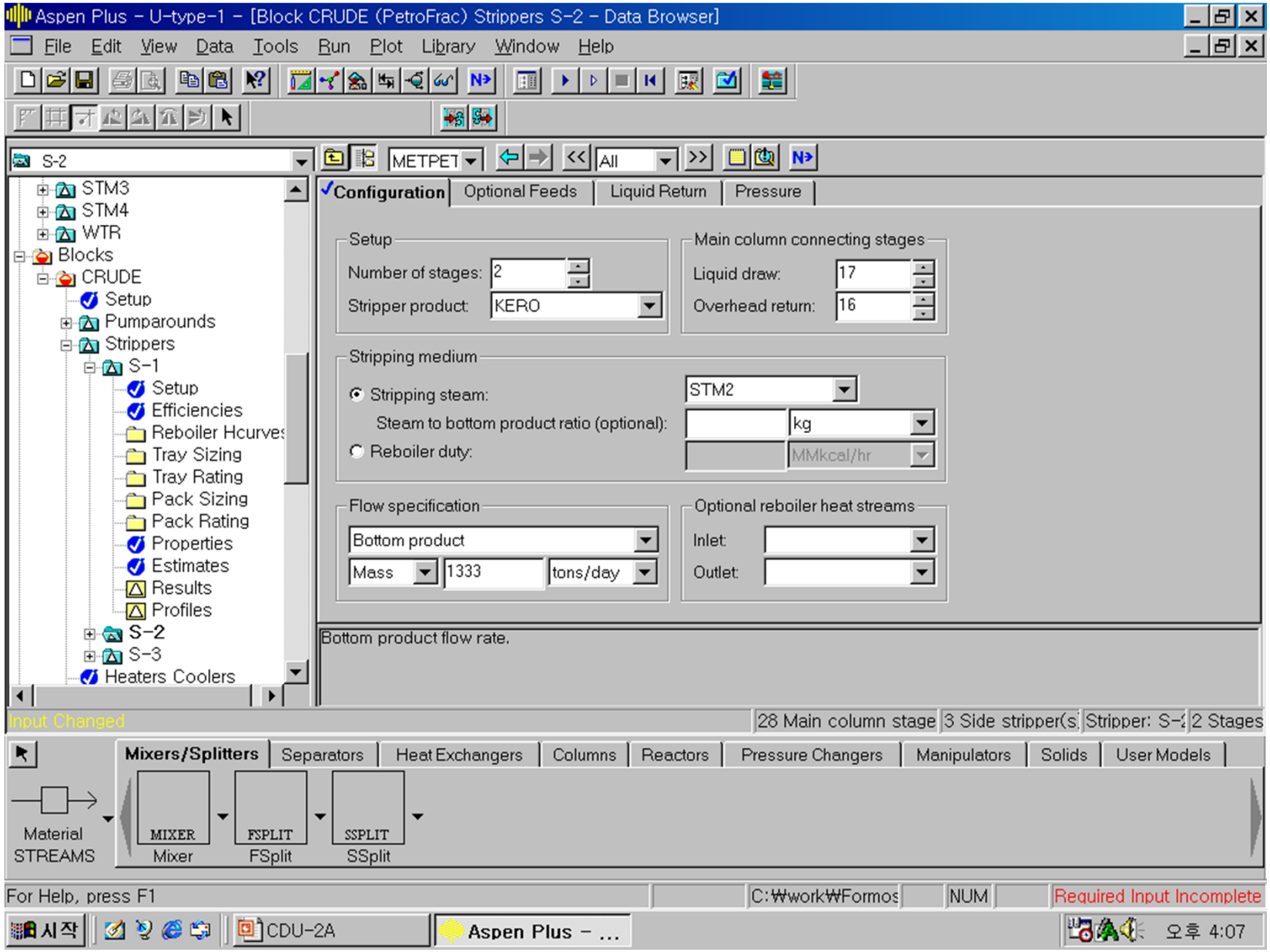
Aspen Plus – ...
오후 4:04

Specifying for Stripper S-2

Enter the following specifications:	
Number of stages	2
Liquid draw stage	17
Overhead return stage	16
Stripper product	KEROSENE
Stripping steam	STM2
Bottom product flow	1,333 Ton/day


Aspen Plus – U-type-1 – [Block CRUDE (PetroFrac) Strippers S-2 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
S-2
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STM3
STM4
WTR
Blocks
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Setup
Pumparounds
Strippers
S-1
Setup
Efficiencies
Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
Pack Rating
Properties
Estimates
Results
Profiles
S-2
S-3
Heaters Coolers
Configuration
Optional Feeds
Liquid Return
Pressure
Setup
Number of stages: 2
Stripper product: KERO
Main column connecting stages
Liquid draw: 17
Overhead return: 16
Stripping medium
Stripping steam: STM2
Steam to bottom product ratio (optional):
kg
Reboiler duty:
MMkcal/hr
Flow specification
Bottom product
Mass 1333 tons/day
Optional reboiler heat streams
Inlet:
Outlet:
Bottom product flow rate.
Input Changed
28 Main column stage
3 Side stripper(s
Stripper: S-2
2 Stages
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
Solids
User Models
Material
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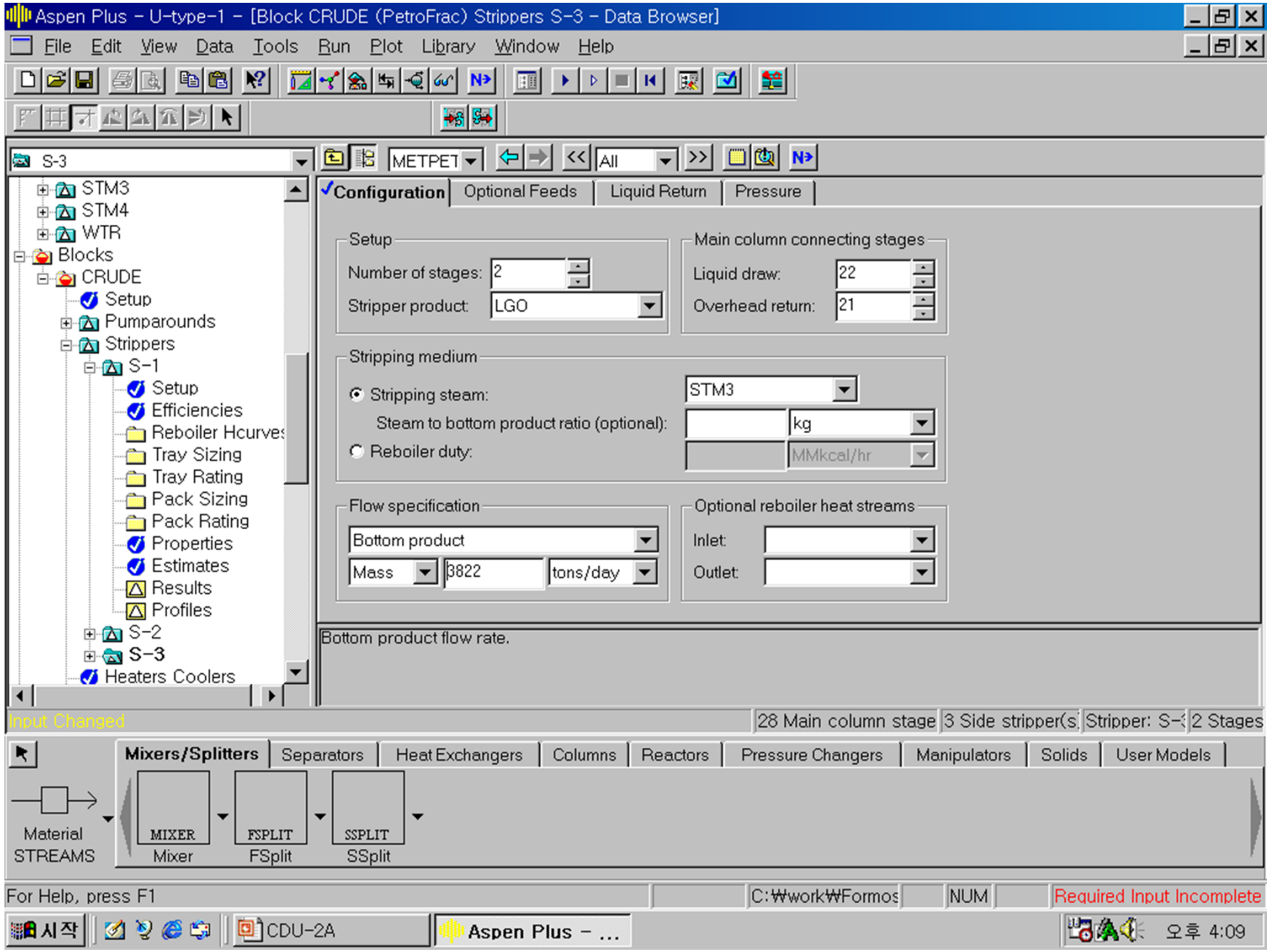
Aspen Plus – ...
오후 4:07

Specifying for Stripper S-3

Enter the following specifications:	
Number of stages	2
Liquid draw stage	22
Overhead return stage	21
Stripper product	LGO
Stripping steam	STM3
Bottom product flow	3,822 Ton/day


Aspen Plus – U-type-1 – [Block CRUDE (PetroFrac) Strippers S-3 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
S-3
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STM4
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Blocks
CRUDE
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Pumparounds
Strippers
S-1
Setup
Efficiencies
Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
Pack Rating
Properties
Estimates
Results
Profiles
S-2
S-3
Heaters Coolers
Configuration
Optional Feeds
Liquid Return
Pressure
Setup
Number of stages: 2
Stripper product: LGO
Main column connecting stages
Liquid draw: 22
Overhead return: 21
Stripping medium
Stripping steam: STM3
Steam to bottom product ratio (optional): kg
Reboiler duty: MMkcal/hr
Flow specification
Bottom product
Mass 3822 tons/day
Optional reboiler heat streams
Inlet:
Outlet:
Bottom product flow rate.
Input Changed
28 Main column stage
3 Side stripper(s
Stripper: S-
2 Stages
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
Solids
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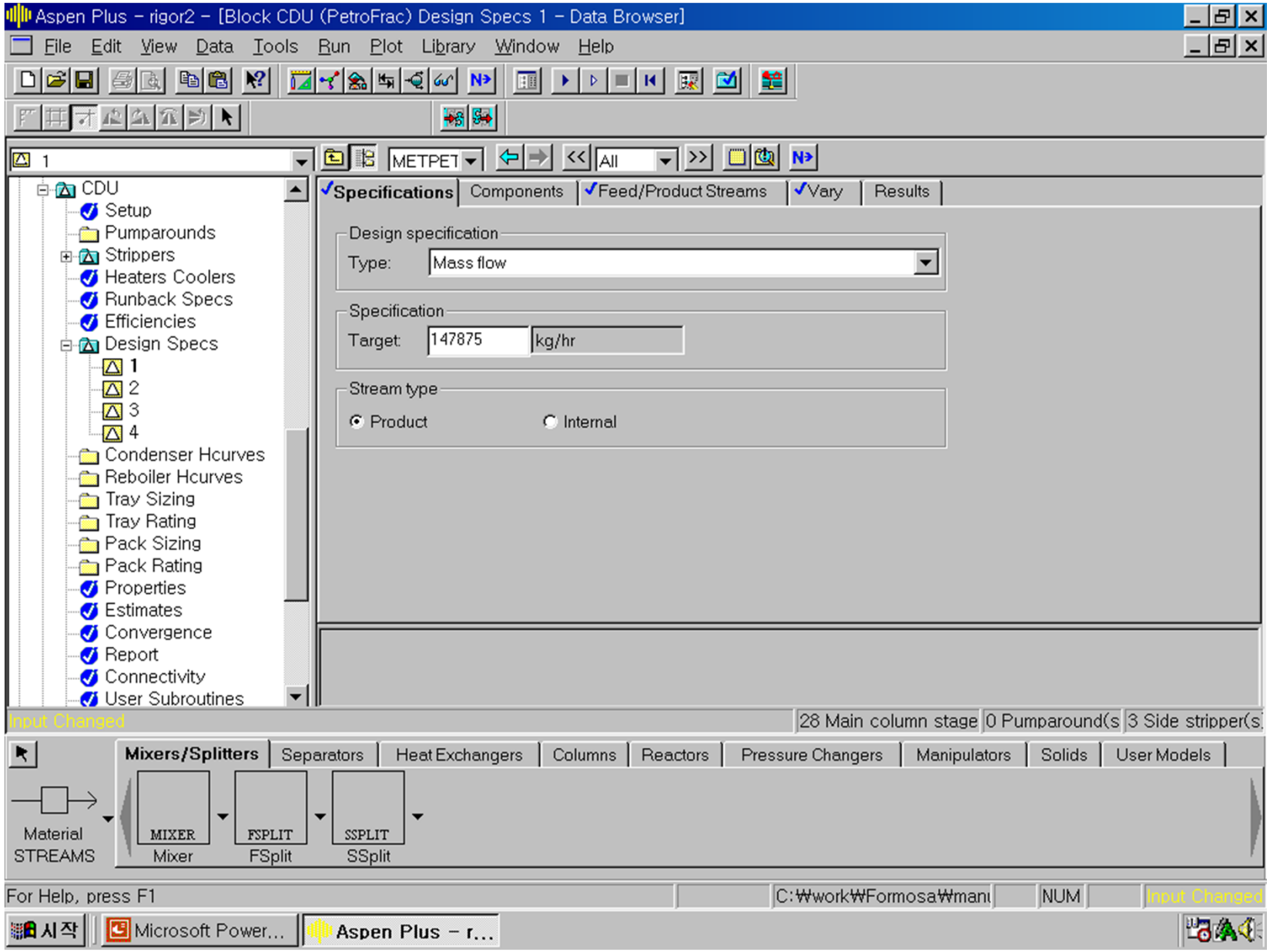
Aspen Plus – ...
오후 4:09

Specifying Mass Flowrate for Each Sidecuts

Specifications of Each Side Distillates Flowrate	
2 (Overhead Vapor)	147875 Kg/Hr
HSR	38375 Kg/Hr
KERO	55542 Kg/Hr
LGO	159250 Kg/Hr


Aspen Plus – rigor2 – [Block CDU (PetroFrac) Design Specs 1 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Condenser Hcurves
Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
Pack Rating
Properties
Estimates
Convergence
Report
Connectivity
User Subroutines
Specifications
Components
Feed/Product Streams
Vary
Results
Design specification
Type: Mass flow
Specification
Target: 147875 kg/hr
Stream type
Product
Internal
Input Changed
28 Main column stage
0 Pumparound(s
3 Side stripper(s
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
Solids
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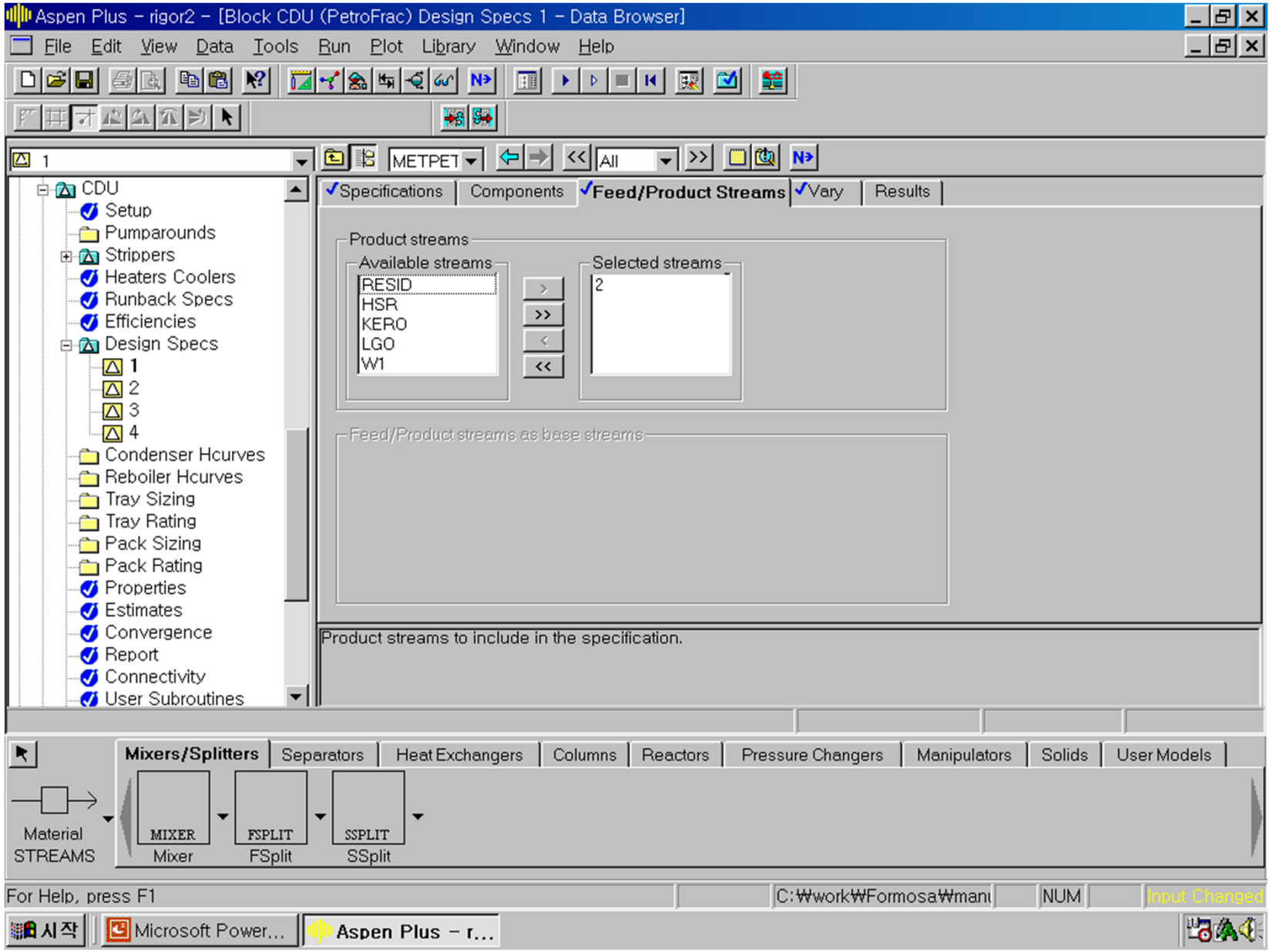
Aspen Plus – rigor2 – [Block CDU (PetroFrac) Design Specs 1 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Reboiler Hcurves
Tray Sizing
Tray Rating
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Estimates
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Product streams
Available streams
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Product streams to include in the specification.
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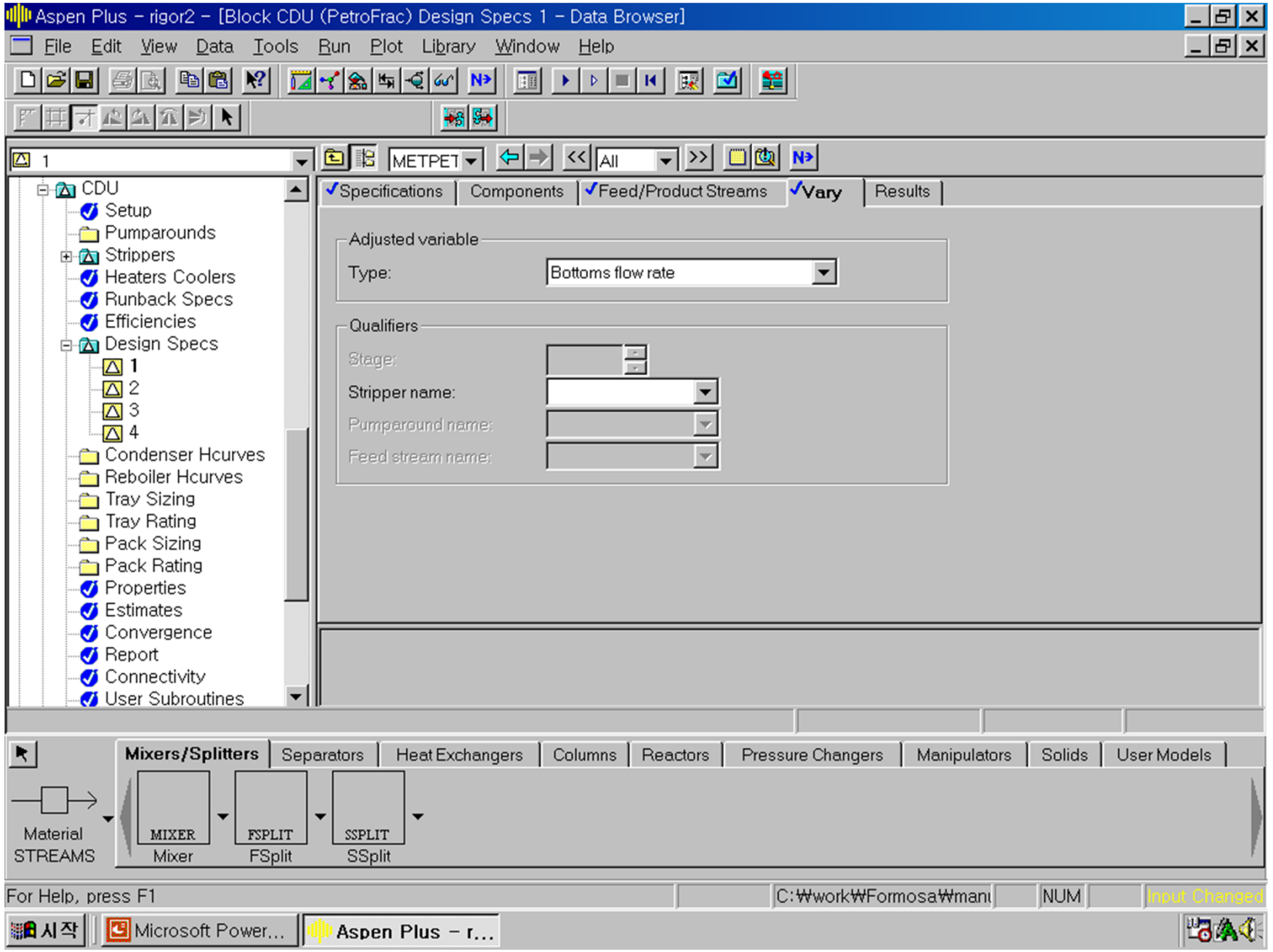
Aspen Plus – rigor2 – [Block CDU (PetroFrac) Design Specs 1 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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User Subroutines
Specifications
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Feed/Product Streams
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Results
Adjusted variable
Type:
Bottoms flow rate
Qualifiers
Stage:
Stripper name:
Pumparound name:
Feed stream name:
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
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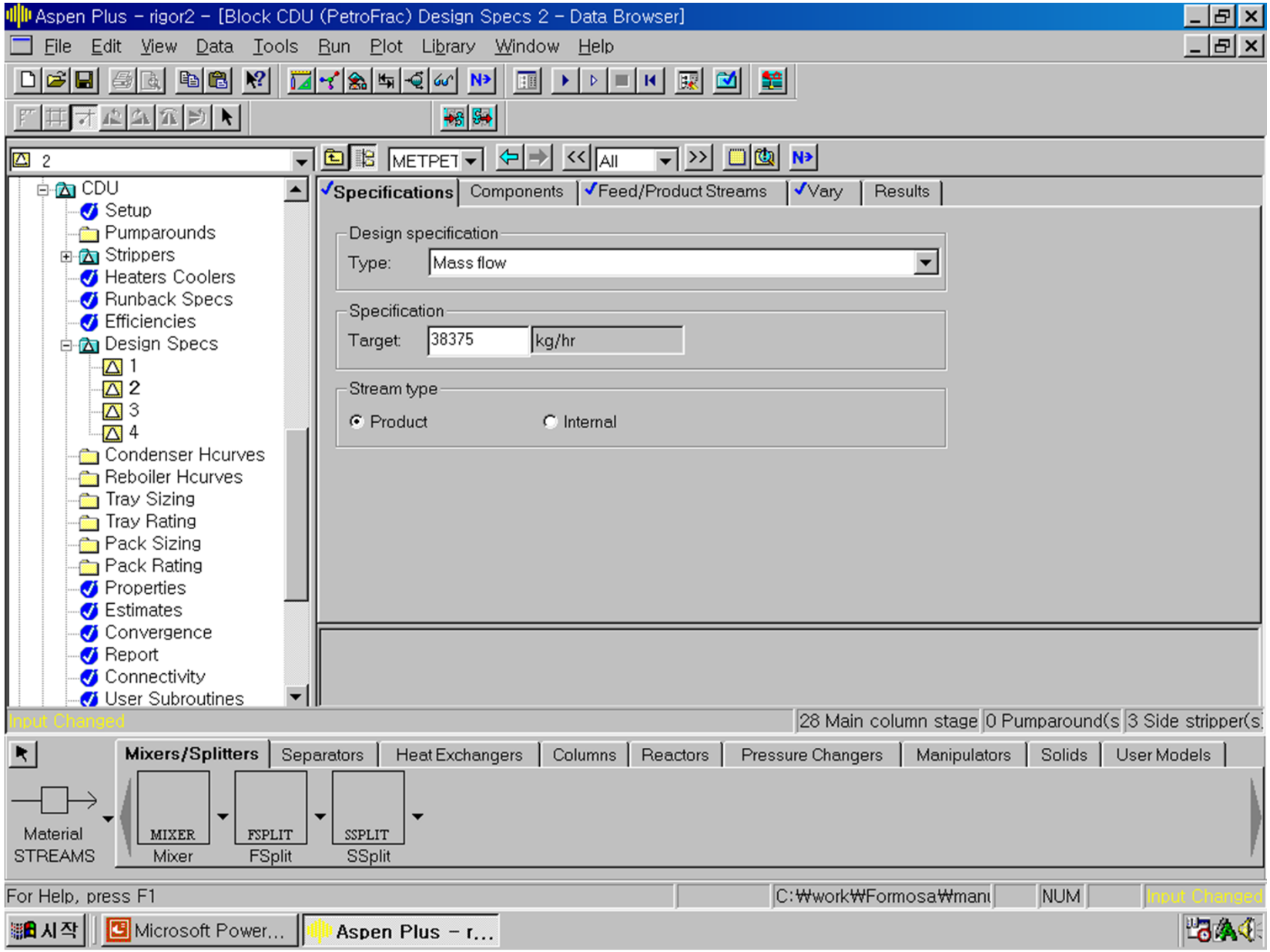
Aspen Plus – rigor2 – [Block CDU (PetroFrac) Design Specs 2 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Pack Rating
Properties
Estimates
Convergence
Report
Connectivity
User Subroutines
Specifications
Components
Feed/Product Streams
Vary
Results
Design specification
Type: Mass flow
Specification
Target: 38375 kg/hr
Stream type
Product
Internal
Input Changed
28 Main column stage
0 Pumparound(s
3 Side stripper(s
Mixers/Splitters
Separators
Heat Exchangers
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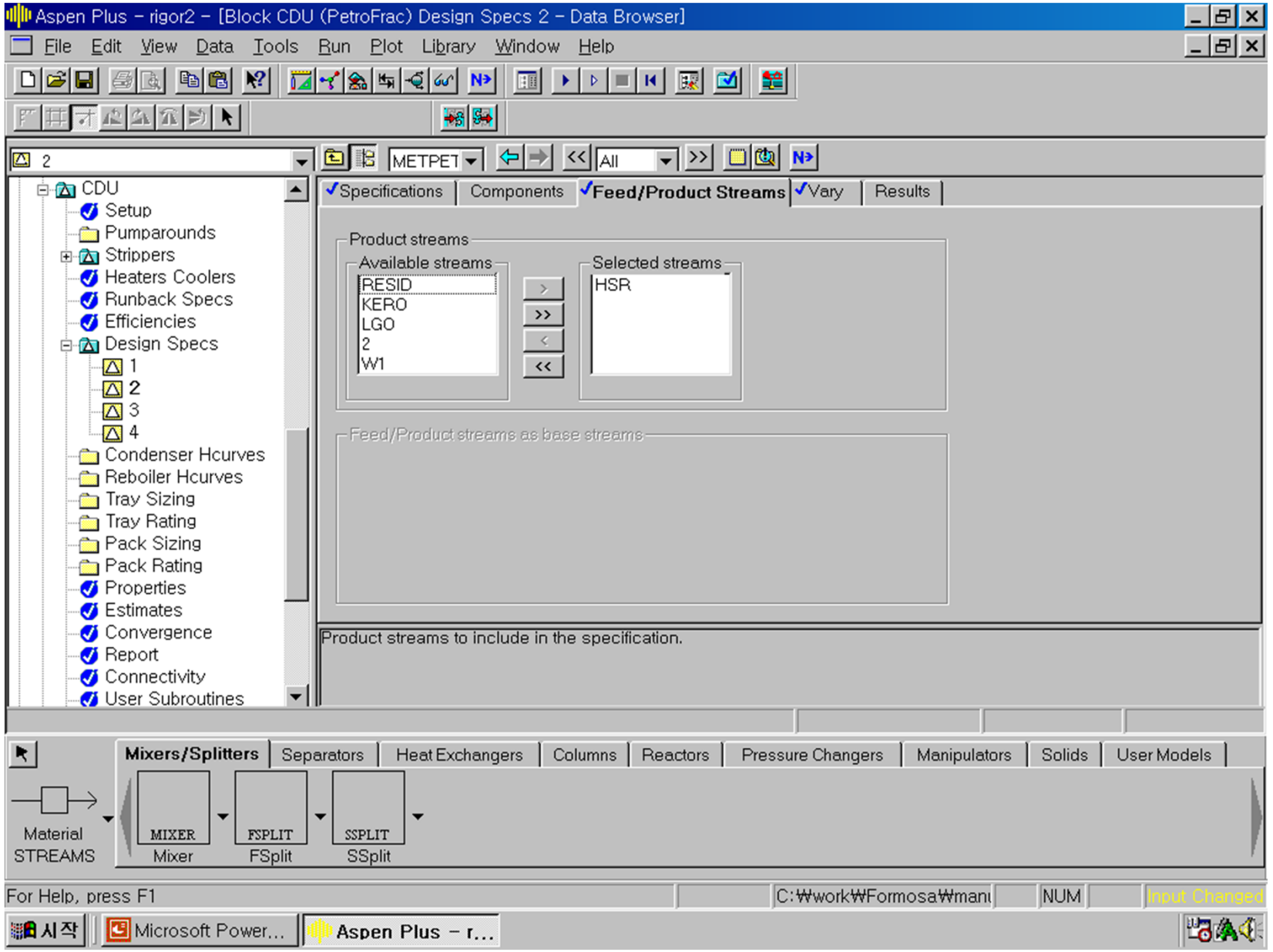
Aspen Plus – rigor2 – [Block CDU (PetroFrac) Design Specs 2 – Data Browser]
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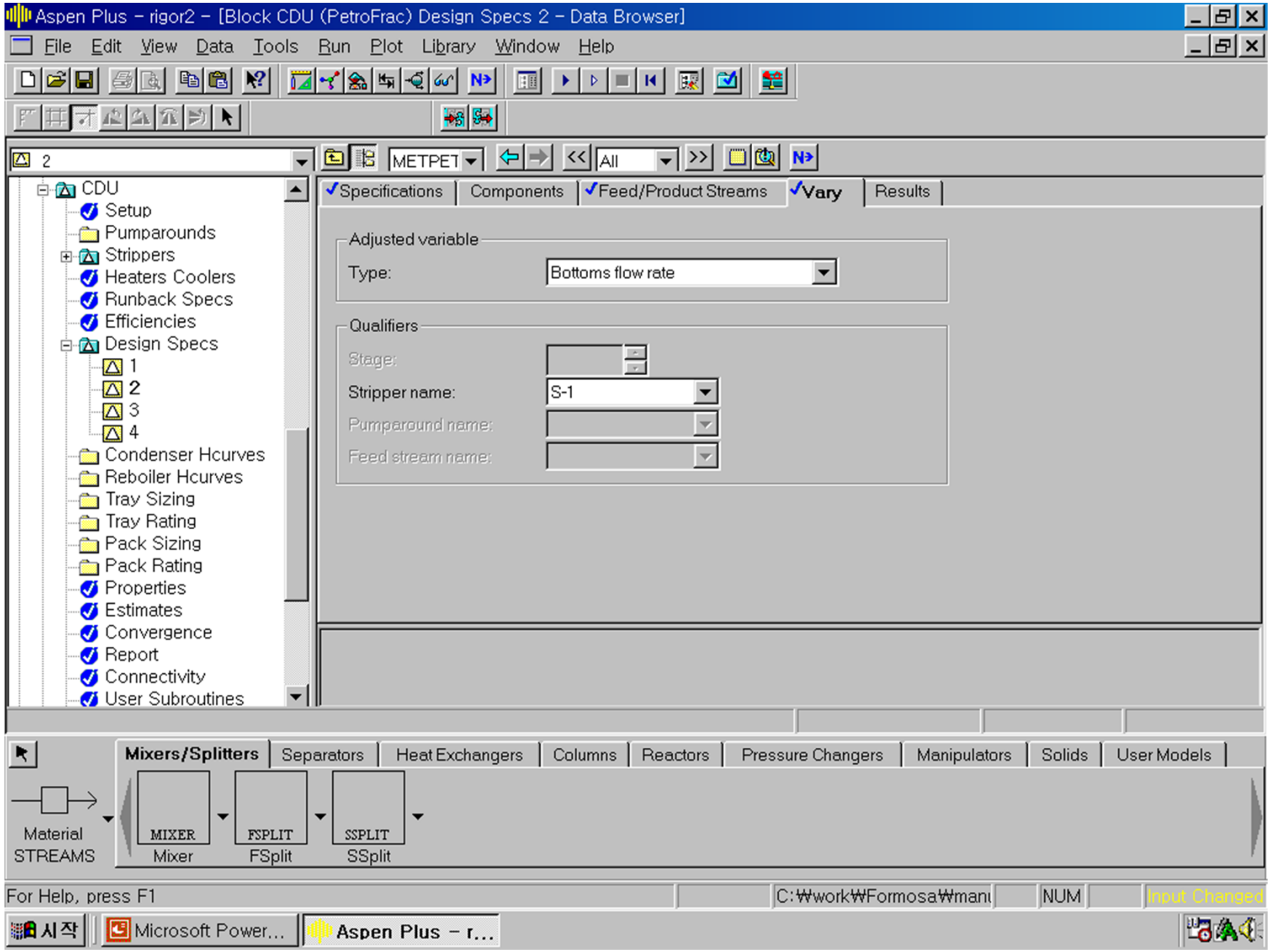
Aspen Plus – rigor2 – [Block CDU (PetroFrac) Design Specs 2 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Type:
Bottoms flow rate
Qualifiers
Stage:
Stripper name:
S-1
Pumparound name:
Feed stream name:
Mixers/Splitters
Separators
Heat Exchangers
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Reactors
Pressure Changers
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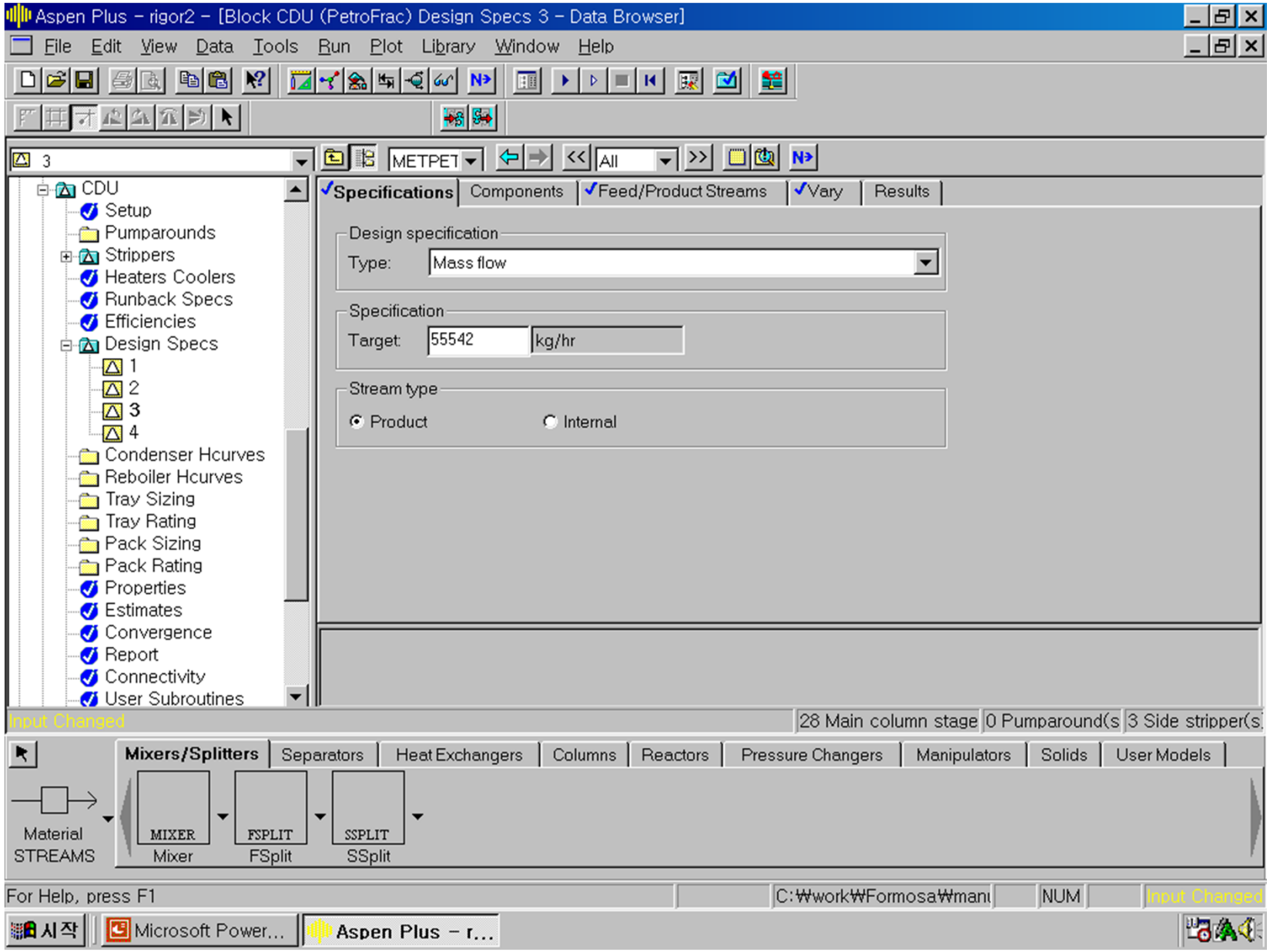
Aspen Plus – rigor2 – [Block CDU (PetroFrac) Design Specs 3 – Data Browser]
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Specifications
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Vary
Results
Design specification
Type: Mass flow
Specification
Target: 55542 kg/hr
Stream type
Product
Internal
Input Changed
28 Main column stage
0 Pumparound(s
3 Side stripper(s
Mixers/Splitters
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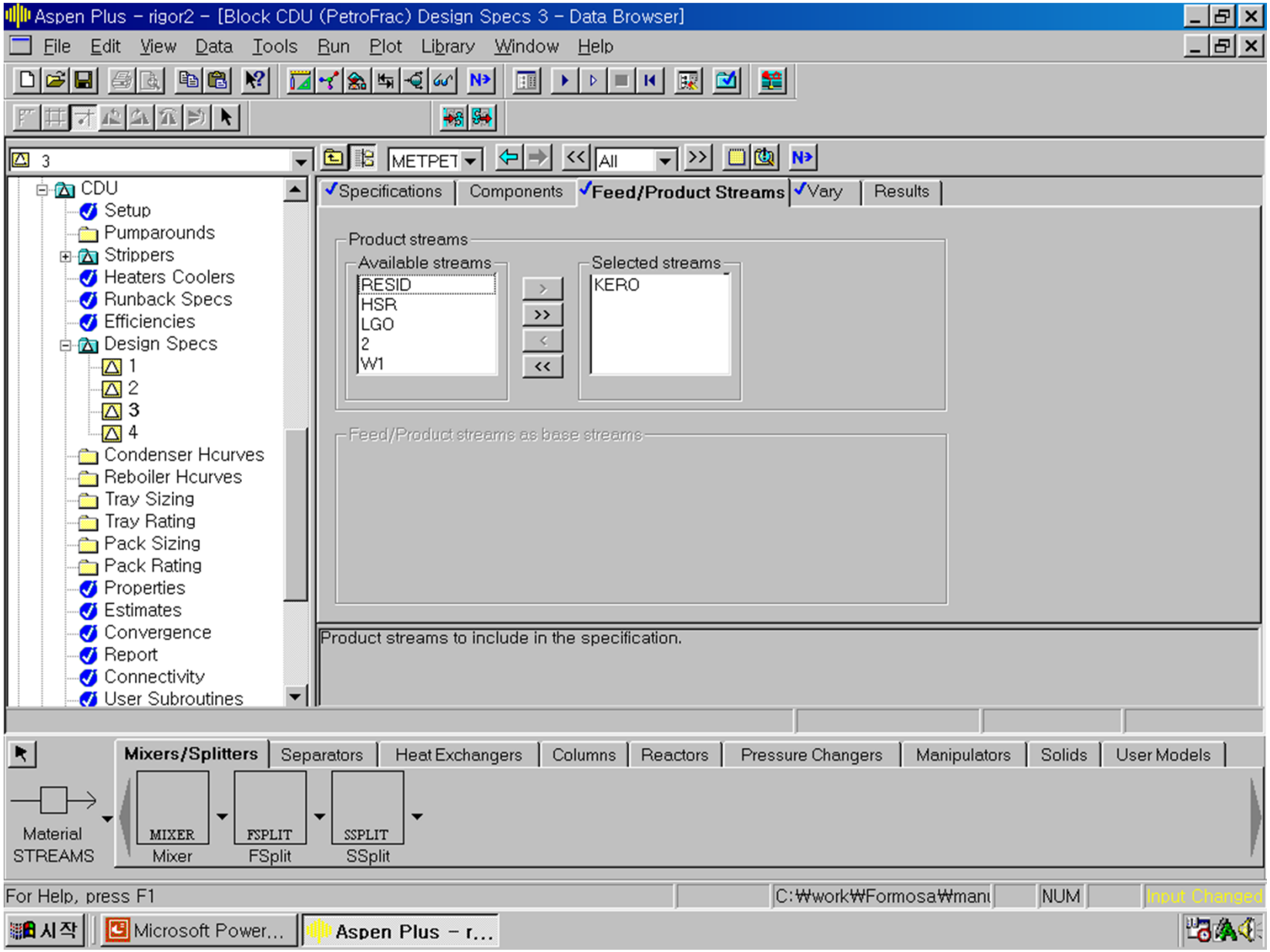
Aspen Plus – rigor2 – [Block CDU (PetroFrac) Design Specs 3 – Data Browser]
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Heat Exchangers
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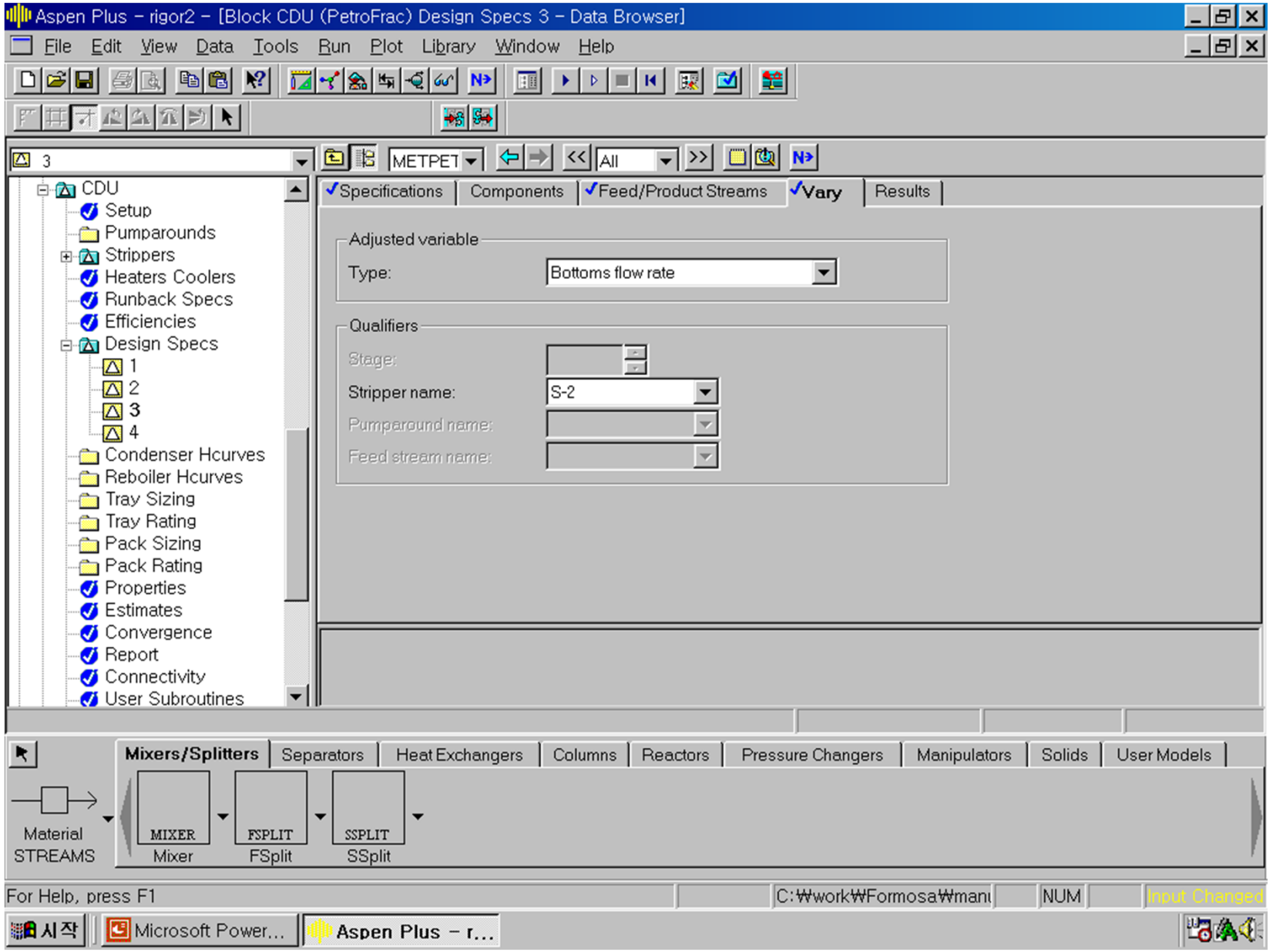
Aspen Plus – rigor2 – [Block CDU (PetroFrac) Design Specs 3 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Pack Rating
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Stripper name:
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Pumparound name:
Feed stream name:
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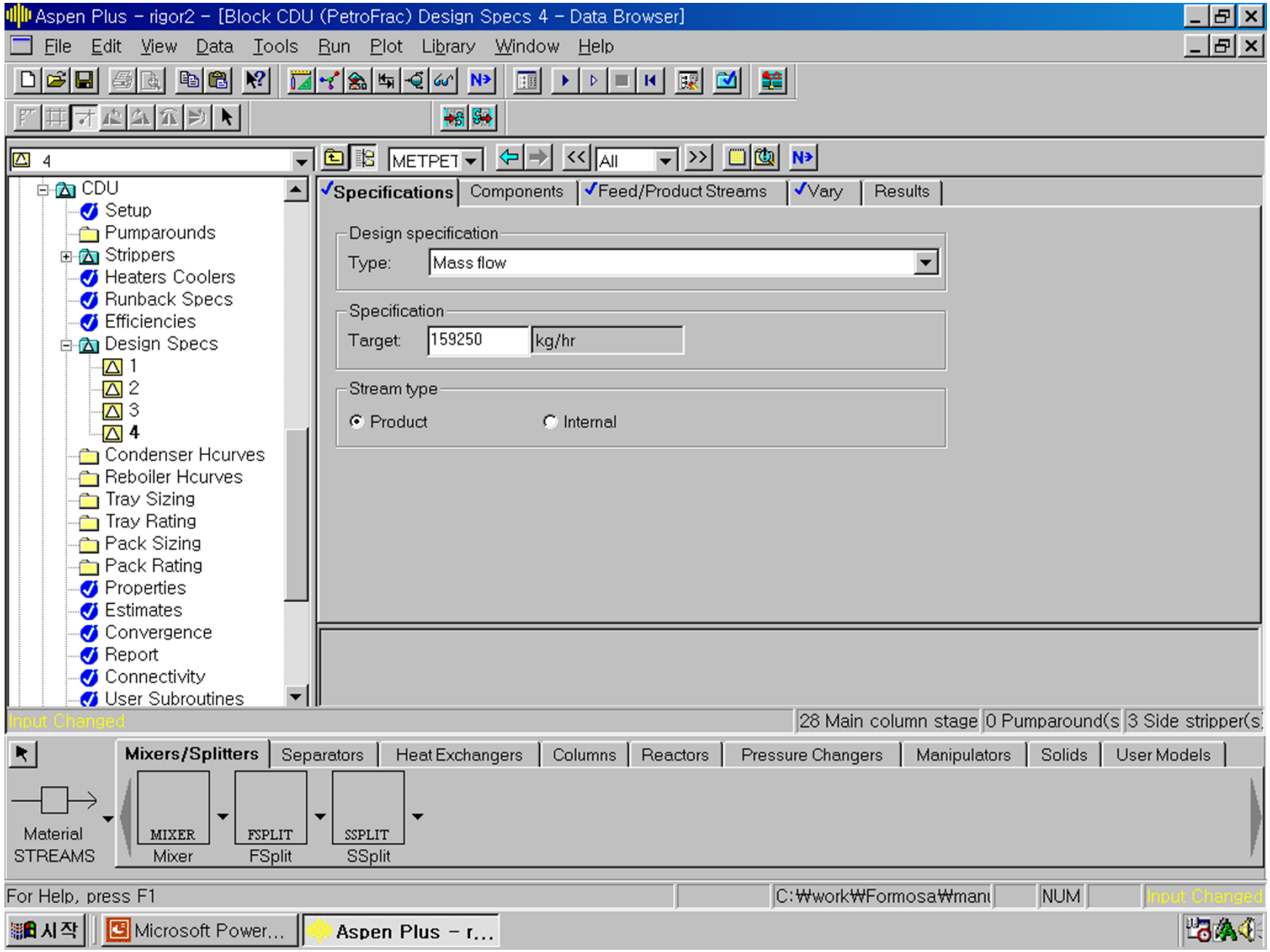
Aspen Plus – rigor2 – [Block CDU (PetroFrac) Design Specs 4 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Heaters Coolers
Runback Specs
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Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
Pack Rating
Properties
Estimates
Convergence
Report
Connectivity
User Subroutines
Specifications
Components
Feed/Product Streams
Vary
Results
Design specification
Type: Mass flow
Specification
Target: 159250 kg/hr
Stream type
Product
Internal
Input Changed
28 Main column stage
0 Pumparound(s
3 Side stripper(s
Mixers/Splitters
Separators
Heat Exchangers
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Reactors
Pressure Changers
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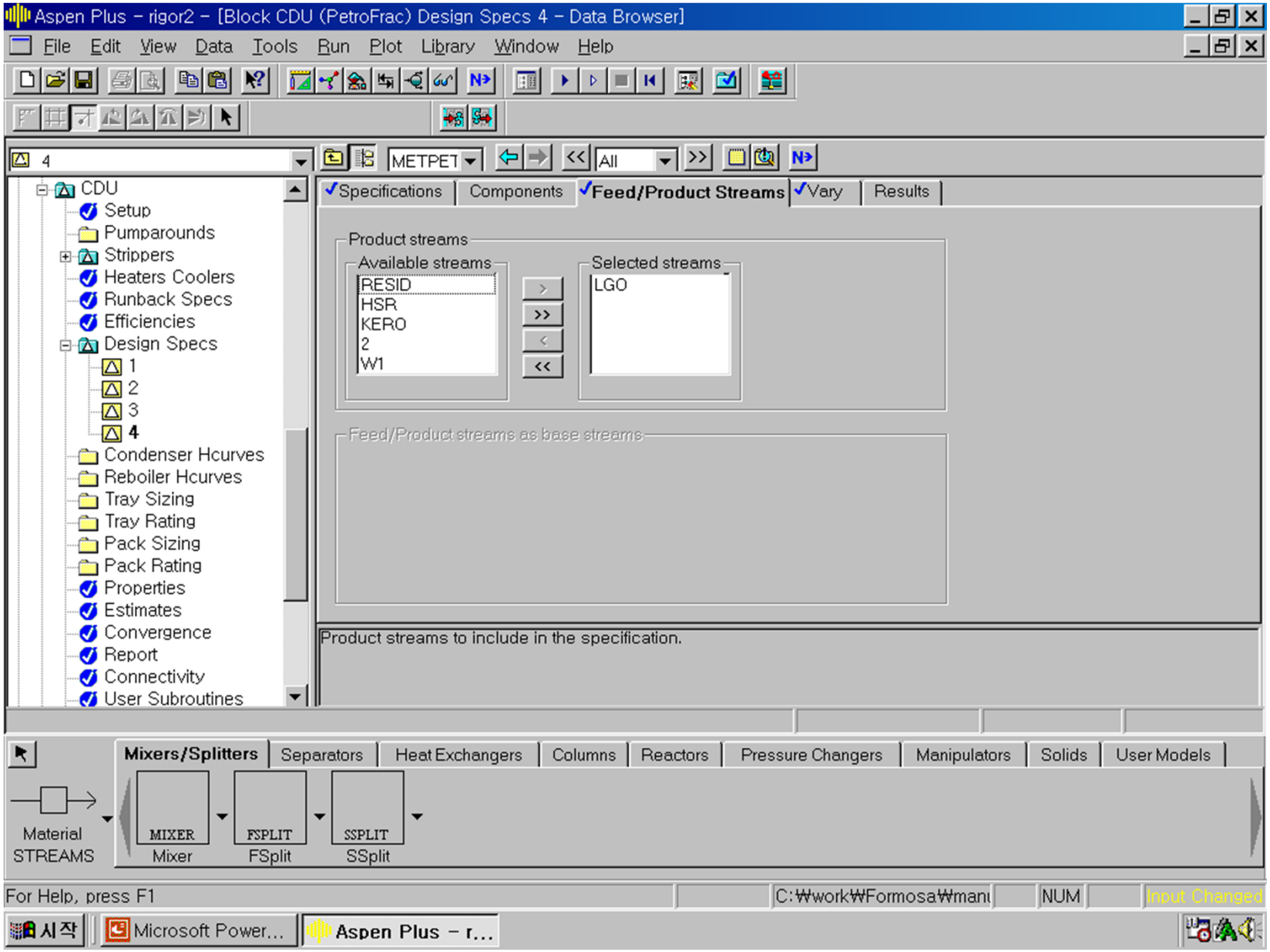
Aspen Plus – rigor2 – [Block CDU (PetroFrac) Design Specs 4 – Data Browser]
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Reboiler Hcurves
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Pack Sizing
Pack Rating
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Product streams to include in the specification.
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Heat Exchangers
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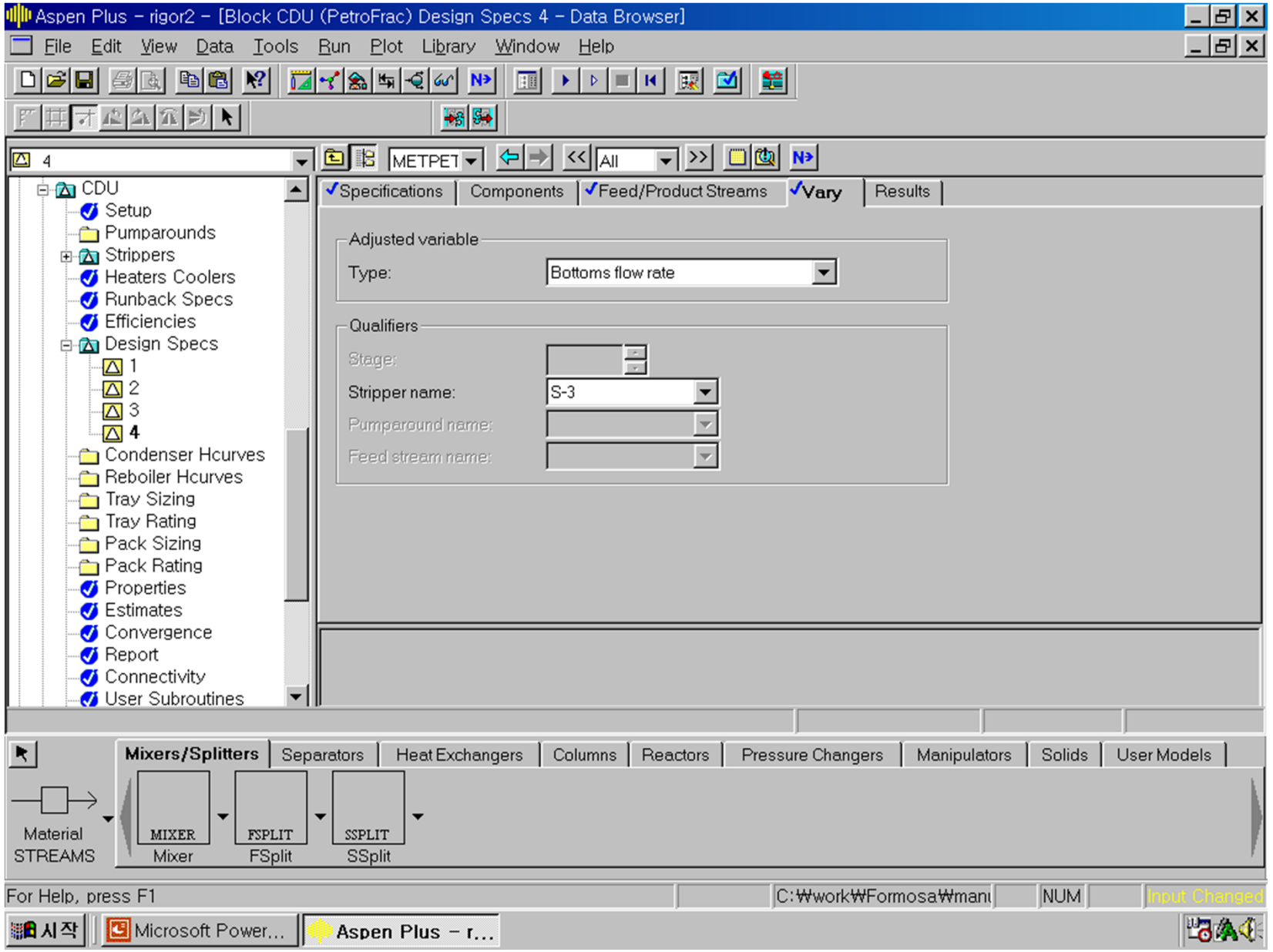
Aspen Plus – rigor2 – [Block CDU (PetroFrac) Design Specs 4 – Data Browser]
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Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
Pack Rating
Properties
Estimates
Convergence
Report
Connectivity
User Subroutines
Specifications
Components
Feed/Product Streams
Vary
Results
Adjusted variable
Type:
Bottoms flow rate
Qualifiers
Stage:
Stripper name:
S-3
Pumparound name:
Feed stream name:
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
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Aspen Plus – r...

Examining Simulation Results: U-type

Design *ASPEN PLUS*	ASTM D86 5% Temperature (°C)	ASTM D86 95% Temperature (°C)	Product Flowrate (Ton/day)
NAPHTHA	71	153	3,549
	61	*153*	*3,549*
HSR	165	196	921
	165	*204*	*921*
KERO	198	235	1,333
	193	*250*	*1,333*
LGO	246	337	3,822
	248	*374*	*3,822*

File Name = U-type.bkp

Modeling a A-type Tower:

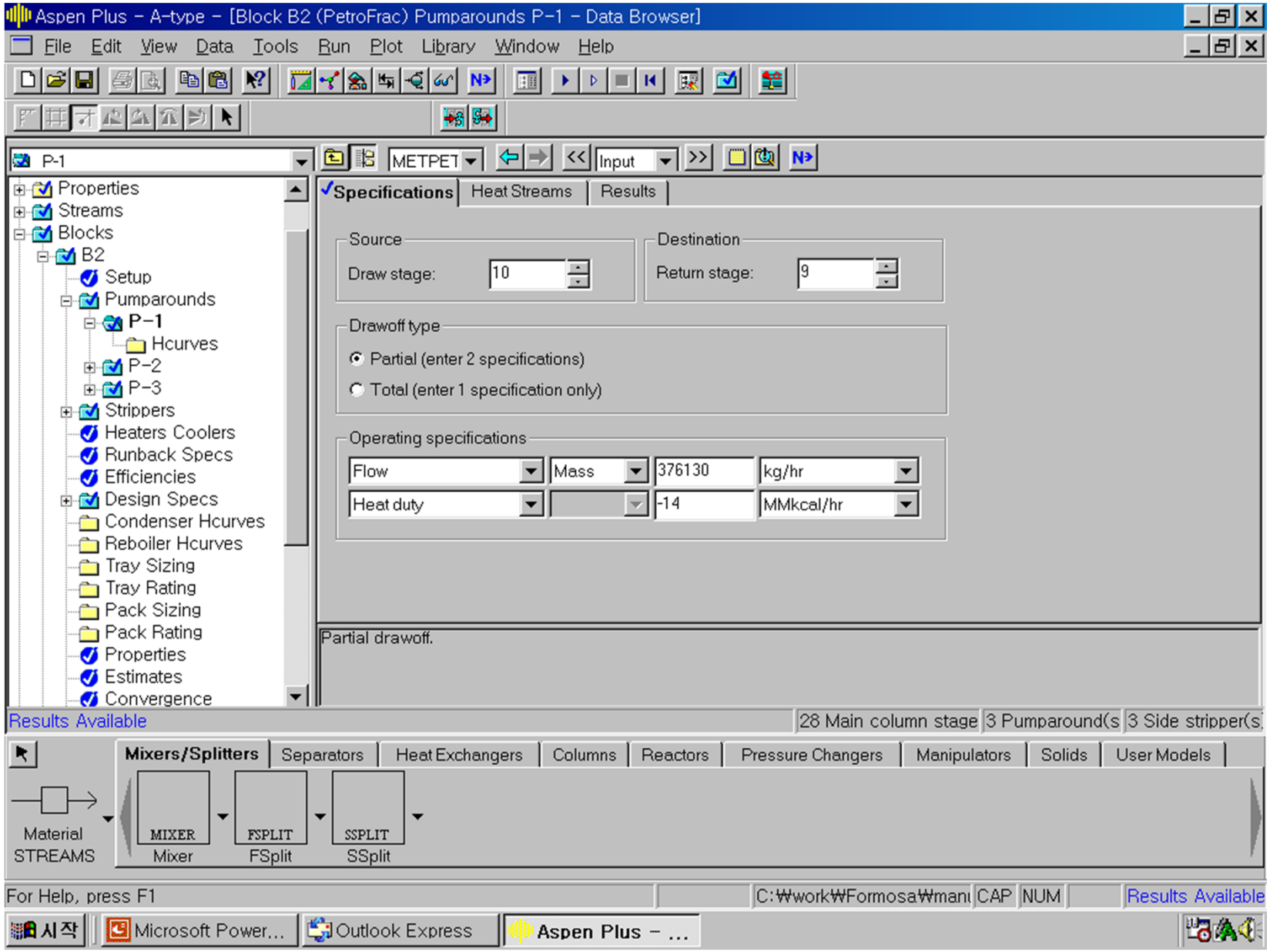
The Tower has:

- **A partial condenser**
- **Three coupled side strippers**
- **Three pump around side coolers.**

File name : A-type.bkp

Specifying for Pumparound Sidecooler P-1

Enter the following specifications:	
Draw stage	10
Return stage	9
Drawoff type	Partial (Enter 2 specifications)
Flowrate	376,130 Kg/hr
Heat Duty	-14.0 MM Kcal/hr


Aspen Plus – A-type – [Block B2 (PetroFrac) Pumparounds P-1 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
P-1
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Input
Properties
Streams
Blocks
B2
Setup
Pumparounds
P-1
Hcurves
P-2
P-3
Strippers
Heaters Coolers
Runback Specs
Efficiencies
Design Specs
Condenser Hcurves
Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
Pack Rating
Properties
Estimates
Convergence
Specifications
Heat Streams
Results
Source
Draw stage: 10
Destination
Return stage: 9
Drawoff type
Partial (enter 2 specifications)
Total (enter 1 specification only)
Operating specifications
Flow Mass 376130 kg/hr
Heat duty -14 MMkcal/hr
Partial drawoff.
Results Available
28 Main column stage
3 Pumparound(s
3 Side stripper(s
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
Solids
User Models
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Results Available
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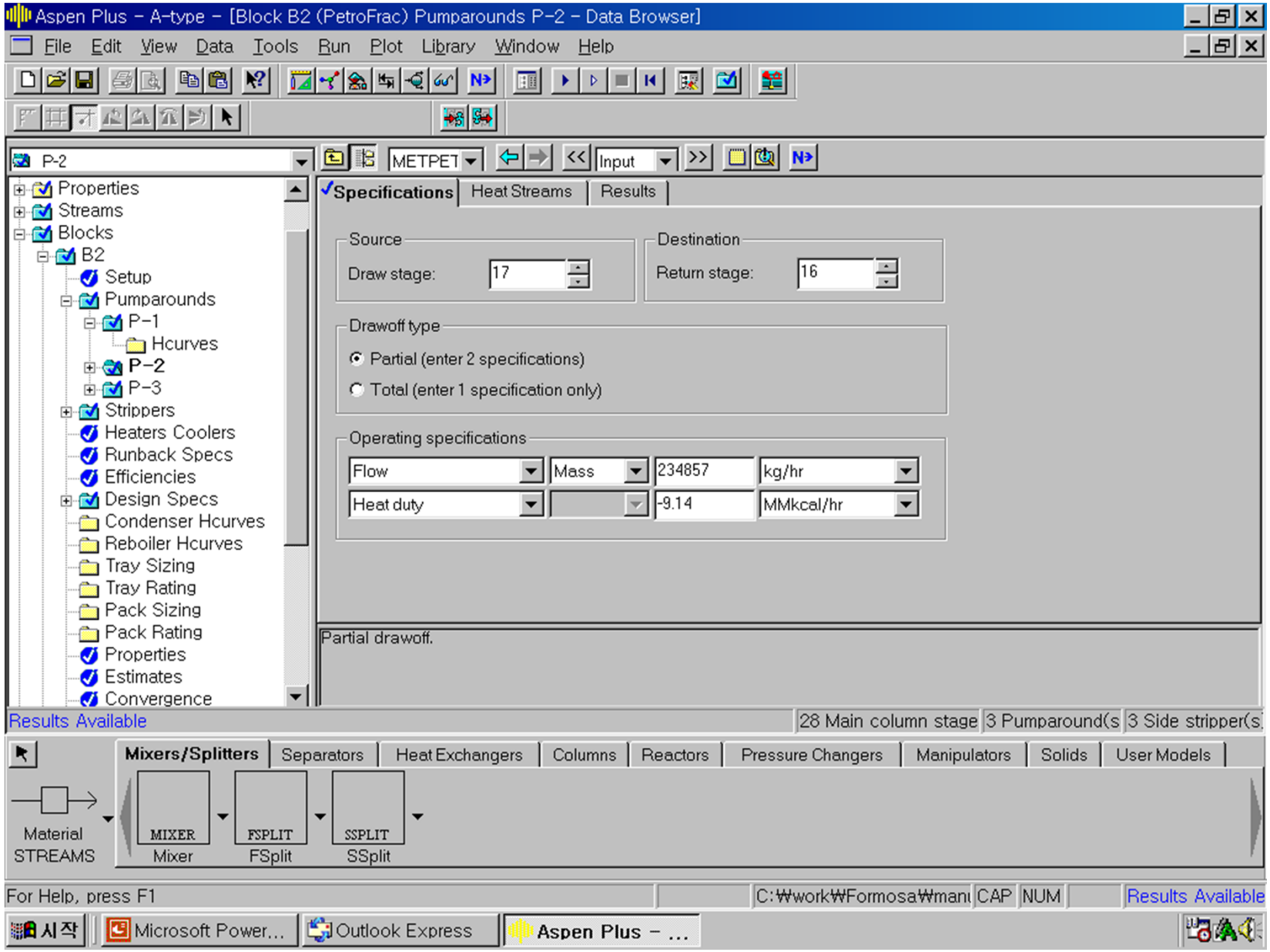
Specifying for Pumparound Sidecooler P-2

Enter the following specifications:	
Draw stage	17
Return stage	16
Drawoff type	Partial (Enter 2 specifications)
Flowrate	234,857 Kg/hr
Heat Duty	-9.14 MM Kcal/hr


Aspen Plus – A-type – [Block B2 (PetroFrac) Pumparounds P-2 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
P-2
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Setup
Pumparounds
P-1
Hcurves
P-2
P-3
Strippers
Heaters Coolers
Runback Specs
Efficiencies
Design Specs
Condenser Hcurves
Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
Pack Rating
Properties
Estimates
Convergence
Specifications
Heat Streams
Results
Source
Draw stage: 17
Destination
Return stage: 16
Drawoff type
Partial (enter 2 specifications)
Total (enter 1 specification only)
Operating specifications
Flow Mass 234857 kg/hr
Heat duty -9.14 MMkcal/hr
Partial drawoff.
Results Available
28 Main column stage
3 Pumparound(s
3 Side stripper(s
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
Solids
User Models
Material
STREAMS
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Mixer
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FSplit
SSPLIT
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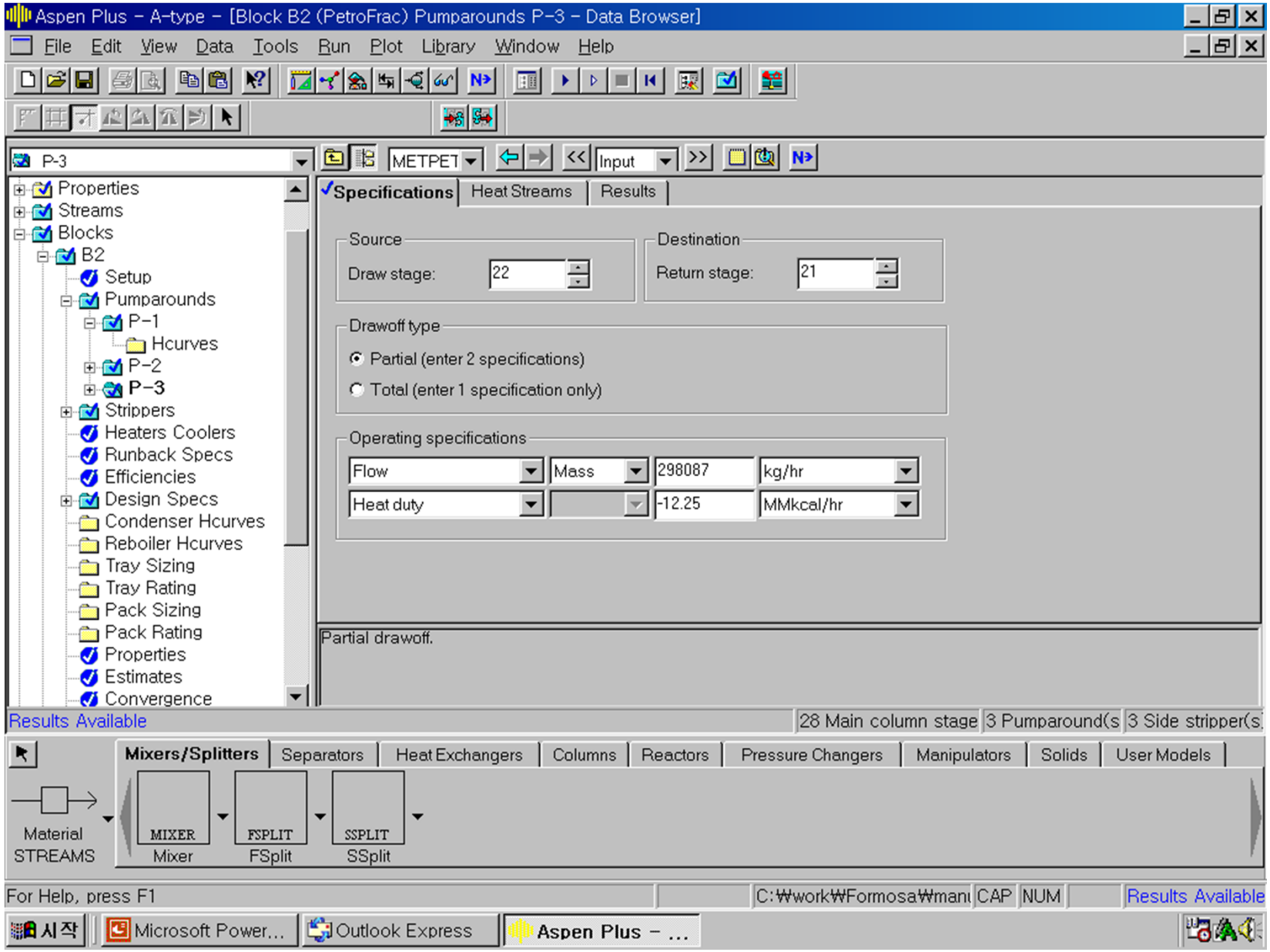
Specifying for Pumparound Sidecooler P-3

Enter the following specifications:	
Draw stage	22
Return stage	21
Drawoff type	Partial (Enter 2 specifications)
Flowrate	298,087 Kg/hr
Heat Duty	-12.25 MM Kcal/hr


Aspen Plus – A-type – [Block B2 (PetroFrac) Pumparounds P-3 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
P-3
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Pumparounds
P-1
Hcurves
P-2
P-3
Strippers
Heaters Coolers
Runback Specs
Efficiencies
Design Specs
Condenser Hcurves
Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
Pack Rating
Properties
Estimates
Convergence
Specifications
Heat Streams
Results
Source
Draw stage: 22
Destination
Return stage: 21
Drawoff type
Partial (enter 2 specifications)
Total (enter 1 specification only)
Operating specifications
Flow Mass 298087 kg/hr
Heat duty -12.25 MMkcal/hr
Partial drawoff.
Results Available
28 Main column stage
3 Pumparound(s
3 Side stripper(s
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
Solids
User Models
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For Help, press F1
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Results Available
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Outlook Express
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Examining Simulation Results: A-type

Design *Simulation*	ASTM D86 5% Temperature (°C)	ASTM D86 95% Temperature (°C)	Product Flowrate (Ton/day)
NAPHTHA	71	153	3,549
	61	*153*	*3,549*
HSR	165	196	921
	150	*196*	*921*
KERO	198	235	1,333
	182	*244*	*1,333*
LGO	246	337	3,822
	238	*367*	*3,822*

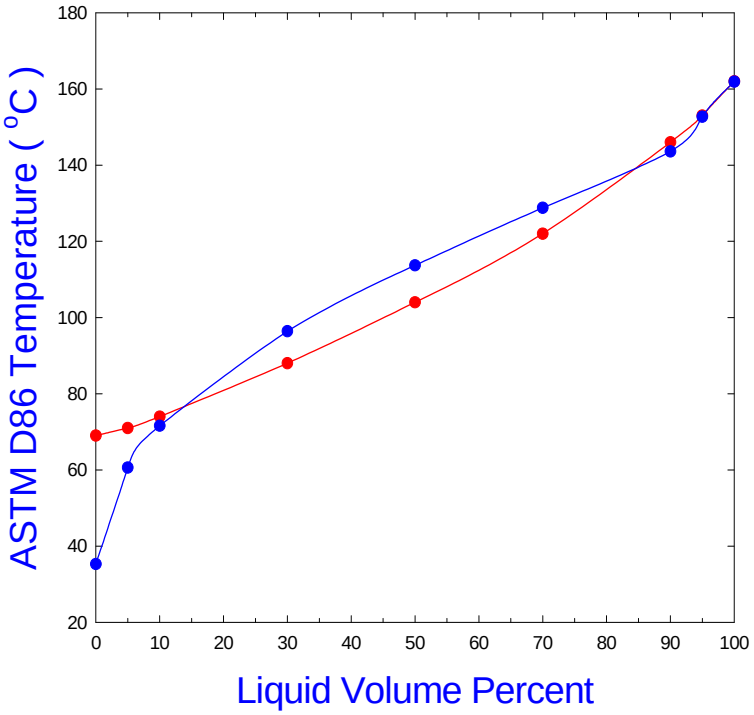
File Name = A-type.bkp

Examining Simulation Results: A-type

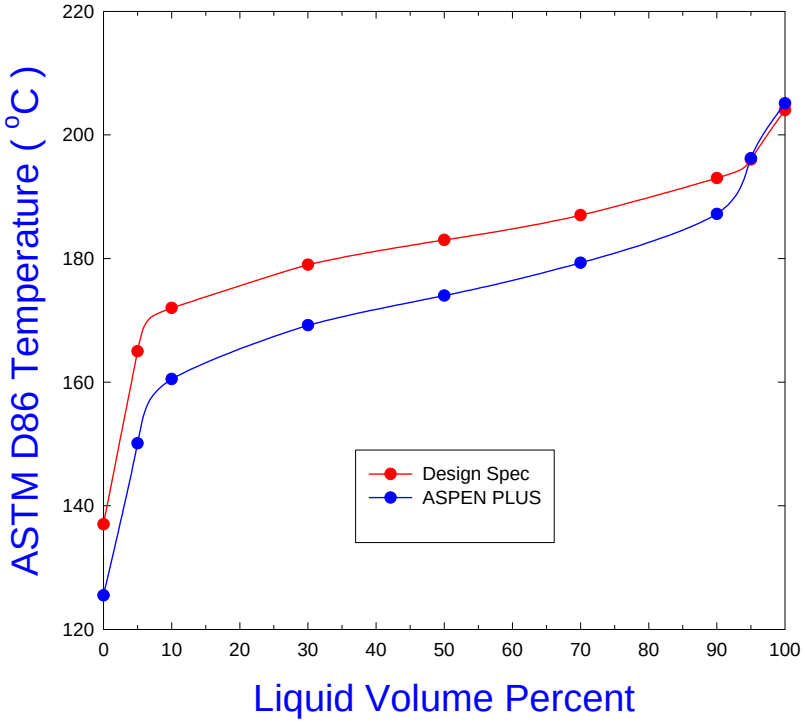
Design *Simulation*	ASTM D86 5% Temperature (°C)	ASTM D86 95% Temperature (°C)	Product Flowrate (Ton/day)
NAPHTHA	71	153	3,549
	61 (77)	*153 (158)*	*3,549*
HSR	165	196	921
	150 (151)	*196 (196)*	*921*
KERO	198	235	1,333
	182 (183)	*244 (244)*	*1,333*
LGO	246	337	3,822
	238 (240)	*367 (367)*	*3,822*

File Name = A-type.bkp
A-type-BK10.bkp

Comparison between Design & Simulation for ASTM D86 Curve

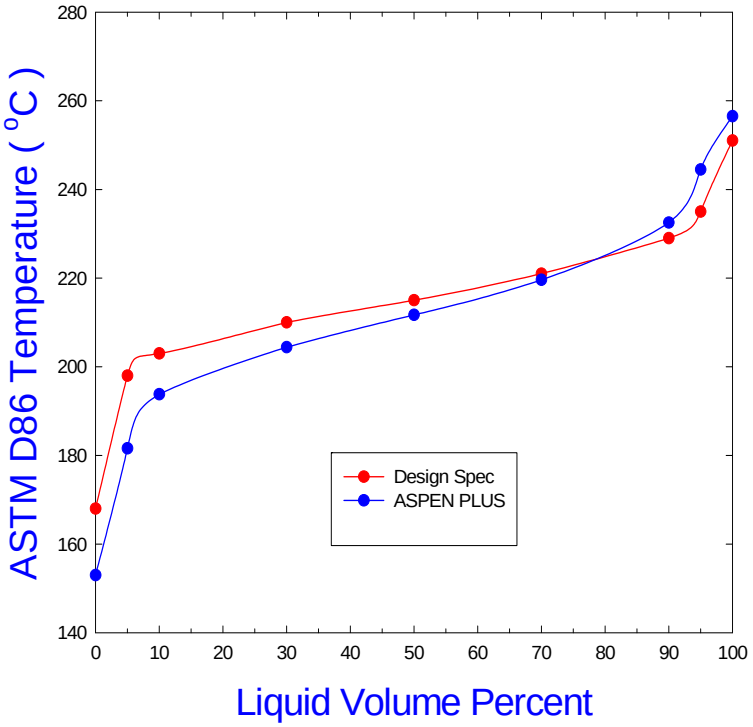


LSR

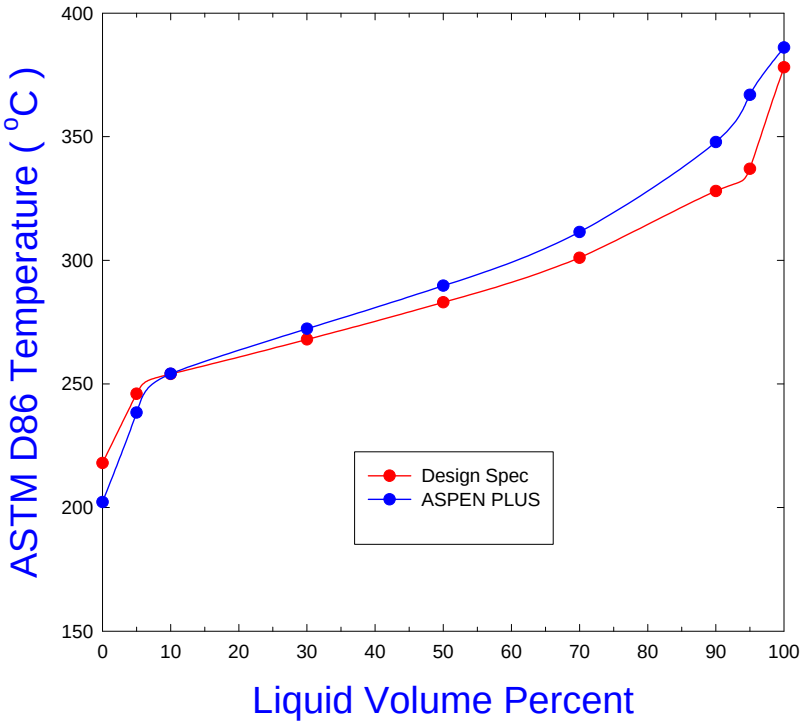


HSR

Comparison between Design & Simulation for ASTM D86 Curve

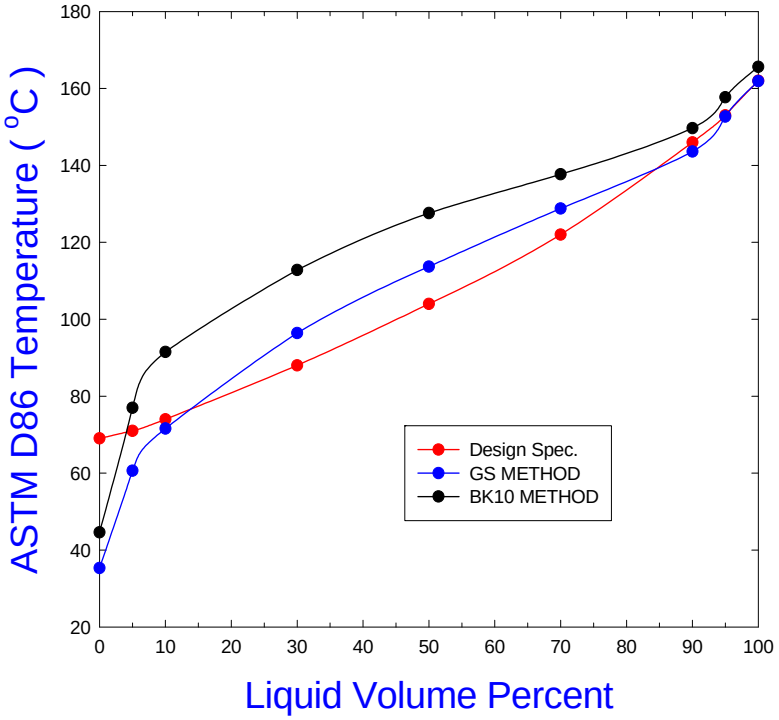


KERO

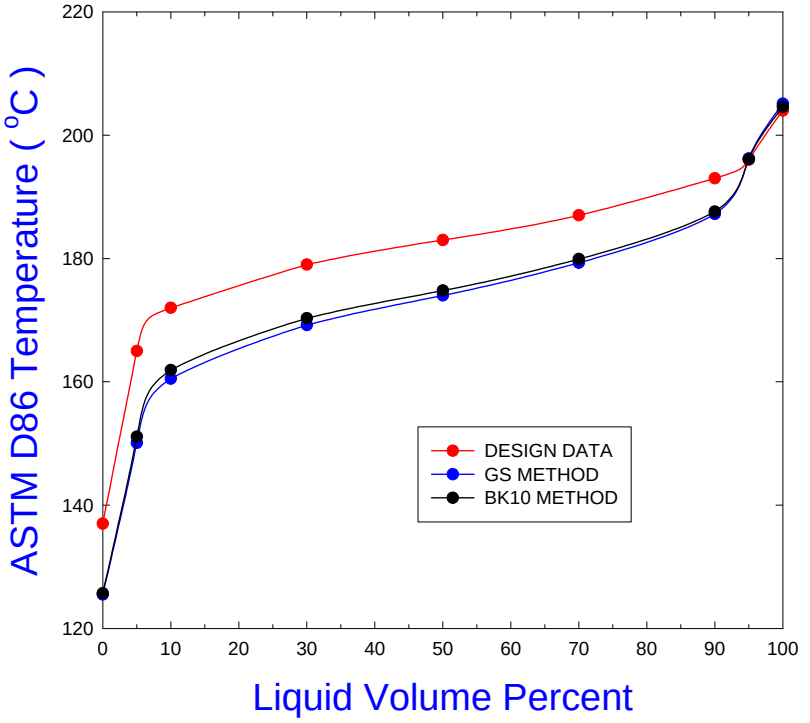


LGO

Comparison between Design & Simulation for ASTM D86 Curve

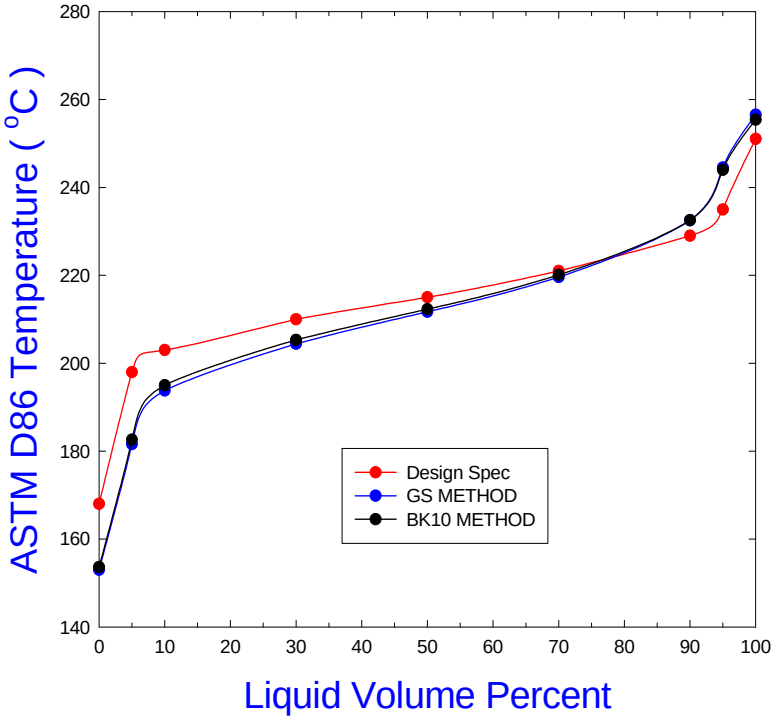


LSR

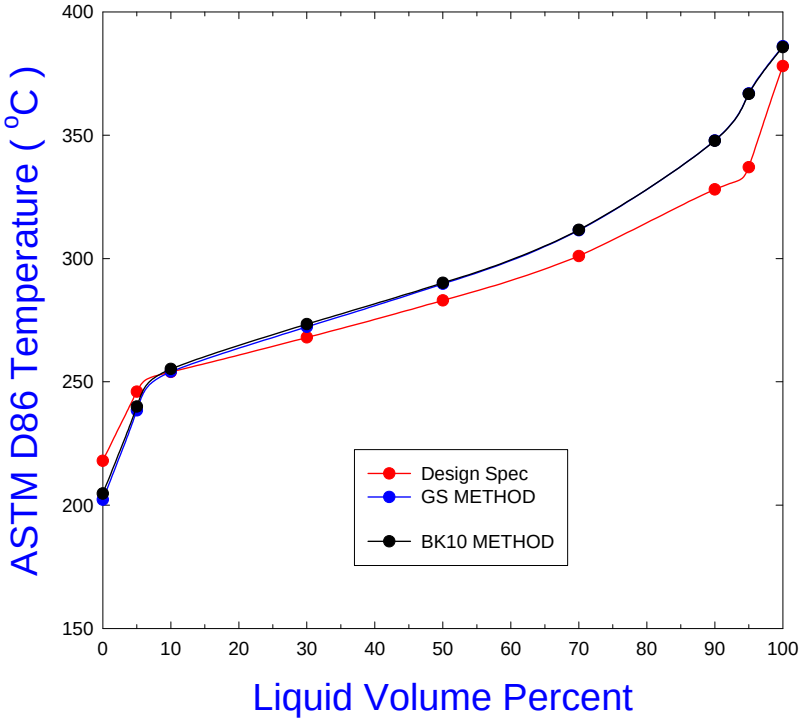


HSR

Comparison between Design & Simulation for ASTM D86 Curve



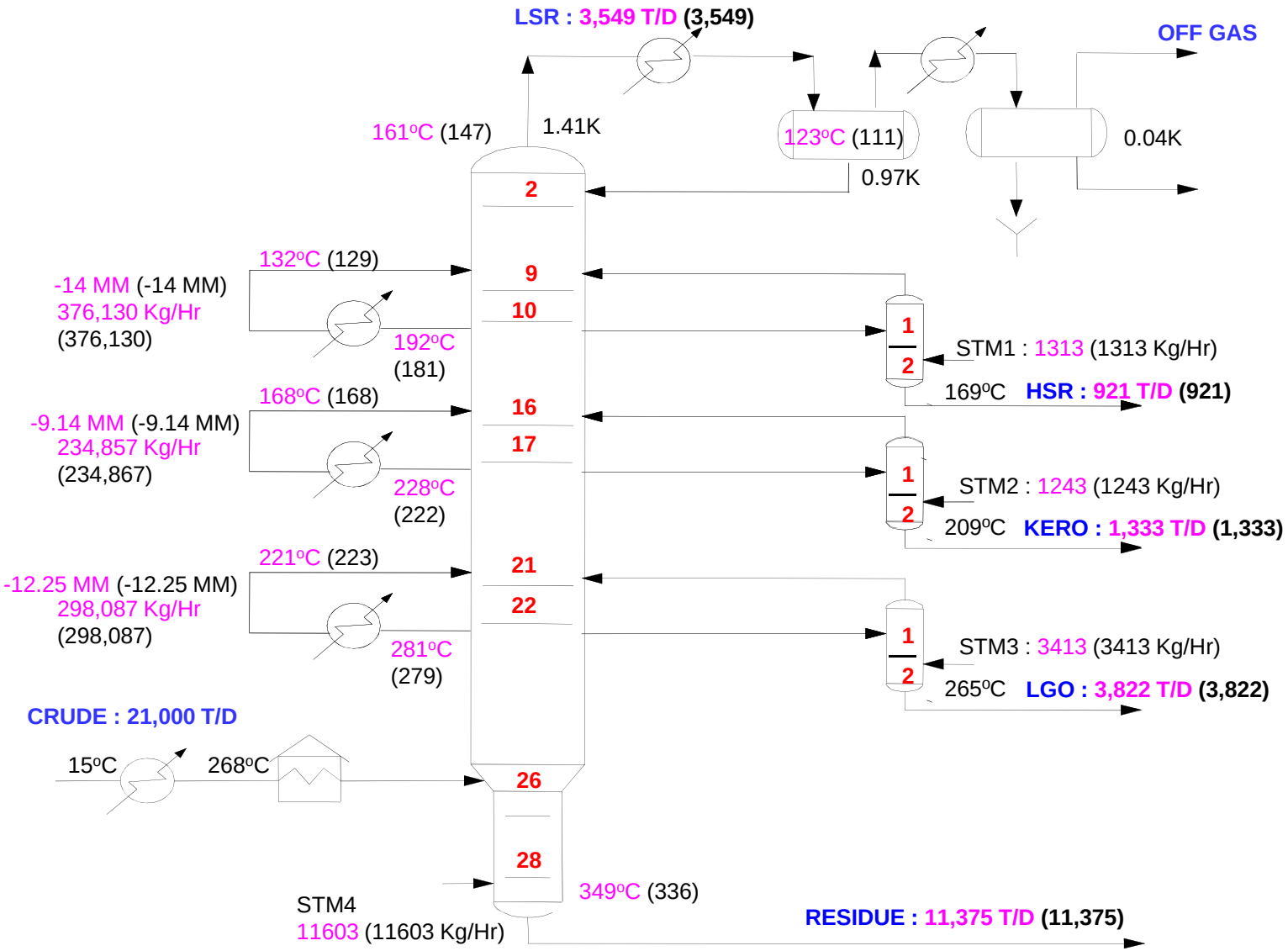
KERO



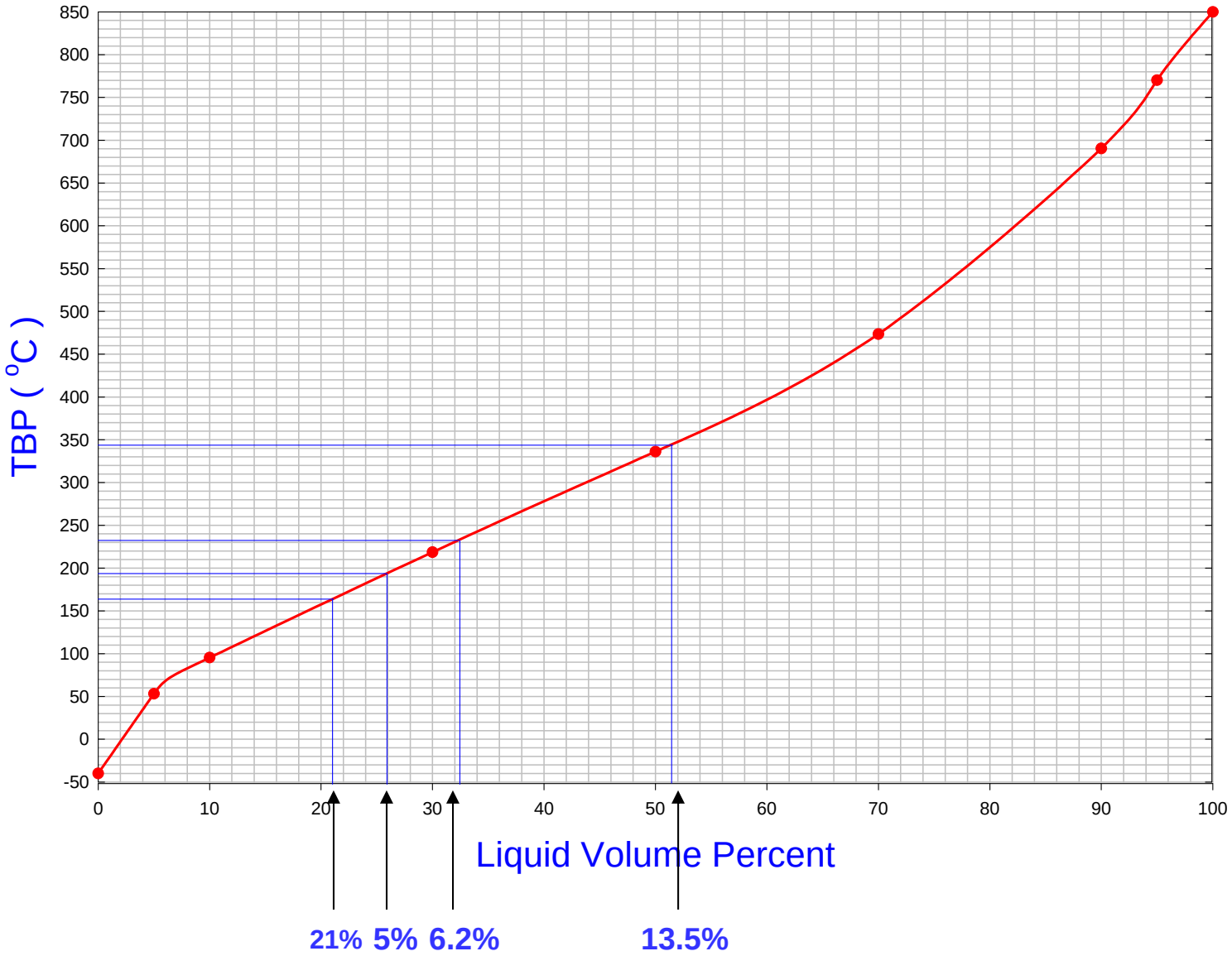
LGO

Comparison with Design Data and Simulation Results

Focusing on Side Distillates Flowrate



TBP vs. LV % for Mixed Crude



Yield Estimation for Each Sidecuts based on TBP Curve

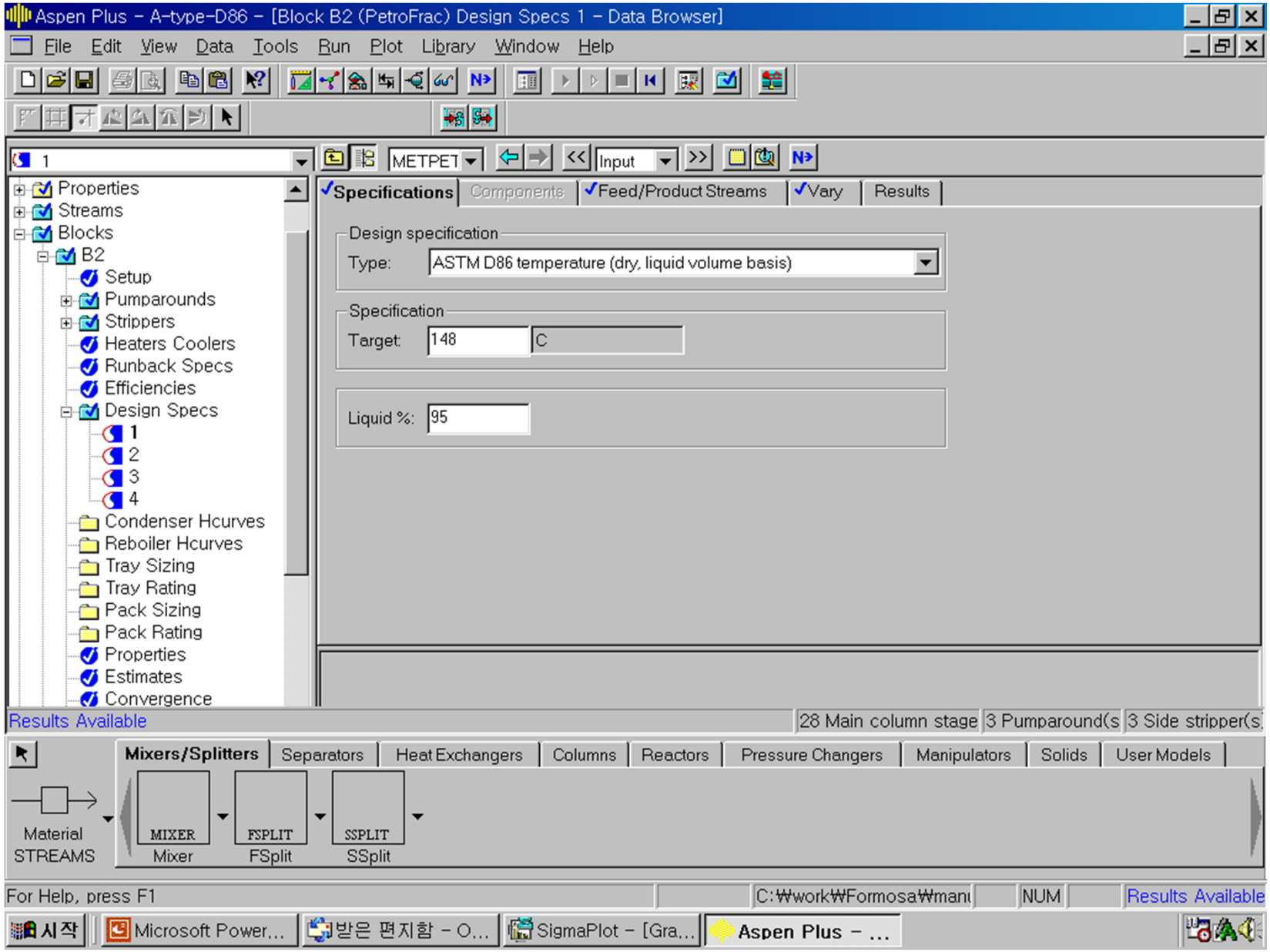
- Specific gravity for a whole mixed crude = 0.8721 (872.1 Kg/m^3)
- 21,000,000 Kg/day / 872.1 Kg/m^3 = 24,080 m^3/day
- LSR Flow = 24,080 m^3/day x 0.21 = 5,057 m^3/day
  5,057 m^3/day x 0.7037 T/m^3 = 3,559 T/D *(3,549 T/D)*
- HSR Flow = 24,080 m^3/day x 0.05 = 1,204 m^3/day
  1,204 m^3/day x 0.7826 T/m^3 = 942 T/D *(921 T/D)*
- KERO Flow = 24,080 m^3/day x 0.062 = 1,493 m^3/day
  1,493 m^3/day x 0.8034 T/m^3 = 1,199 T/D *(1,333 T/D)*
- LGO Flow = 24,080 m^3/day x 0.135 = 16,326 m^3/day
  16,326 m^3/day x 0.8456 T/m^3 = 13,805 T/D *(11,375 T/D)*

Side Distillate	Flow (T/D)	Yield, wt %
LSR	3,559 *(3,549)*	16.9 *(16.9)*
HSR	942 *(921)*	4.49 *(4.39)*
KERO	1,199 *(1,333)*	5.71 *(6.35)*
LGO	13,805 *(11,375)*	72.9 *(72.36)*

Specifying ASTM D86 95% for Each Sidecuts

Specifications of Each Side Distillates ASTM	
LSR	153 ^{o}C
HSR	196 ^{o}C
KERO	235 ^{o}C
LGO	337 ^{o}C

File Name = A-type-D86.bkp


Aspen Plus – A-type-D86 – [Block B2 (PetroFrac) Design Specs 1 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
Pack Rating
Properties
Estimates
Convergence
Specifications
Components
Feed/Product Streams
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Results
Design specification
Type: ASTM D86 temperature (dry, liquid volume basis)
Specification
Target: 148 C
Liquid %: 95
Results Available
28 Main column stage
3 Pumparound(s
3 Side stripper(s
Mixers/Splitters
Separators
Heat Exchangers
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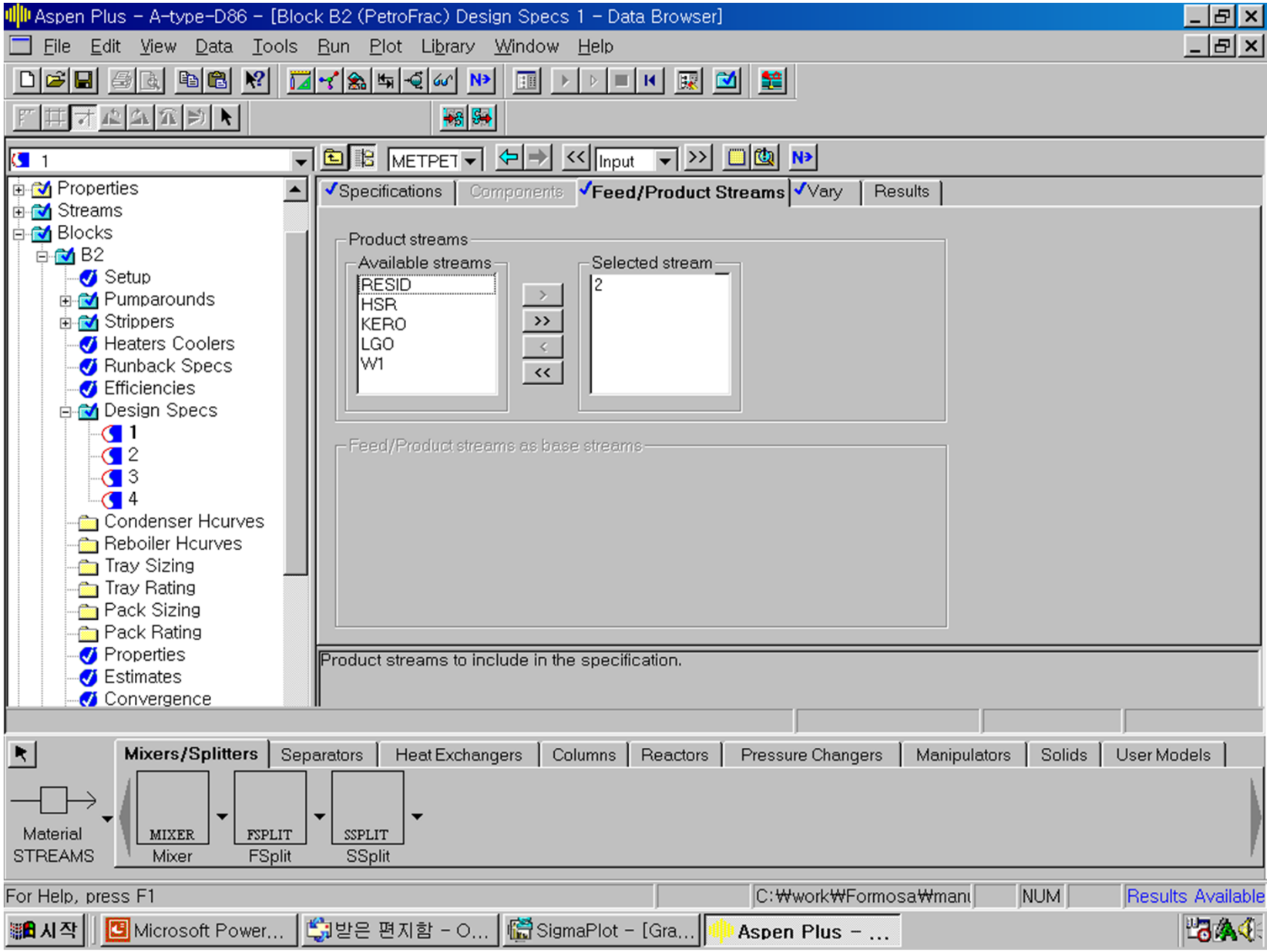
Aspen Plus – A-type-D86 – [Block B2 (PetroFrac) Design Specs 1 – Data Browser]
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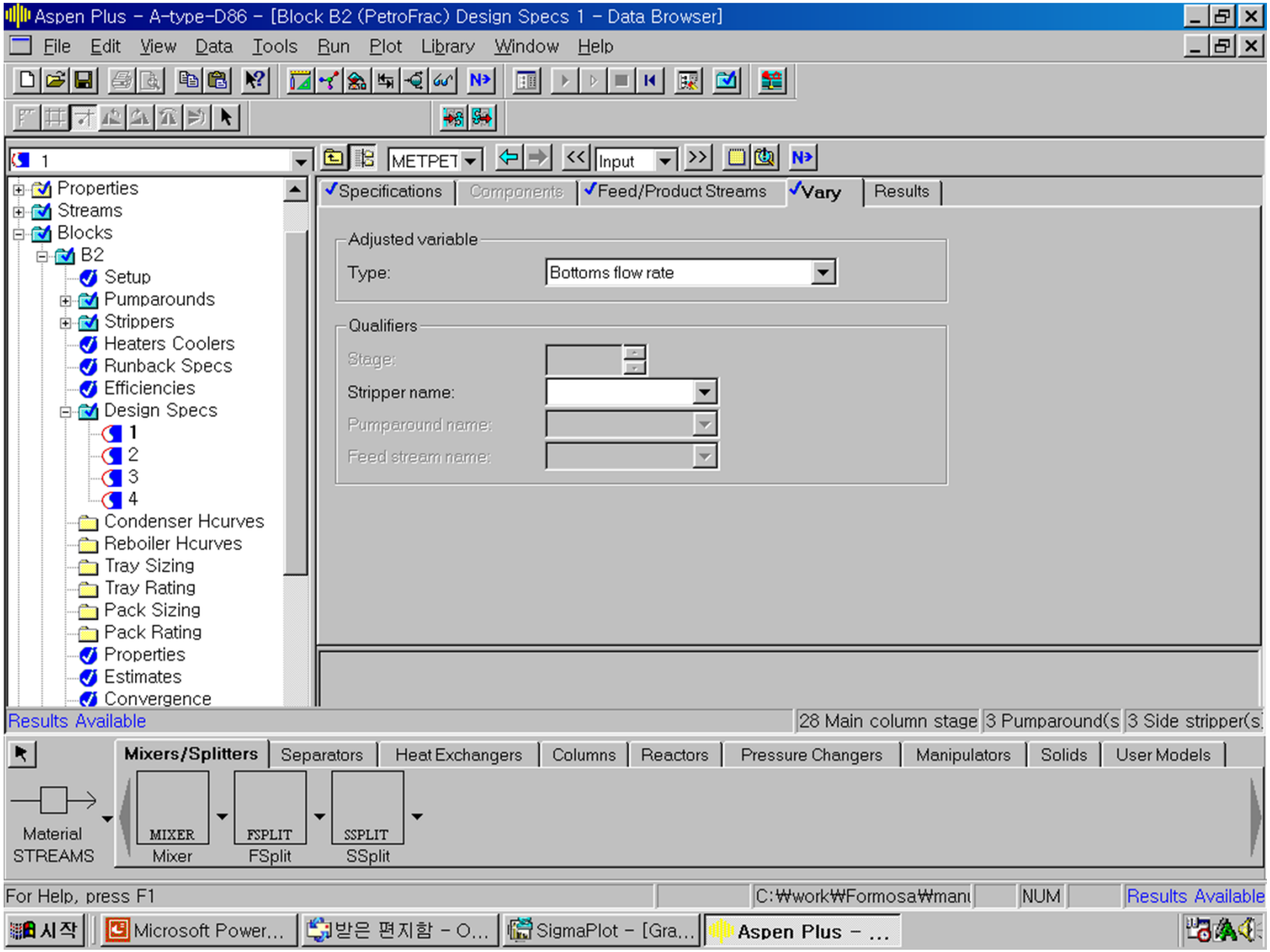
Aspen Plus – A-type-D86 – [Block B2 (PetroFrac) Design Specs 1 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
Pack Rating
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Bottoms flow rate
Qualifiers
Stage:
Stripper name:
Pumparound name:
Feed stream name:
Results Available
28 Main column stage
3 Pumparound(s
3 Side stripper(s
Mixers/Splitters
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Heat Exchangers
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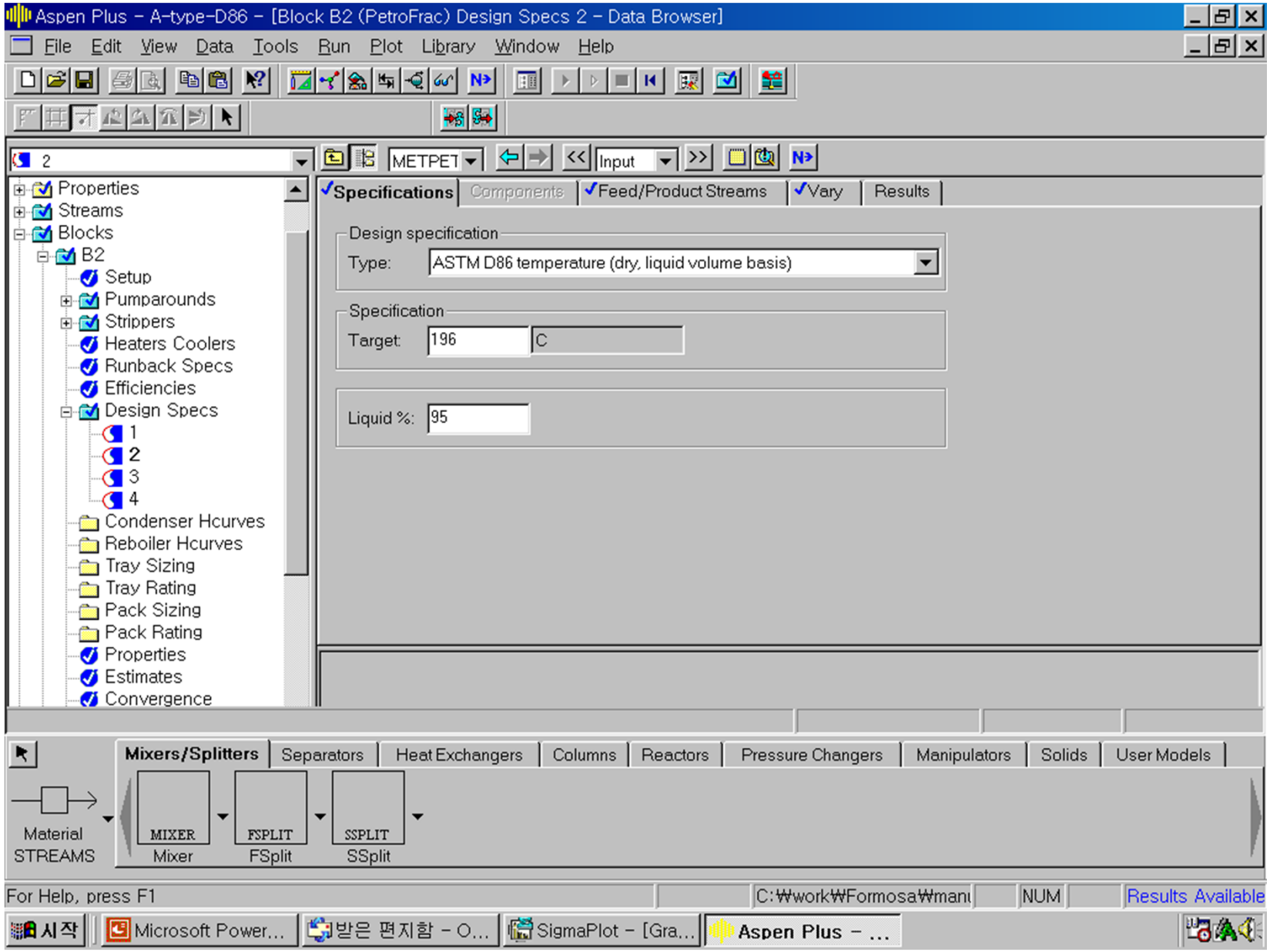
Aspen Plus – A-type-D86 – [Block B2 (PetroFrac) Design Specs 2 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Heaters Coolers
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Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
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Properties
Estimates
Convergence
Specifications
Components
Feed/Product Streams
Vary
Results
Design specification
Type: ASTM D86 temperature (dry, liquid volume basis)
Specification
Target: 196 C
Liquid %: 95
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
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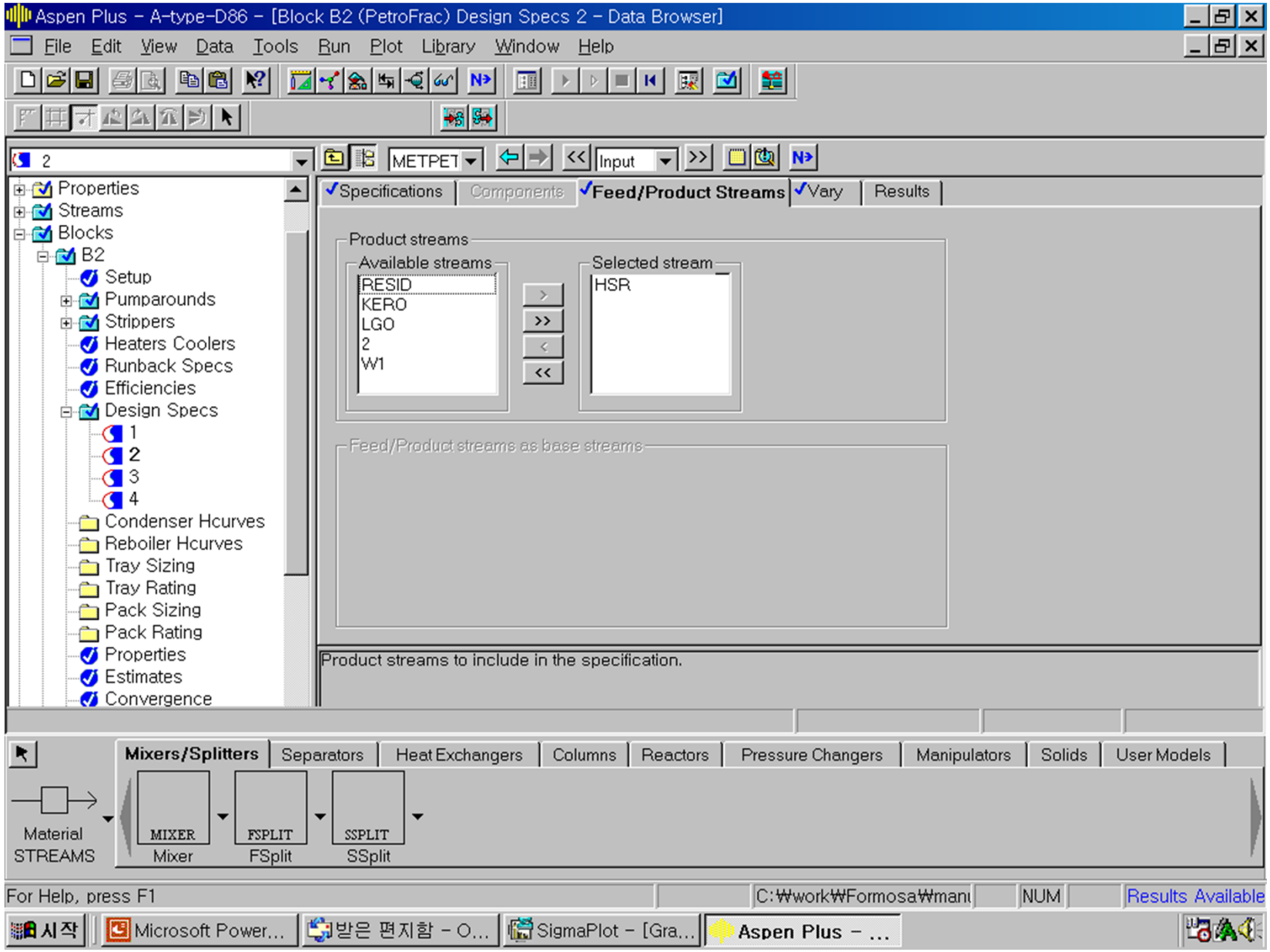
Aspen Plus – A-type-D86 – [Block B2 (PetroFrac) Design Specs 2 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Reboiler Hcurves
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Tray Rating
Pack Sizing
Pack Rating
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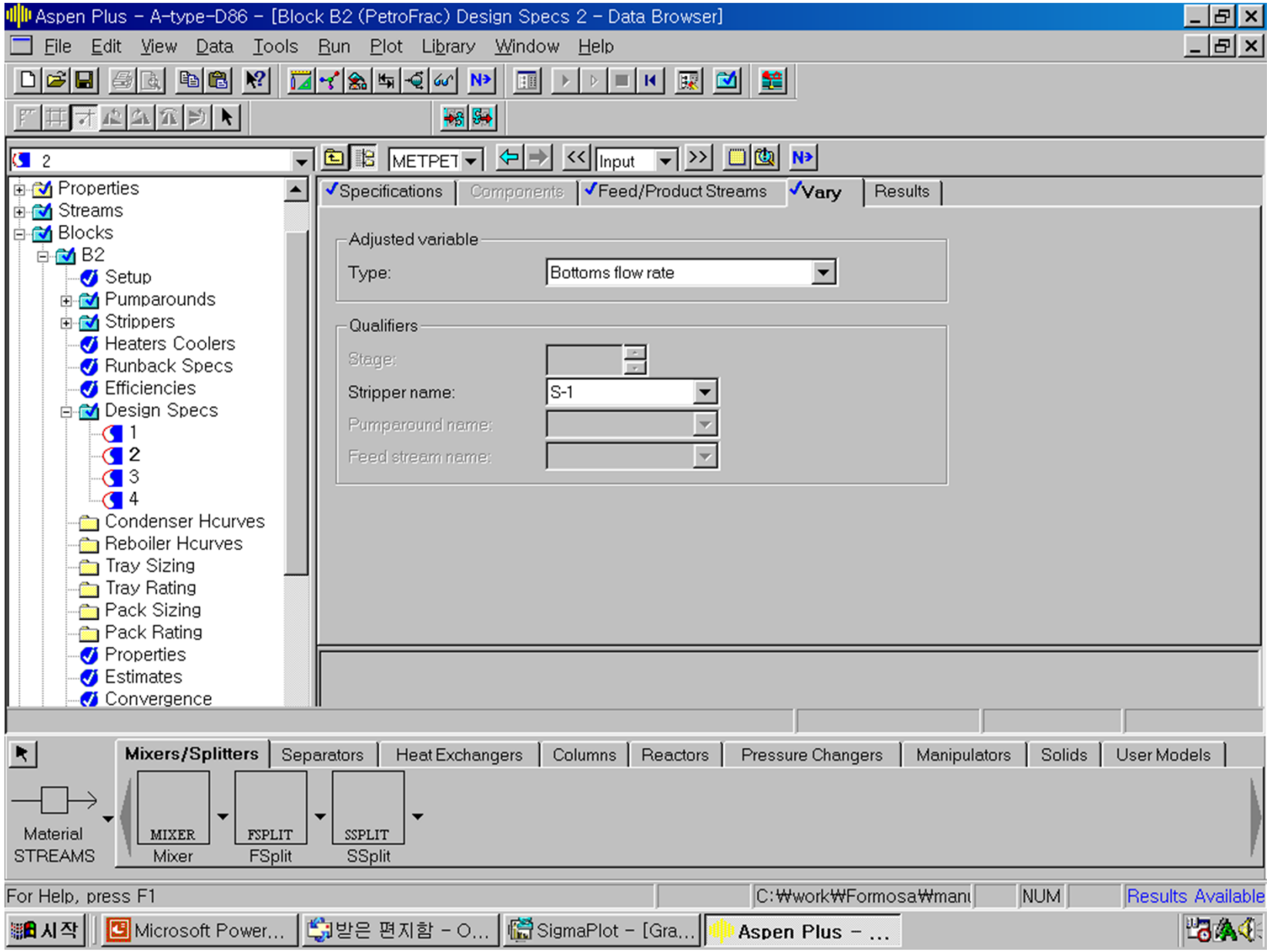
Aspen Plus – A-type-D86 – [Block B2 (PetroFrac) Design Specs 2 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Tray Sizing
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Pack Sizing
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Feed/Product Streams
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Bottoms flow rate
Qualifiers
Stage:
Stripper name:
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Feed stream name:
Mixers/Splitters
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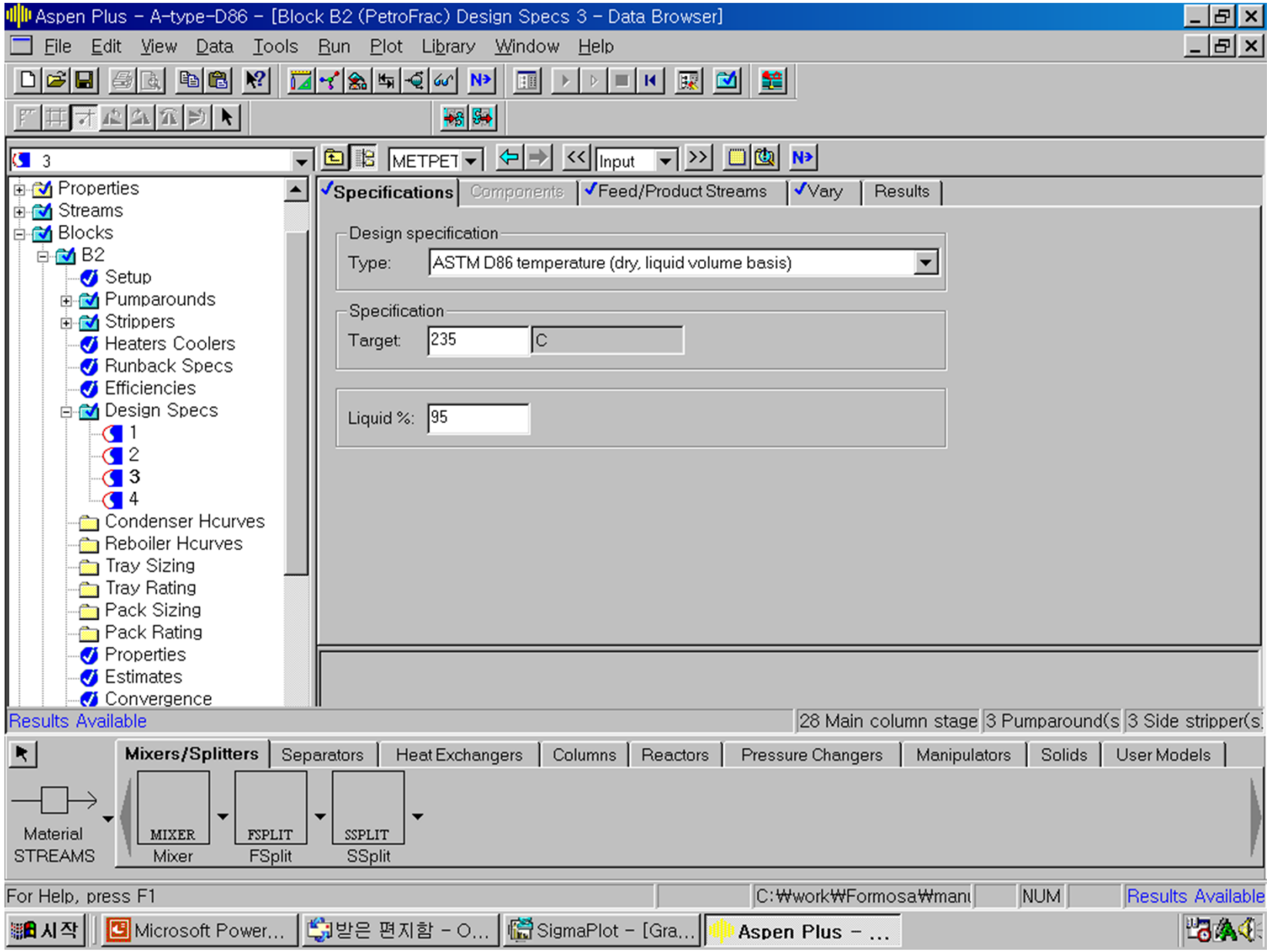
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File Edit View Data Tools Run Plot Library Window Help
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Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
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Properties
Estimates
Convergence
Specifications
Components
Feed/Product Streams
Vary
Results
Design specification
Type: ASTM D86 temperature (dry, liquid volume basis)
Specification
Target: 235 C
Liquid %: 95
Results Available
28 Main column stage
3 Pumparound(s
3 Side stripper(s
Mixers/Splitters
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Heat Exchangers
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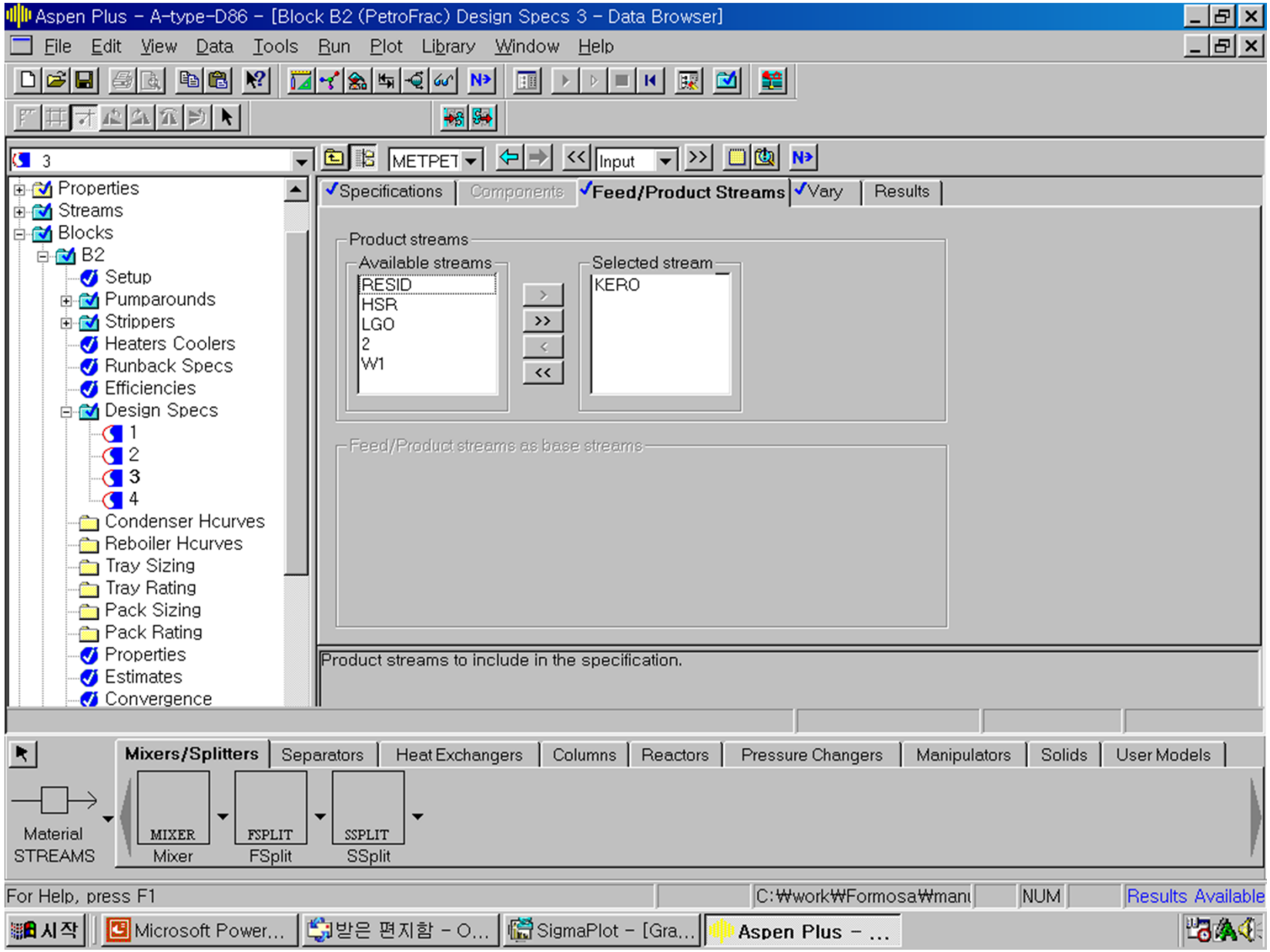
Aspen Plus – A-type-D86 – [Block B2 (PetroFrac) Design Specs 3 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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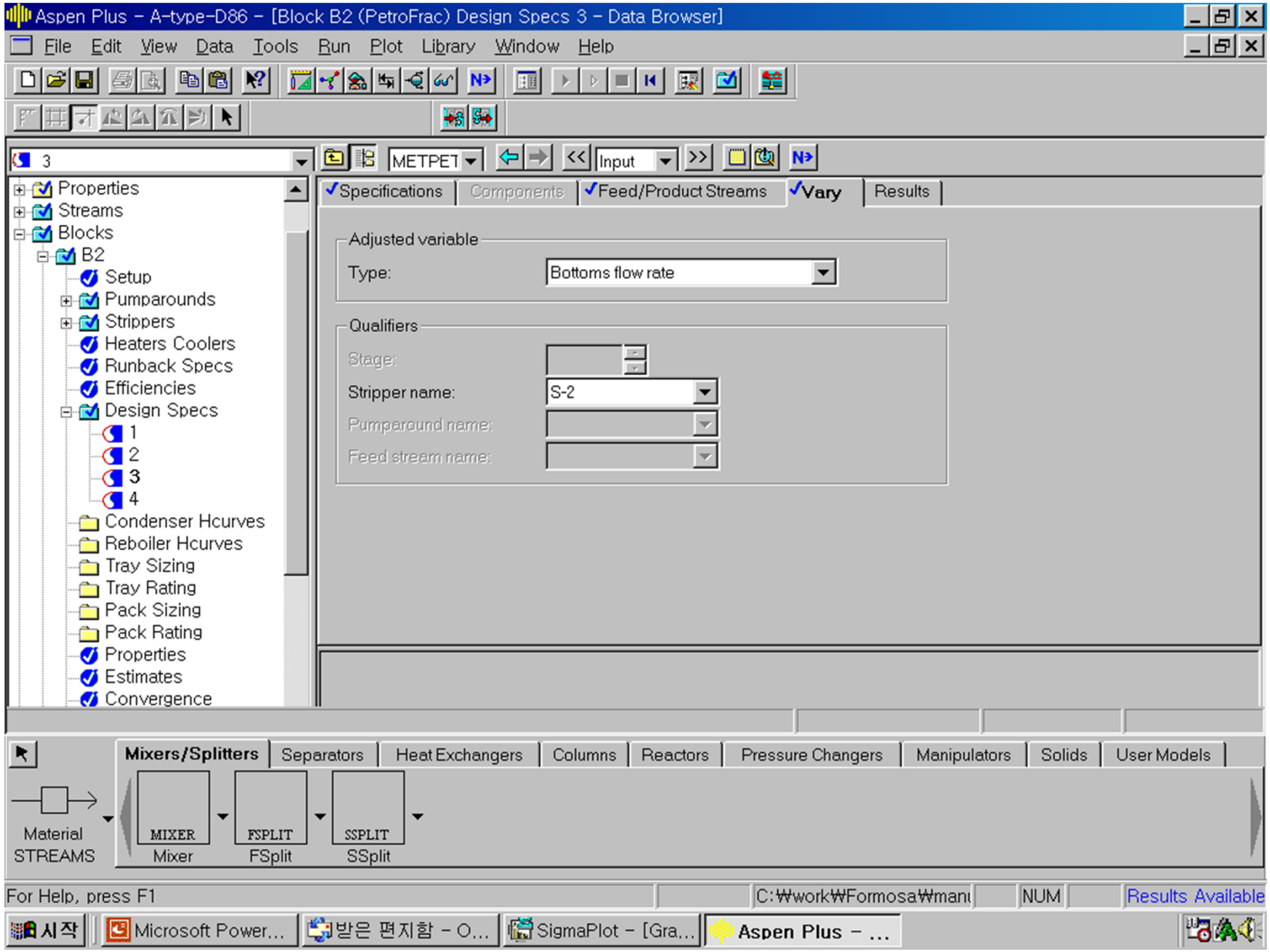
Aspen Plus – A-type-D86 – [Block B2 (PetroFrac) Design Specs 3 – Data Browser]
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Feed/Product Streams
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Bottoms flow rate
Qualifiers
Stage:
Stripper name:
S-2
Pumparound name:
Feed stream name:
Mixers/Splitters
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Heat Exchangers
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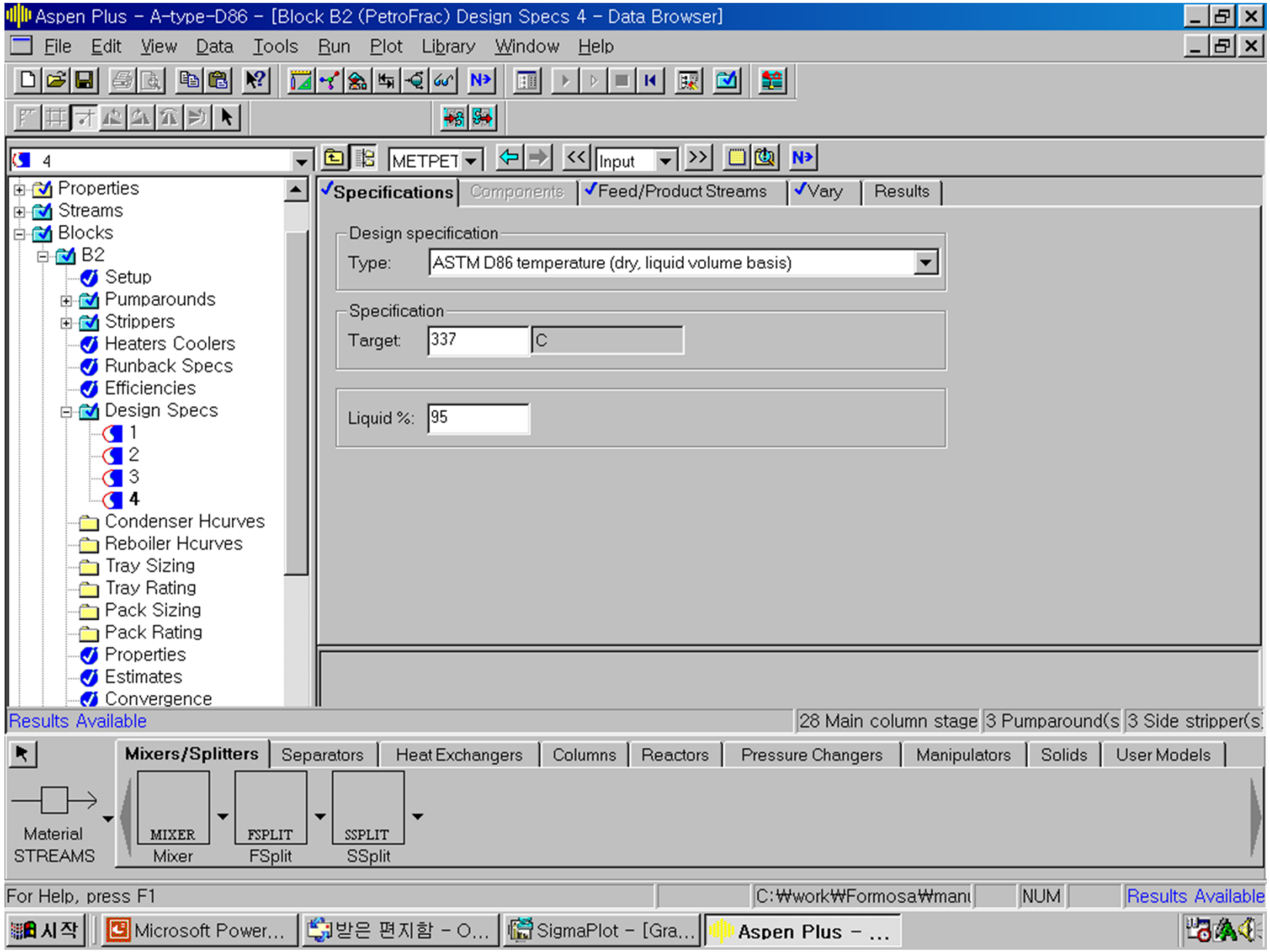
Aspen Plus – A-type-D86 – [Block B2 (PetroFrac) Design Specs 4 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Pumparounds
Strippers
Heaters Coolers
Runback Specs
Efficiencies
Design Specs
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Condenser Hcurves
Reboiler Hcurves
Tray Sizing
Tray Rating
Pack Sizing
Pack Rating
Properties
Estimates
Convergence
Specifications
Components
Feed/Product Streams
Vary
Results
Design specification
Type: ASTM D86 temperature (dry, liquid volume basis)
Specification
Target: 337 C
Liquid %: 95
Results Available
28 Main column stage
3 Pumparound(s
3 Side stripper(s
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
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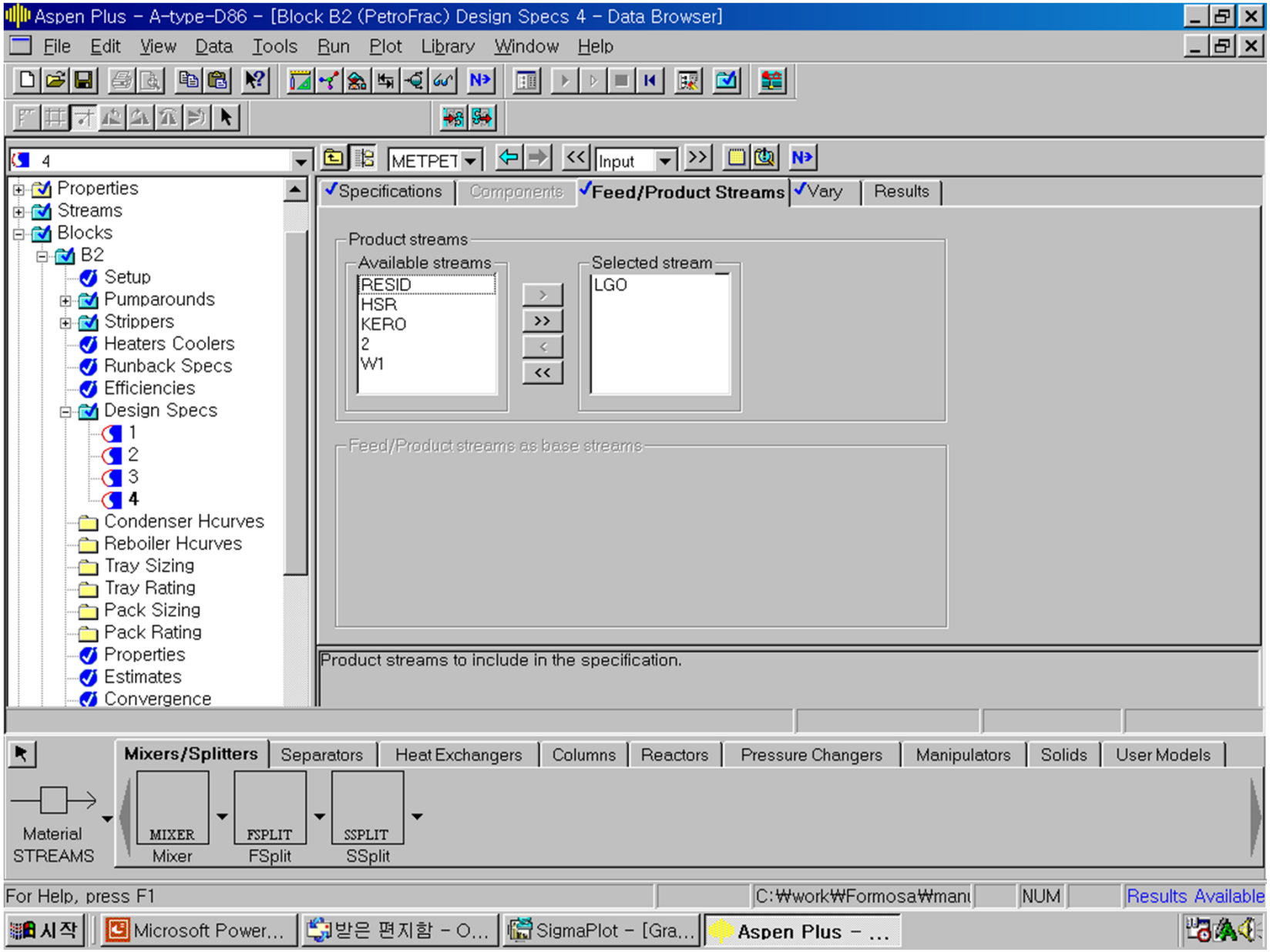
Aspen Plus – A-type-D86 – [Block B2 (PetroFrac) Design Specs 4 – Data Browser]
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Reboiler Hcurves
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Tray Rating
Pack Sizing
Pack Rating
Properties
Estimates
Convergence
Specifications
Components
Feed/Product Streams
Vary
Results
Product streams
Available streams
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HSR
KERO
2
W1
Selected stream
LGO
Feed/Product streams as base streams
Product streams to include in the specification.
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
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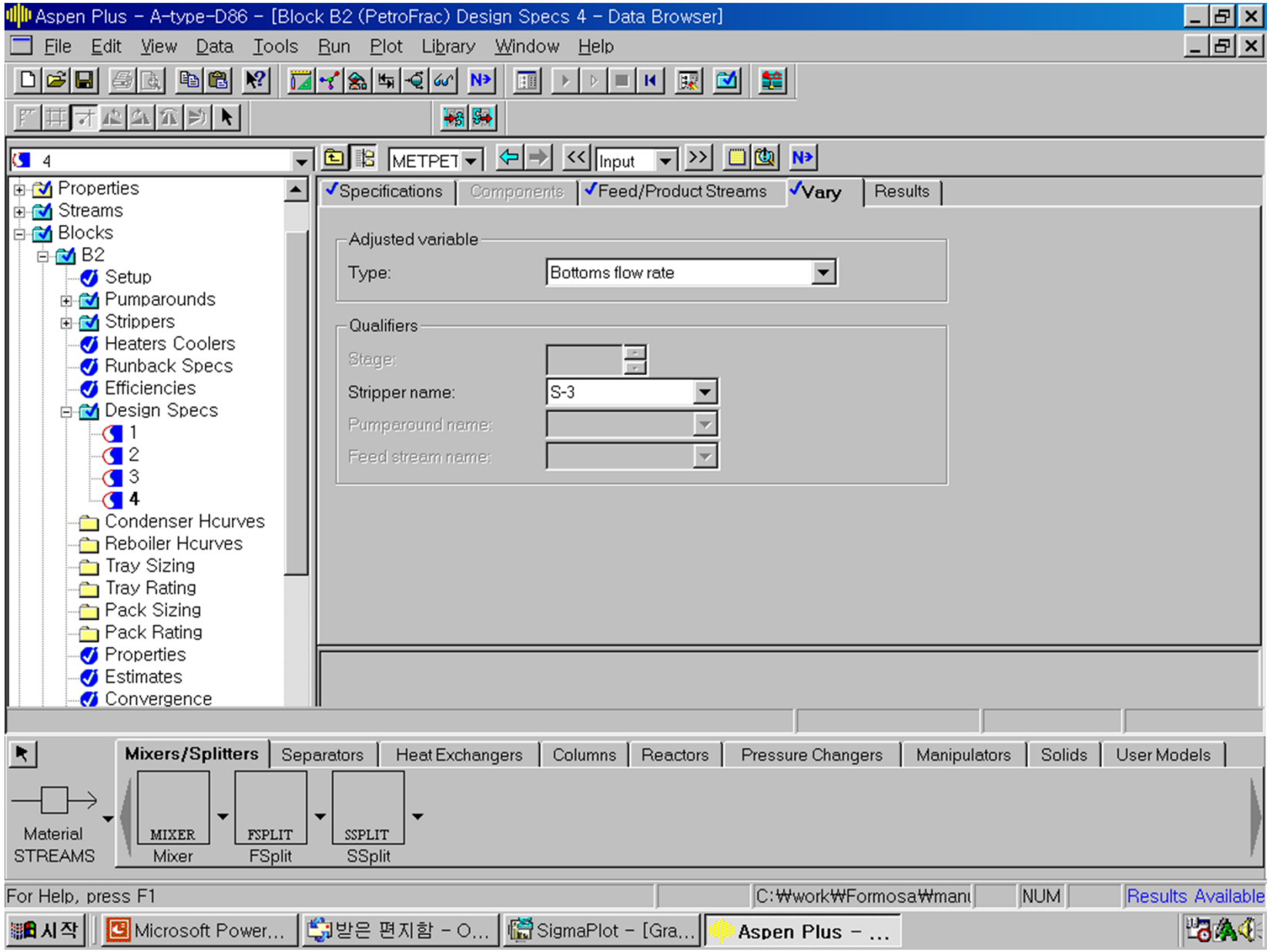
Aspen Plus – A-type-D86 – [Block B2 (PetroFrac) Design Specs 4 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Pumparounds
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Tray Sizing
Tray Rating
Pack Sizing
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Properties
Estimates
Convergence
Specifications
Components
Feed/Product Streams
Vary
Results
Adjusted variable
Type:
Bottoms flow rate
Qualifiers
Stage:
Stripper name:
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Pumparound name:
Feed stream name:
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
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Examining Simulation Results: A-type

Design *Simulation*	ASTM D86 5% Temperature (°C)	ASTM D86 95% Temperature (°C)	Product Flowrate (Ton/day)
NAPHTHA	71	153	3,549
	60.1	*153.7*	*3,069*
HSR	165	196	921
	136.6	*196*	*1,166*
KERO	198	235	1,333
	173.5	*235*	*932*
LGO	246	337	3,822
	221	*337*	*2,904*

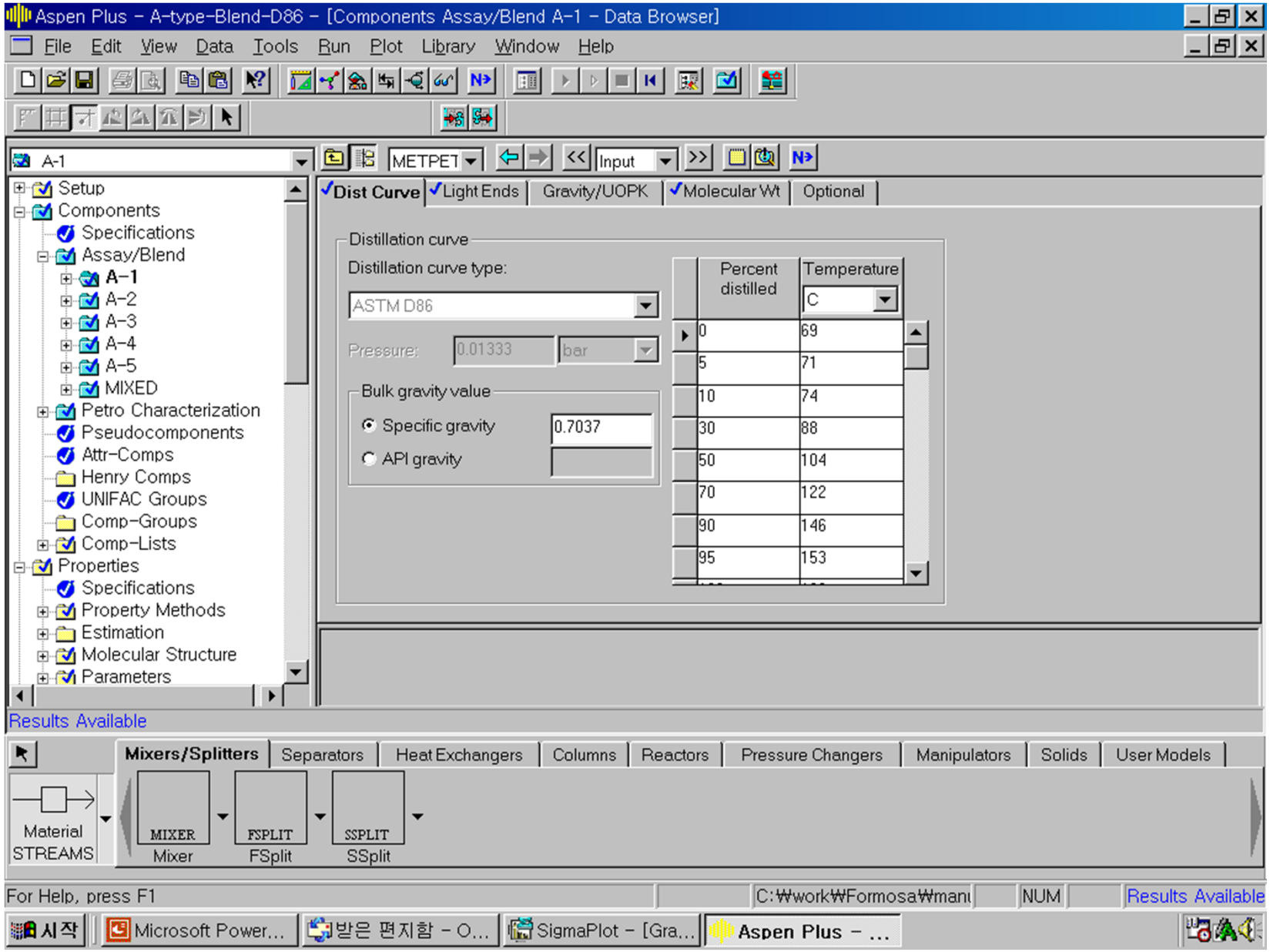
File Name = A-type-D86.bkp

Blending Products to Represent the Feed:

	USR	HSR	KERO	LGO		RESID
TBP Cut Point, °C	IBP – 166	166 - 193	193 - 232	232 - 243		343 Plus
Sp. Gr.	0.7037	0.7826	0.8034	0.8456		0.9713
ASTM D86	C5+				D1160	
IBP	69	137	168	218	IBP	319
5% vol	71	165	198	246	5% vol	368
10%	74	172	203	254	10%	381
30%	88	179	210	268	30%	454
50%	104	183	215	283	50%	533
70%	122	187	221	301	70%	684
90%	146	193	229	328	90%	874
95%	153	196	235	337	95%	-
EP	162	204	251	378	EP	-

File name : A-type-Blend-D86.bkp

For LSR Cut


Aspen Plus – A-type-Blend-D86 – [Components Assay/Blend A-1 – Data Browser]
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A-5
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Pseudocomponents
Attr-Comps
Henry Comps
UNIFAC Groups
Comp-Groups
Comp-Lists
Properties
Specifications
Property Methods
Estimation
Molecular Structure
Parameters
Dist Curve
Light Ends
Gravity/UOPK
Molecular Wt
Optional
Distillation curve
Distillation curve type:
ASTM D86
Pressure:
0.01333
bar
Bulk gravity value
Specific gravity
0.7037
API gravity
Percent distilled
Temperature
C
0 69
5 71
10 74
30 88
50 104
70 122
90 146
95 153
Results Available
Mixers/Splitters
Separators
Heat Exchangers
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Reactors
Pressure Changers
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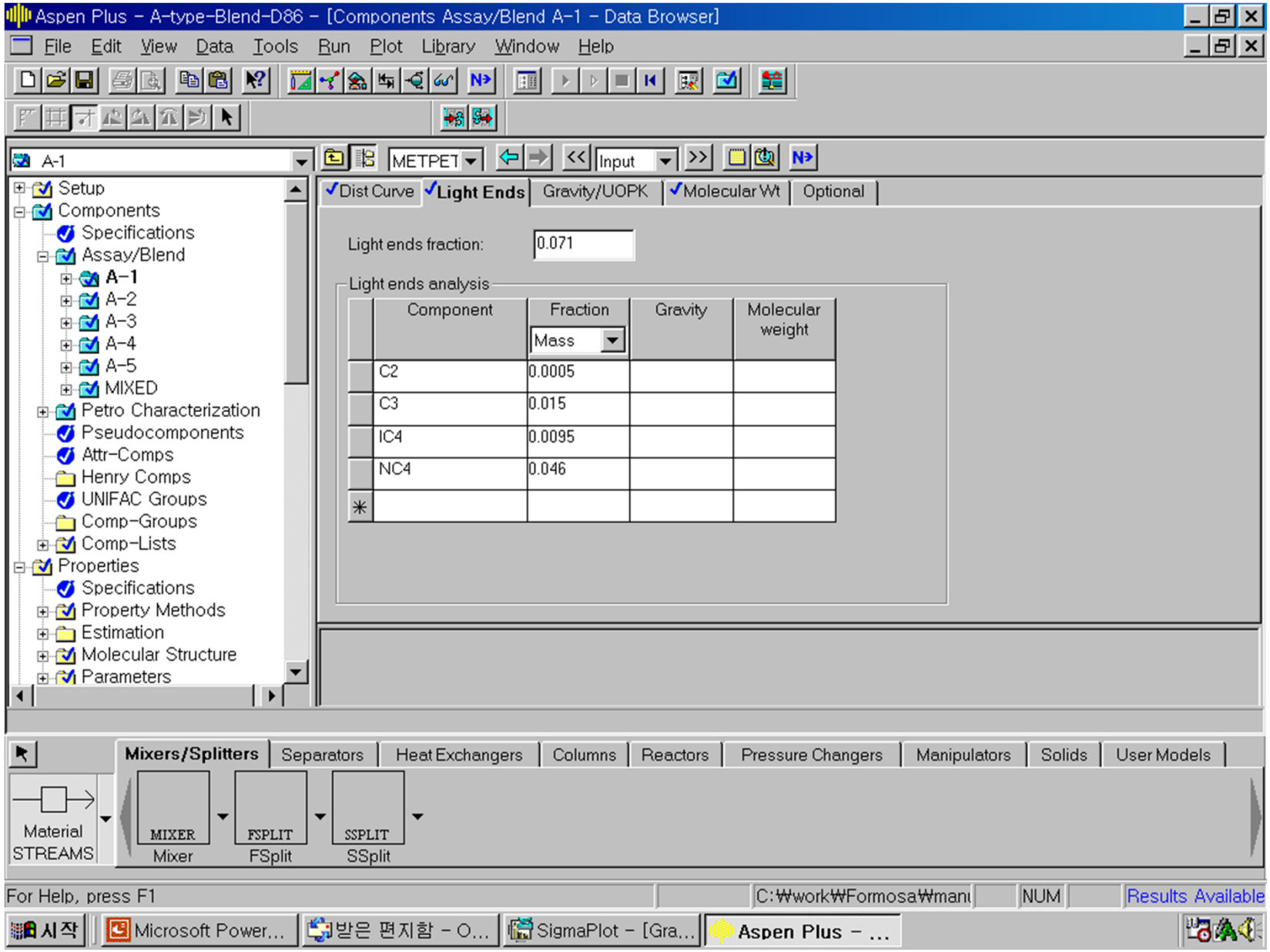
Aspen Plus – A-type-Blend-D86 – [Components Assay/Blend A-1 – Data Browser]
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Comp-Lists
Properties
Specifications
Property Methods
Estimation
Molecular Structure
Parameters
Dist Curve
Light Ends
Gravity/UOPK
Molecular Wt
Optional
Light ends fraction: 0.071
Light ends analysis
Component
Fraction
Mass
Gravity
Molecular weight
C2 0.0005
C3 0.015
IC4 0.0095
NC4 0.046
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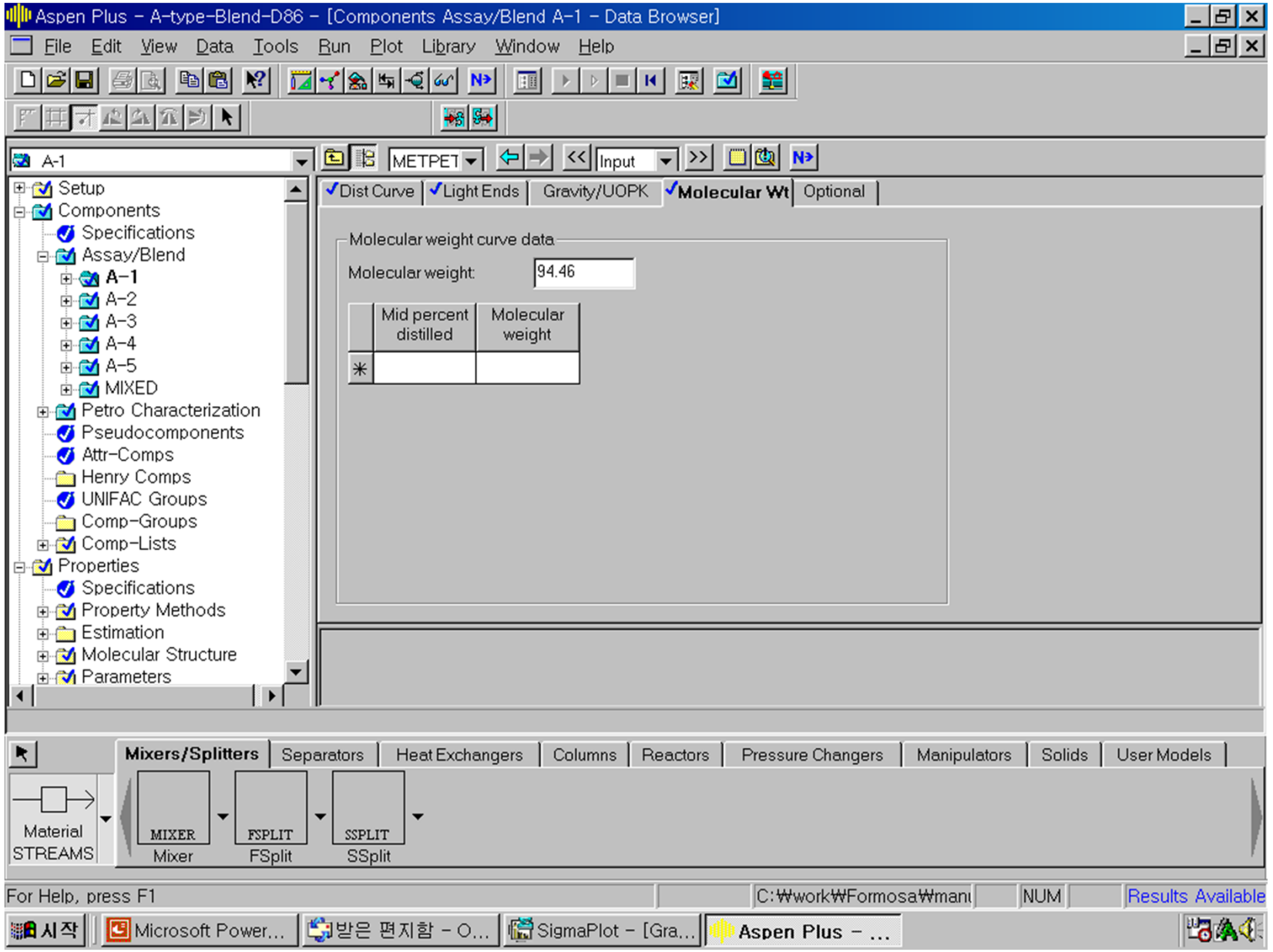
Aspen Plus – A-type-Blend-D86 – [Components Assay/Blend A-1 – Data Browser]
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Comp-Lists
Properties
Specifications
Property Methods
Estimation
Molecular Structure
Parameters
Dist Curve
Light Ends
Gravity/UOPK
Molecular Wt
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Molecular weight curve data
Molecular weight:
94.46
Mid percent distilled
Molecular weight
Mixers/Splitters
Separators
Heat Exchangers
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Reactors
Pressure Changers
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Solids
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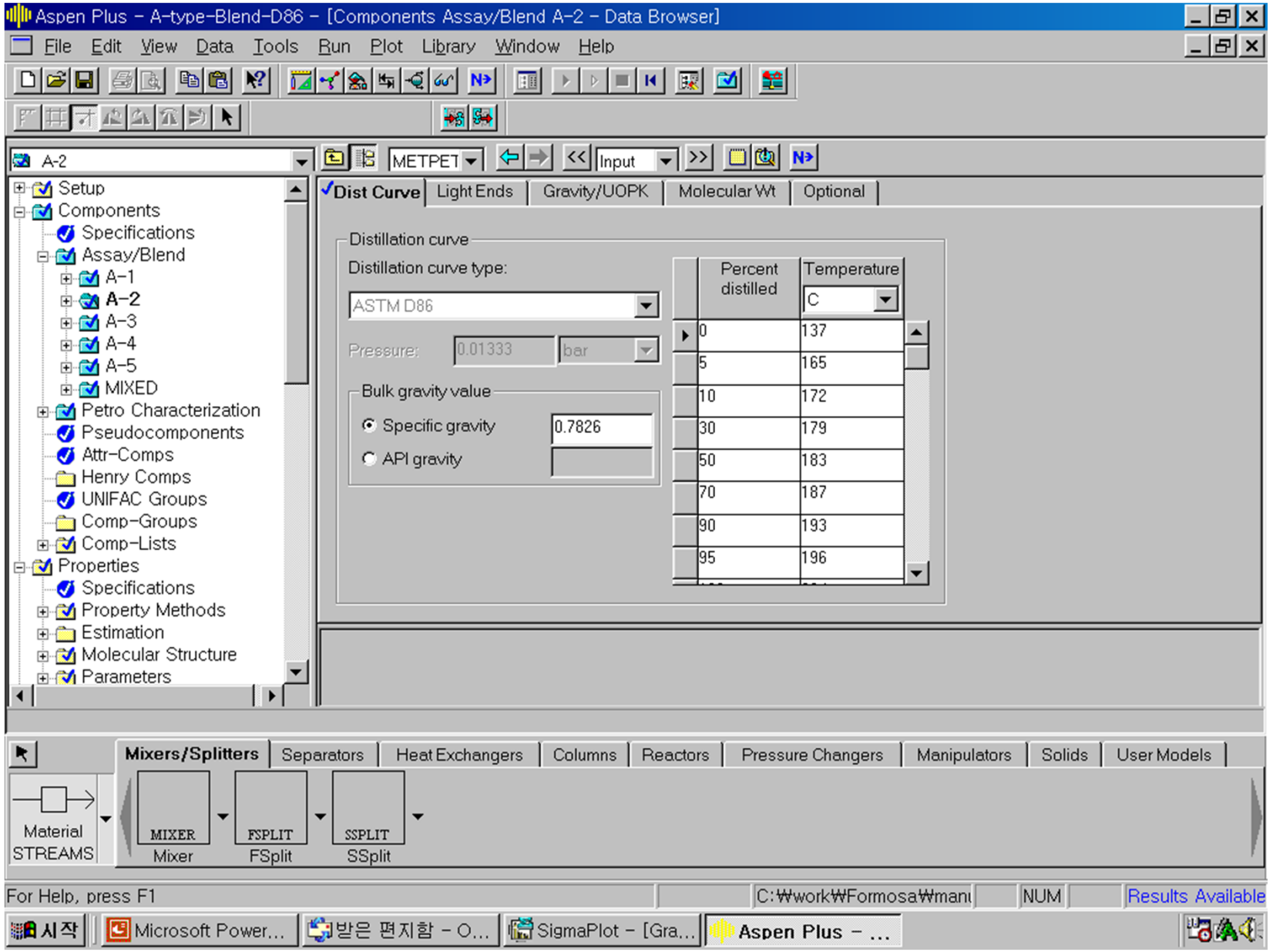
For HSR Cut


Aspen Plus – A-type-Blend-D86 – [Components Assay/Blend A-2 – Data Browser]
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A-4
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Attr-Comps
Henry Comps
UNIFAC Groups
Comp-Groups
Comp-Lists
Properties
Specifications
Property Methods
Estimation
Molecular Structure
Parameters
Dist Curve
Light Ends
Gravity/UOPK
Molecular Wt
Optional
Distillation curve
Distillation curve type:
ASTM D86
Pressure:
0.01333
bar
Bulk gravity value
Specific gravity
0.7826
API gravity
Percent distilled
Temperature
C
0 137
5 165
10 172
30 179
50 183
70 187
90 193
95 196
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
Solids
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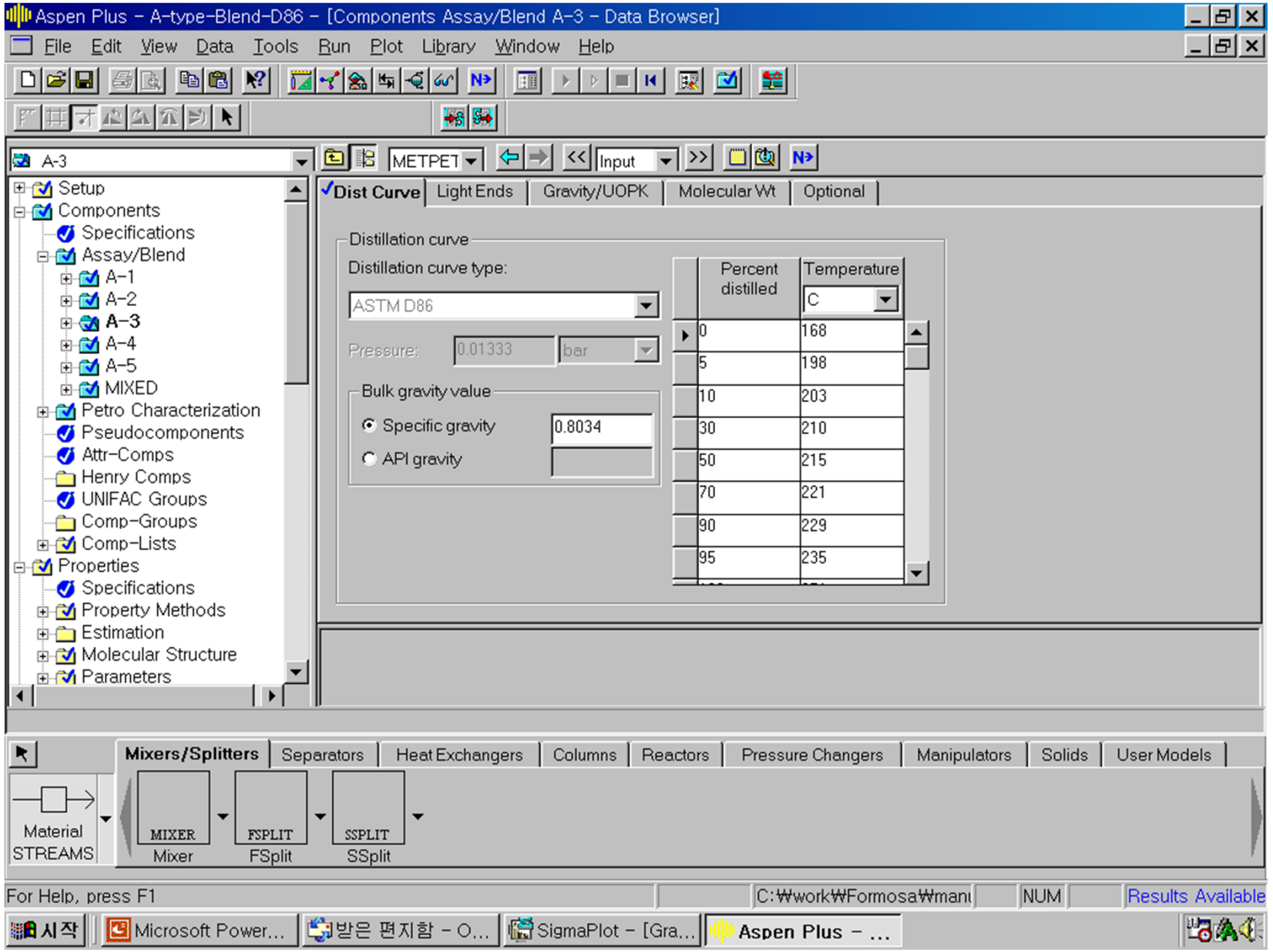
For KERO Cut


Aspen Plus – A-type-Blend-D86 – [Components Assay/Blend A-3 – Data Browser]
File Edit View Data Tools Run Plot Library Window Help
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Attr-Comps
Henry Comps
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Comp-Lists
Properties
Specifications
Property Methods
Estimation
Molecular Structure
Parameters
Dist Curve
Light Ends
Gravity/UOPK
Molecular Wt
Optional
Distillation curve
Distillation curve type:
ASTM D86
Pressure:
0.01333
bar
Bulk gravity value
Specific gravity
0.8034
API gravity
Percent distilled
Temperature
C
0 168
5 198
10 203
30 210
50 215
70 221
90 229
95 235
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
Pressure Changers
Manipulators
Solids
User Models
Material STREAMS
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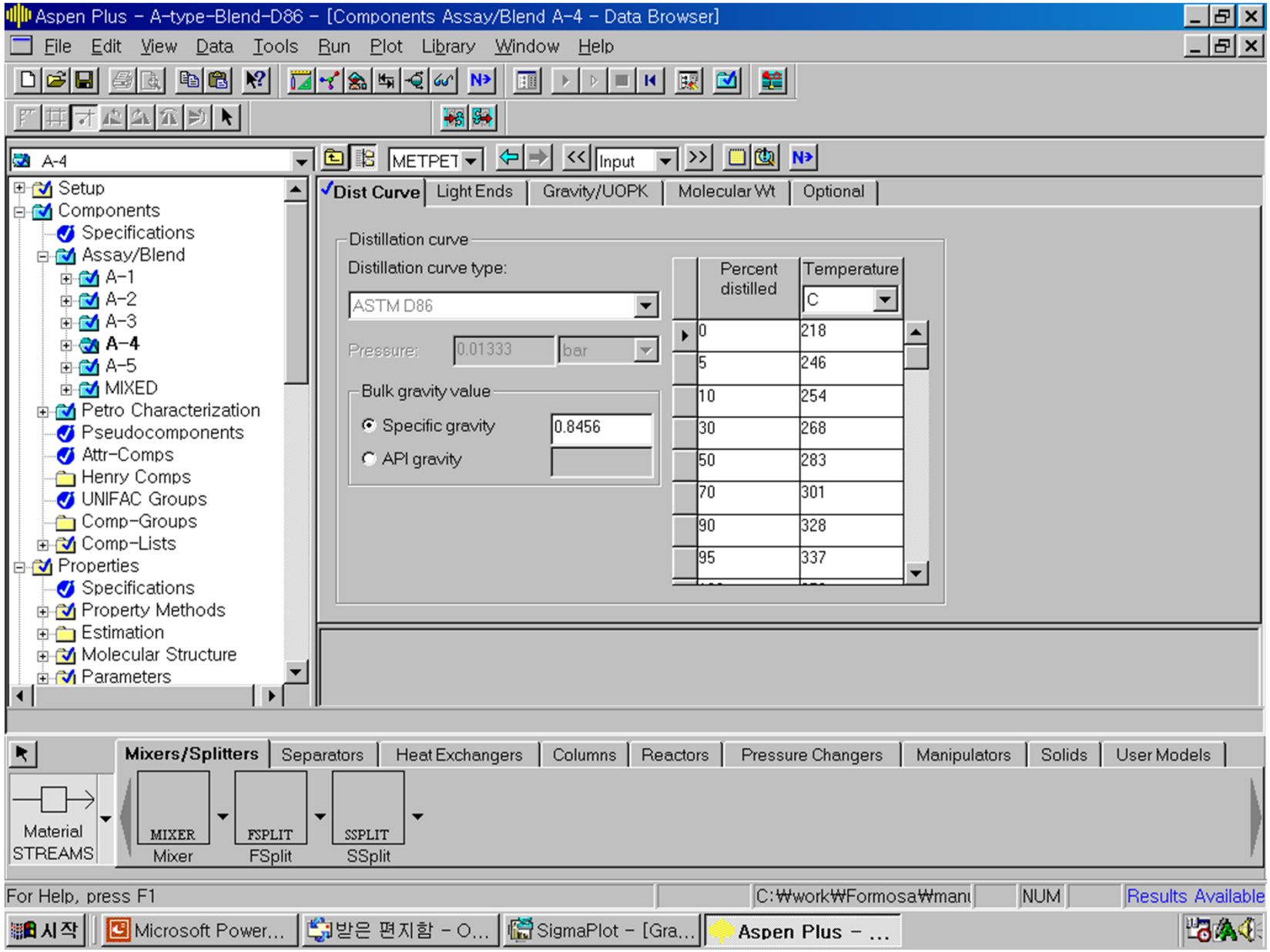
For LGO Cut


Aspen Plus – A-type-Blend-D86 – [Components Assay/Blend A-4 – Data Browser]
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Henry Comps
UNIFAC Groups
Comp-Groups
Comp-Lists
Properties
Specifications
Property Methods
Estimation
Molecular Structure
Parameters
Dist Curve
Light Ends
Gravity/UOPK
Molecular Wt
Optional
Distillation curve
Distillation curve type:
ASTM D86
Pressure:
0.01333
bar
Bulk gravity value
Specific gravity
0.8456
API gravity
Percent distilled
Temperature
C
0 218
5 246
10 254
30 268
50 283
70 301
90 328
95 337
Mixers/Splitters
Separators
Heat Exchangers
Columns
Reactors
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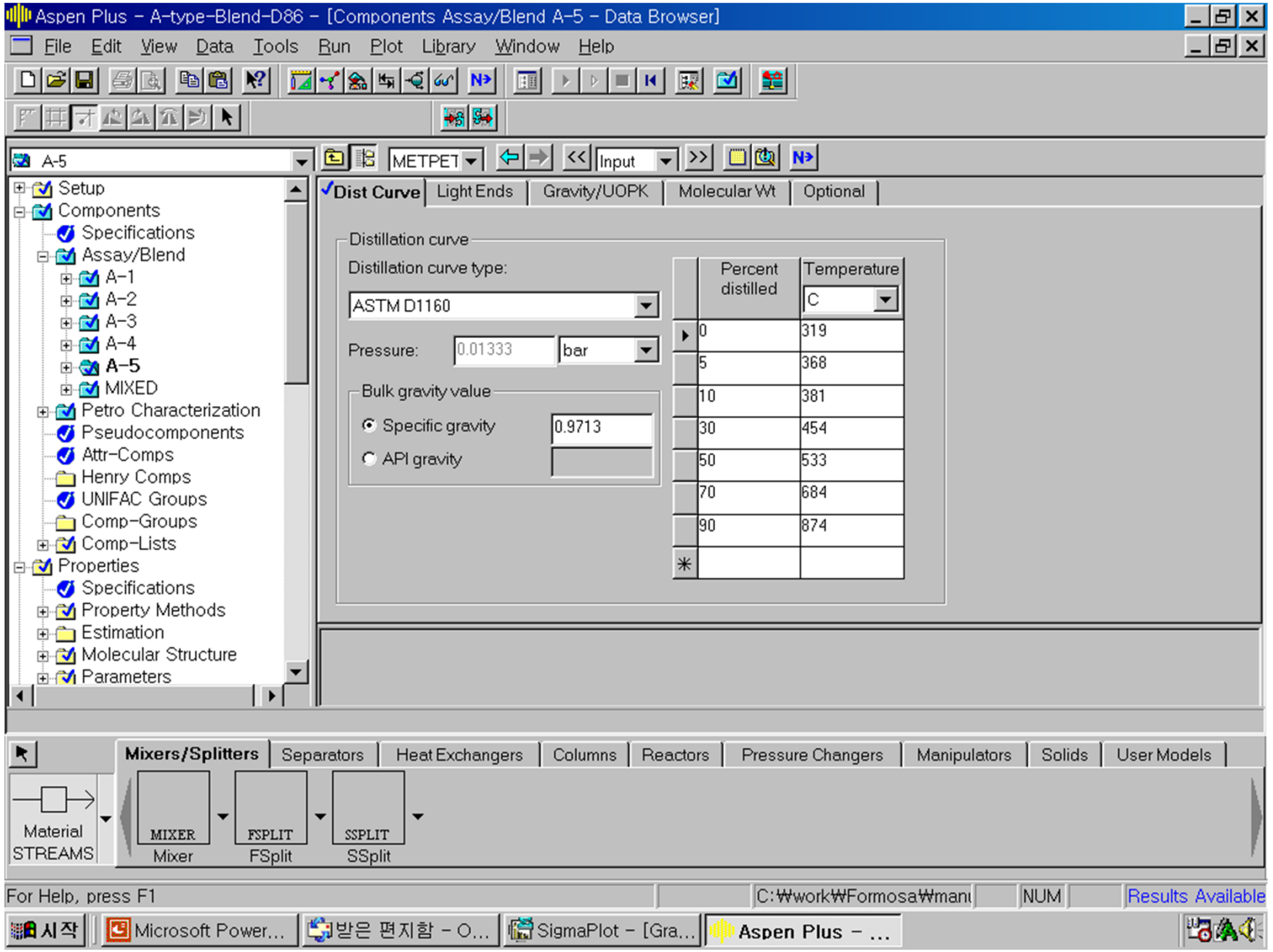
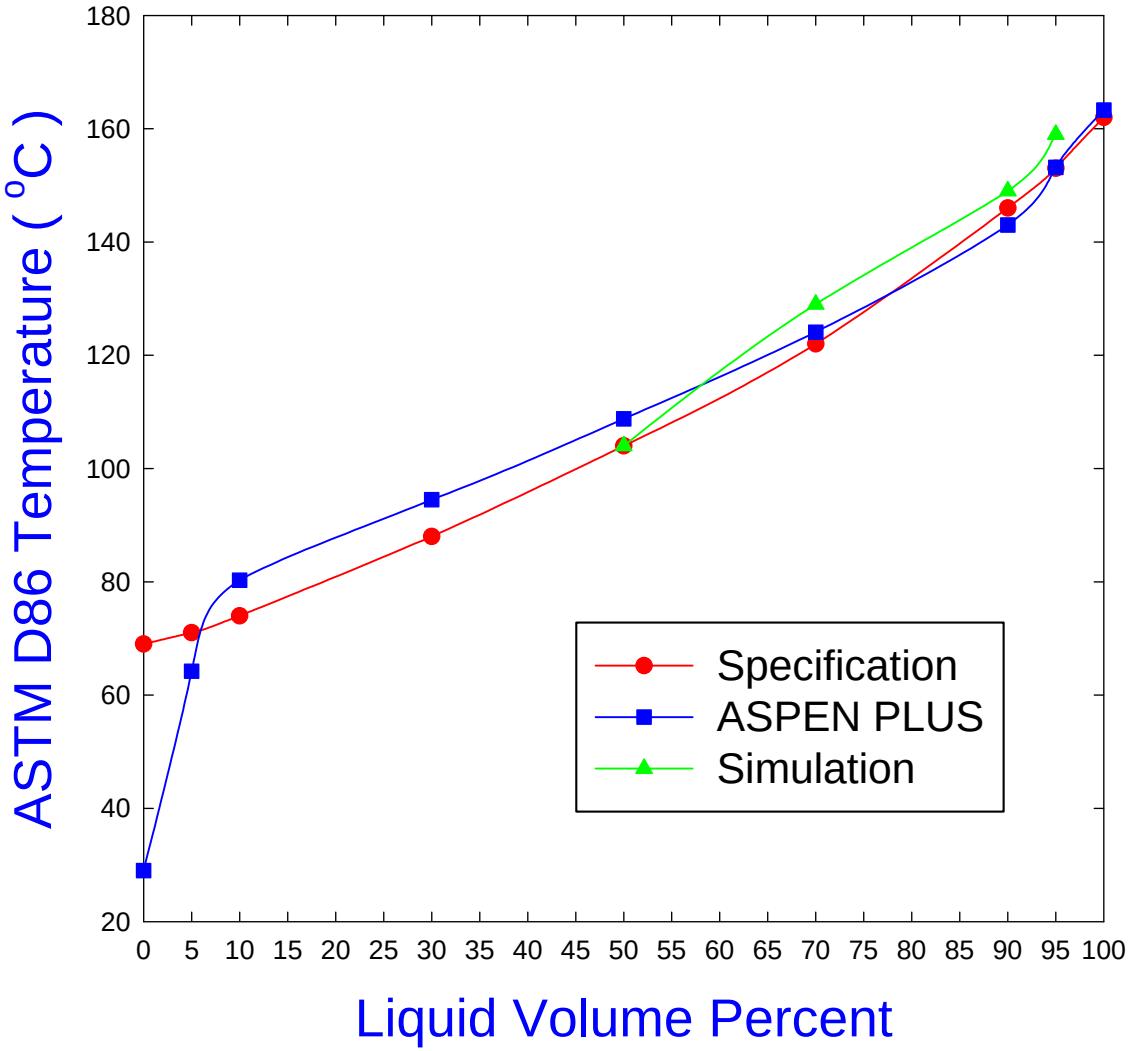


Examining Simulation Results:

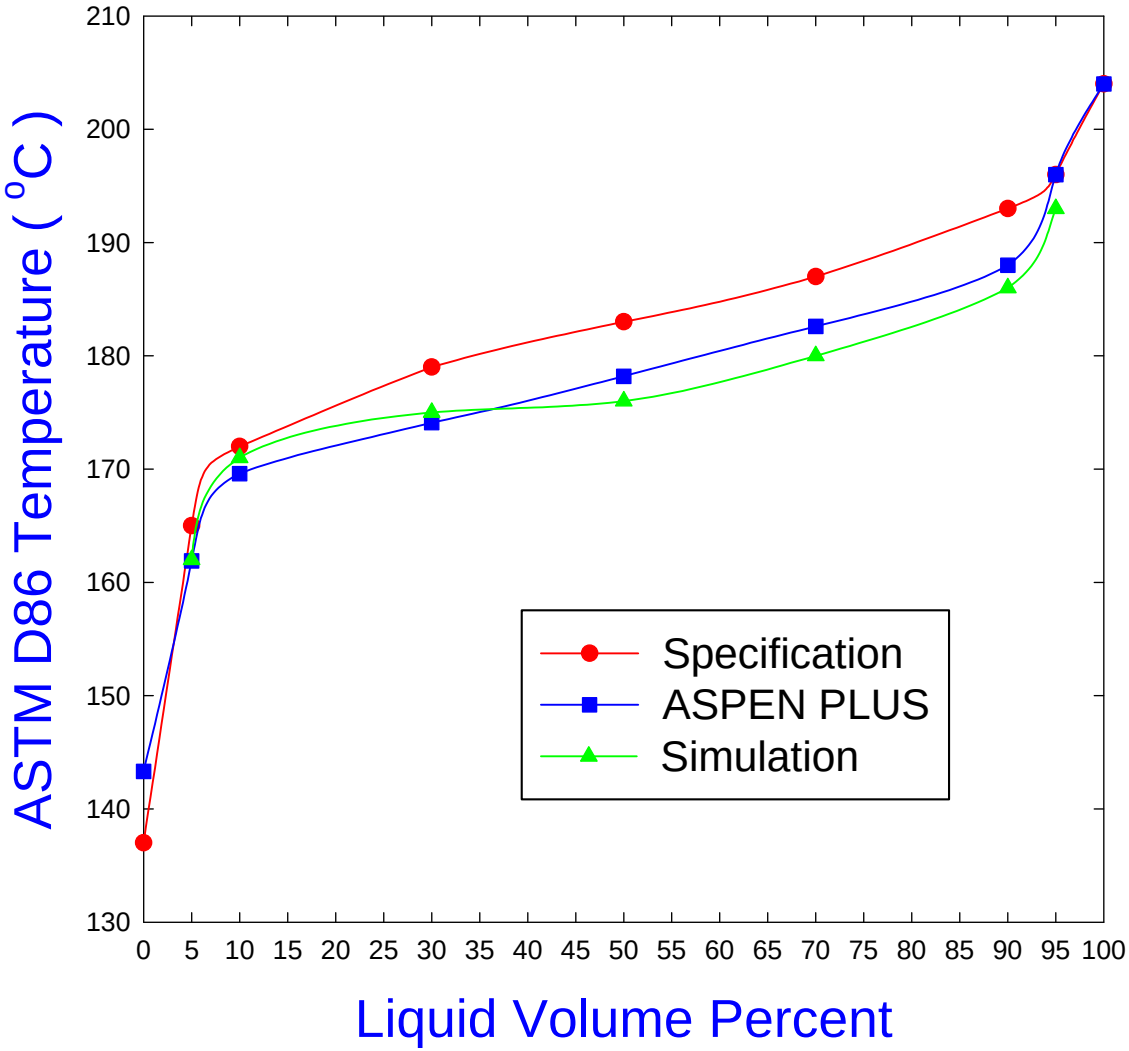
Spec. *(sim)* ***ASPEN PLUS***	ASTM D86 5% Temperature (°C)	ASTM D86 95% Temperature (°C)	Product Flowrate (Ton/day)
NAPHTHA	71	153	3,549 (16.9%)
	64	*153*	*3,835 (18.3%)*
HSR	165 *(162)*	196	921 (4.4%)
	162	*196*	*793 (3.8%)*
KERO	198 *(190)*	235	1,333 (6.3%)
	190	*235*	*1,066 (5.1%)*
LGO	246 *(238)*	337	3,822 (18.2%)
	238	*337*	*3,547 (16.9%)*

File Name = A-type-Blend-D86-N-SIDE4.bkp

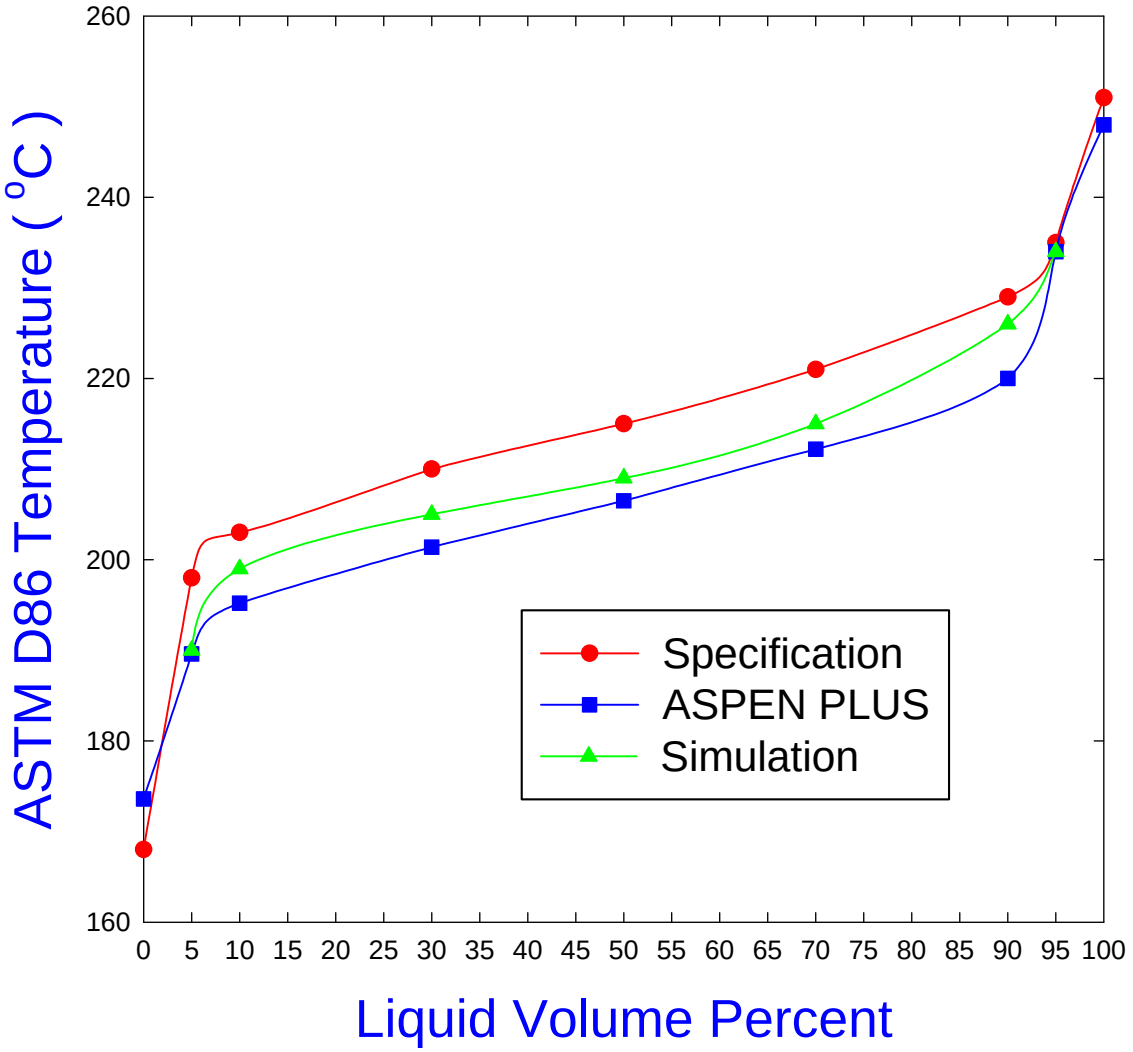
Plot of ASTM D86 Curve for LSR



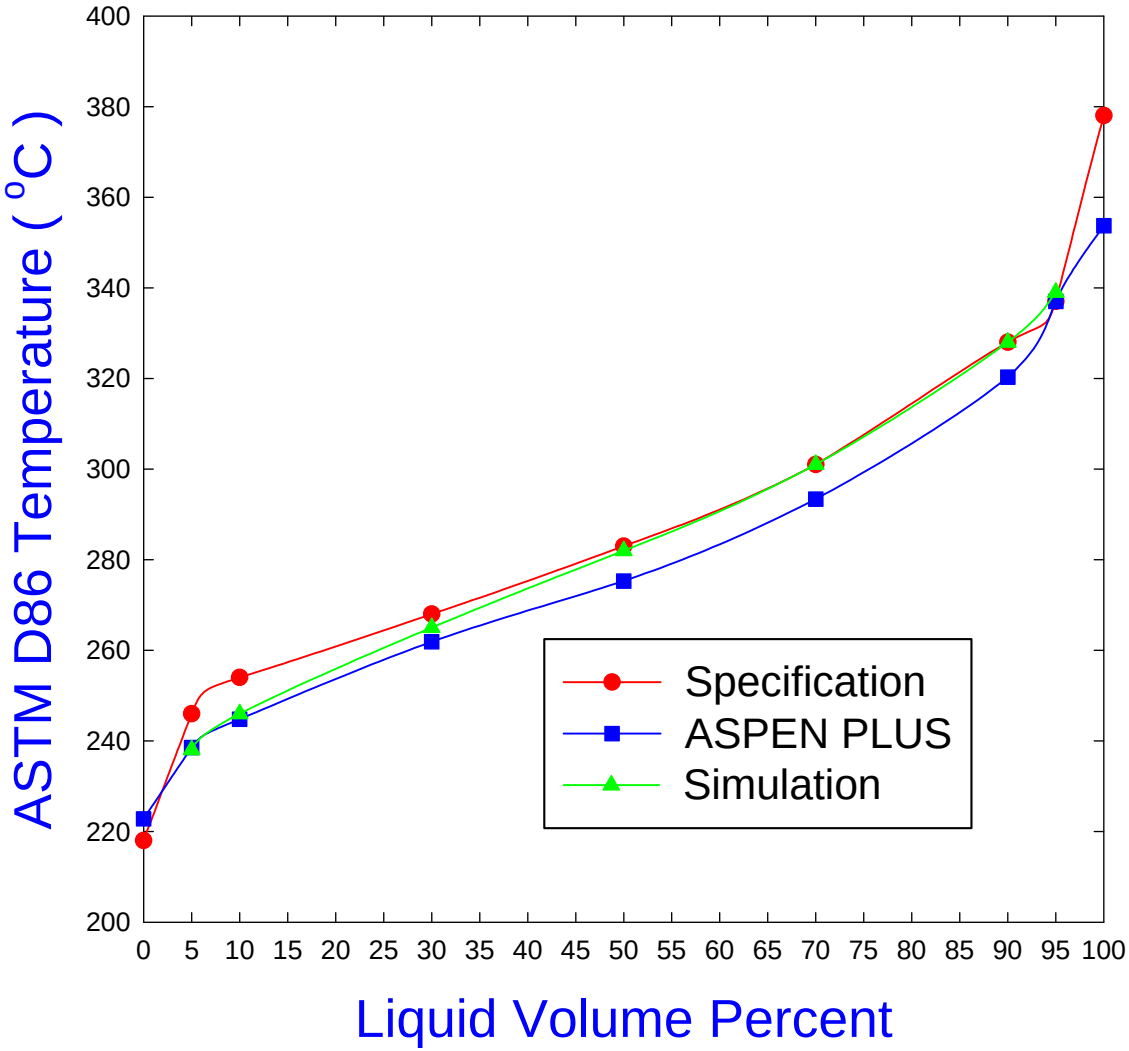
Plot of ASTM D86 Curve for HSR



Plot of ASTM D86 Curve for KERO

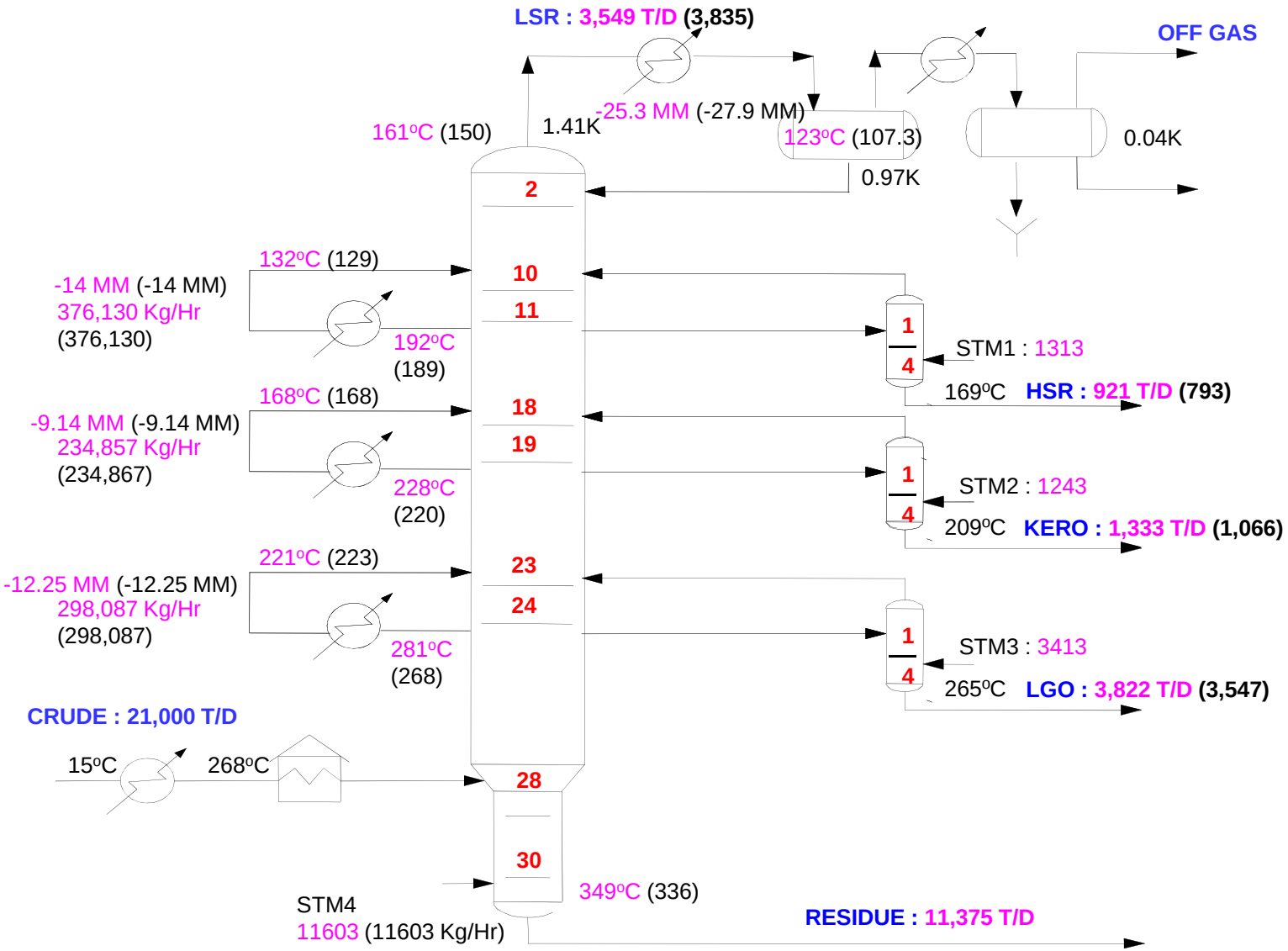


Plot of ASTM D86 Curve for LGO



Comparison with Design Data and Simulation Results

Focusing on ASTM D86 Temperatures



Conclusions

- ASTM D86 95% of simulation results are coincide with design data for each side distillates except bottom residue.

- ASTM D86 5% (or gap temperatures) can be adjusted by varying stripping steam flowrates and number of stages for side strippers.

- Blending side distillate products to characterize the feed crude is an useful procedure to simulate a Crude Distillation Unit.