HYSYS

Guidance Books

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Definition

A chemical process simulator that is used to mathematically model chemical process, from operations to full chemical plants & refiniries.

Function

HYSYS *is able to perform many of the core calculations of chemical engineering, including those concerned with* ***mass & energy balance****,* ***VLE****,* ***heat & mass transfer****,* ***chemical kinetics****,* ***fractionation****, and* ***pressure drop****.*

Speciality

The Most requested process simulator that has been trusted for over 35 years.

Experience the latest innovations in process simulation and achieve up to 98% accuracy on the V11.

In addition, it can be used to see the antoine value and determine physical properties for unknown components.

My Purpose

I created this book in order to maximize the chemical engineering field in an era that has already industrialized 4.0 or even more, where everything is completely using digitalized.

On the other hand, my hope is that students can apply more deeply about HYSYS because it is very useful when they have graduated. As well as being able to evaluate manual calculations that are compared with the HYSYS calculation.

-Present for My beloved Mom-

Working Instruction

- ➢ Determine the right tool to solve the problem:
  - ~ Manual calculation, then
  - ~ Simulator HYSYS compare
- ➢ How to used HYSYS:
  - ~ Determine the component & thermodynamic model / Fluid Package.
  - ~ Specify the process:
    - ➢ Set the feed properties
    - ➢ Decide the unit operations
  - ~ Determine the connectivity of stream for each unit operations
  - ~ Fix the parameter operations
  - ~ Run and check the result

Manage the unit value

1. Click **Tools** on the Tab menu
2. Click **Preferences**
3. Click bottom **Variable**
4. Any option is available,
5. When you want to set the unit, as following below:

   Clone > **Unit Set Name** to rename > Click symbol **Az↓ >** Click **Unit** with blue colour > set the unit you want.

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Basic

1. **Phase**

   A mixture amounts of 100 lbmole/hr with composition (in % mole) Propane 69%, n-Butane 21% and n-Pentane 10%. Determine the phase of the mixture at 140F and 200 psia, Is it only 1 phase (Liquid or Vapor) or two phases?

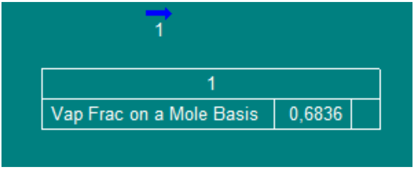
   Clue: Peng Robinson.

   Step:

- File > New > Case > Add > Input 3 components above
- Fluid Packages
- Enter Simulation
- Input blue stream in the Object Palette

- Input the condition:
  T = 150 F,
  P = 200 psia &
  Molar Flow = 100 lbmole/hr.
- Input the compositions:
  Propane : 0.69
  n-Butane : 0.21
  n-Pentane : 0.10
  *The unit: *Mole Fractions*

Conclusion:
Value of Phase:
0 = total liquid
1 = total vapor
0 – 1 = mixture.



2. **Boiling & Dew Point**

Mixture with amount of 100 lbmole/hr and compositions (% mole) Propane 69%, n-Butane 21% dan n-Pentane 10%. Determine the *boiling / dew point from the mixture at* 200 psia.

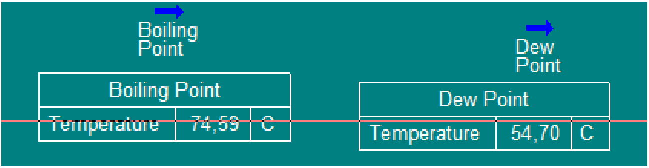
Step:

- Do as the number 1 till insert the compositions value
- Set the Vapour / Phase Fraction
  1 untuk **boiling**
  0 untuk **dew**
- Input P = 200 psia
- Mass flow = 100 lbmole/hr

Conclusion:

Dew Point = 54.70 °C

Boiling Point = 74.59 °C



3. CGR dan WGR

Determine Condensate Gas Ratio (CGR) and Water Gas Ratio (WGR) on Sbbl/MSCF unit at 21 bar and 50 ^oC.

Clue: SRK (Soave Redlich Kwong)

Components, as below:

Component	% Mole	Molecular Weight	Density kg/m^3
H2O	27.34		
N2	0.06		
CO2	3.50		
C1	57.86		
C2	4.34		
C3	3.36		
i-C4	0.78		
n-C4	0.85		
i-C5	0.38		
n-C5	0.23		
C6_CUT	0.17	84	685
C7_CUT	0.28	96	750
C8_CUT	0.32	107	770
C9_CUT	0.19	121	790
C10_CUT	0.10	134	805
C11_PLUS	0.25	195	870

***Note**

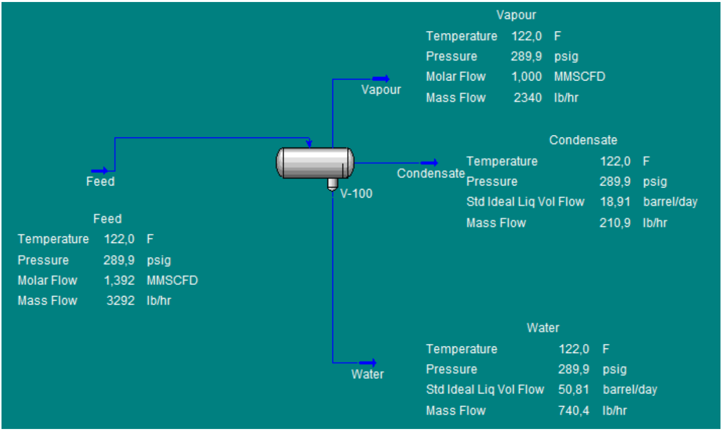
- ~ Sbbl = Standard barrels
- ~ MMSCF = 1 Mill std ft^3

Step:

- ➢ Input components
- ➢ Click Hypothetical for the component from C6 till C11
- ➢ Click Hypo Manager then add and input the name
- ➢ Set Hydrocarbon as component class.
- ➢ Add Hypo 6x then insert name, MW & Density.
- ➢ Click Estimation Unknown Props
- ➢ Blue means our input and red means the calculated result.
- ➢ Close 2x then add group/hypo.

- Input the Fluid Package.
- Enter simulation
- Insert blue stream and input the compositions
- Insert 3 Phase Separator with names of Inlet (Feed), Vapour (Vapour), Light (Condensate) and Heavy Liquid (Water).
- Set the Molar Flow Vapour = 1 MMSCFD
- Click show tabel on each stream & choice variabel Temperature, Pressure, Molar Flow dan Mass Flow.

- The result we can see that:
  .... Sbbl/day @ 1 MMSCFD.



4. Petroleum Fraction

Determine the phase & mass flow of 100000 barrel/day crude oil at 450 F & 75 psia within below:

Clue: PR

Assay Liquid Volume %	Boiling Temperature (F)
0	15
4.5	90
9	165
14.5	240
20	310
30	436
40	524
50	620
60	740
70	885
76	969
80	1015
85	1050

Bulk Properties	
Standard Density	29.320 API

Light Ends	Liquid Volume %
Methane	0.00650
Ethane	0.02250
Propane	0.32000
i-Butane	0.24000
n-Butane	0.82000
H2O	0.00000

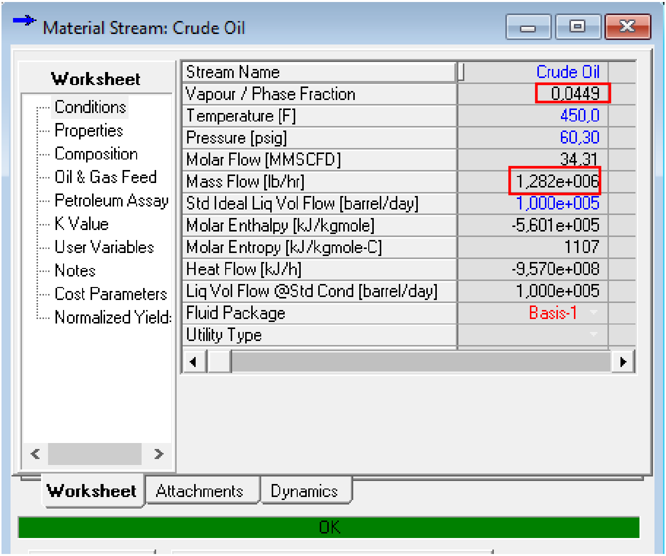
Step:

- Input the components & FP
- Click Oil Manager then set basis-1 & select **Enter Oil Environment**
- Click **Add,** then **bulk** into Used, fill the **Standard Density** with 54.82 lb/cuft, type of viscosity = Dynamic, Viscosity 1st Temp. 100 F & 2nd 210 F.
- Change **Assay Data Type** into TBP then click **Edit Assay** also input the data above & OK.
- Click **Light Ends** changes to Ignore into input composition & on the **Input Data** pick Light Ends & fill the data above.
- Click **Calculate** then **Close.**

- Click **Cut/Blend** then **Add** & **Add** again last is **close**.
- Click **Instal Oil** then set Crude Oil as **Stream Name**
- Click **Return to Basis Environment**
- Then click **Return to Simulation Environment**
- **Save As** Crude Oil file name if want to use it again
- Input blue **Stream** & check the composition also input the condition operation as above.

Conclusion:

1. Fase &
2. Mass flow is reported



Unit Operation

1. **Valve**

   Liquid is flashing with valve at 1 atm then insert to separator.

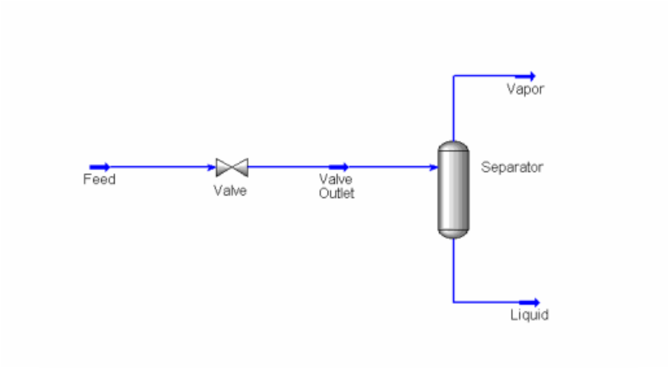
   Compositions:
   Metana : 50 lbmol/hr
   Etana : 70 lbmol/hr
   Propana : 60 lbmol/hr
   Determine molar flow & compositions at 100 psia.

   Step:

- File > New > Case
- Component > Add > Input the components
- FP > Add > PR
- Enter Simulation

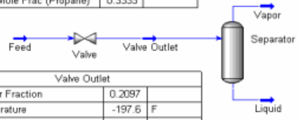
- Input the blue stream & rename “Feed” > fill the composition (basis Mole Flows)
- Condition:
  Vap Phase 0 >
  P 100 psia >
  Molar flow 180 lbmol/hr
- Insert Valve > Inlet (Feed) > Outlet (VLV Out)
- Worksheet > VLV Out P 14.70 psia > Pressure drop on ΔP will be shown
- Insert Separator > Inlet (VLV Out) > Vapour Outlet (Vap) > Liquid Outlet (Liq)
- To show the tabel > right click on the stream then show table.

Result:



Feed		
Vapour Fraction	0.0000	
Temperature	-154.6	F
Pressure	100.0	psia
Molar Flow	180.0	lbmole/hr
Comp Mole Frac (Methane)	0.2778	
Comp Mole Frac (Ethane)	0.3889	
Comp Mole Frac (Propane)	0.3333	

Vapor		
Vapour Fraction	1.0000	
Temperature	-197.6	F
Pressure	14.70	psia
Molar Flow	37.74	lbmole/hr
Comp Mole Frac (Methane)	0.9651	
Comp Mole Frac (Ethane)	0.0341	
Comp Mole Frac (Propane)	0.0009	



Valve Outlet		
Vapour Fraction	0.2097	
Temperature	-197.6	F
Pressure	14.70	psia
Molar Flow	180.0	lbmole/hr
Comp Mole Frac (Methane)	0.2778	
Comp Mole Frac (Ethane)	0.3889	
Comp Mole Frac (Propane)	0.3333	

Liquid		
Vapour Fraction	0.0000	
Temperature	-197.6	F
Pressure	14.70	psia
Molar Flow	142.3	lbmole/hr
Comp Mole Frac (Methane)	0.0954	
Comp Mole Frac (Ethane)	0.4830	
Comp Mole Frac (Propane)	0.4215	

2. **3-Phase Separator**

   How much the output of Gas, Oil and water when Input Stream 25.000 BPD at 21 bara & 50 ^{o}C. Compositions:

comp	%mole	MW	density(kg/m3)
H2O	27.34		
N2	0.006		
CO2	3.50		
C1	57.86		
C2	4.34		
C3	3.36		
i-C4	0.78		
n-C4	0.85		
i-C5	0.38		
n-C5	0.23		
C6_CUT	0.17	84	685
C7_CUT	0.28	96	750
C8_CUT	0.32	107	770
C9_CUT	0.19	121	790
C10_CUT	0.10	134	805
C11_PLUS	0.25	195	870

   Also determine WGR & CGR!

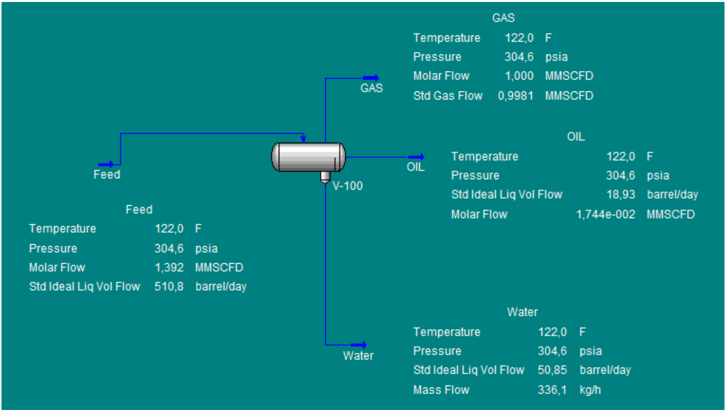
Step:

- Input H_2O till n-C5
- Component > hypothectical > input MW & density > estimate unknown
- FP > SRK (Oil & Gas)
- Insert the blue Stream & fill the condition operation
- Setting the composition (Basis Mole Fractions)
- Insert **3 phase separator** > light liquid (Oil), Heavy (Water).
- Result can be seen when the table show on the stream.
- Determine WGR&CGR
- Delete molar flow in Stream 1
- Input Molar flow for gas = 1 MMSCFD

Result:

WGR : 1 : 50.85

CGR : 1 : 18.91



3. **Heat Exchanger**

How much the calor generated if benzene at 400 kpa & 90 ^oC will be cooled to 40 ^oC with Heat Exchanger by water at 25 ^oC 400 kpa & the flow is 1000 kg/hr benzene while 10000 kg/hr of water. And also:

a. Temperature output with 1000 kj/ch heat transfer ?
b. Mass flow if using water 30 ^oC?

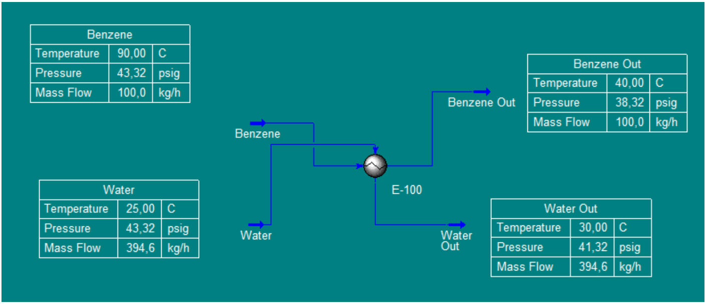
Step:

- Input components and so the FP
- Insert 2 blue stream (rename with benzene dan water)
- 1st Benzene at 90 ^oC 400 kpa and mass flow 100 kg/hr with composition benzene = 1

- 2nd Water at 25 ºC 400 kpa and mass flow 10000 kg/hr with composition water = 1
- Insert HE,
  Tube in named Benzene & Tube out = Benzene out. Shell in = Water & Shell out : Water out
- Click parameter: assumed dP Shell : 2 psig & tube : 5 psig
- Click worksheet then input Temp. benzene out : 40 ºC
- Click Rating then look at overal UA (It shown kj/Ch alias kj per ºC required)
- To know temp. benzene out when UA 1000 kj/Ch is: delete first temp. benzene out then input UA = 1000 Kj/Ch.

- To know mass flow water out of 30 ^{o}C. delete first heat flow then input benzene out temp. 40 ^{o}C & delete mass flow water then input temp. water out 30 ^{o}C. Mass flow will be shown & less also affect to capability of pump

Result:



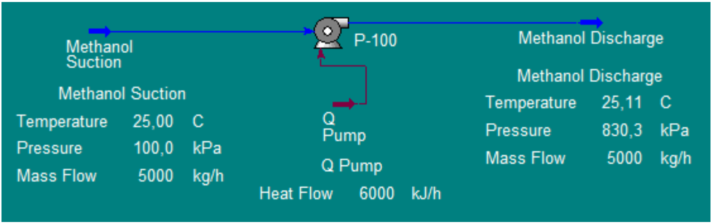
4. Pump (for liquid)

How much the Power required to pump Metanol with mass flow of 5000 kg/h at 100 kpa into 6 barg. Also how much the temperature increasing if the Power is become 6000 kJ/hr?

Step:

- Input the components & FP is using PR.
- Insert blue Stream (rename Metanol Suction) with T = 25 ^{o}C, P = 100 kpa & mass flow 5000 kg/hr. Composition metanol 0.86 & water 0.14
- Insert pump inlet as Metanol Suction & outlet as Metanol discharge.

- Input P out 6 barg & rename energy as Energy-Pump. Then, heat flow will be shown on Stream Energy & so the Power.
  *Kj/h / 3600 = kW
- To detail can show it in show table in the stream then set as you want (variable).
- To know the temperature increase. Delete first P out & input heat flow 6000 kJ/hr.
  Result:



5. Compressor

How much the Power required to compress 73% Methane 27% Ethane at 33 ^{o}C with mass flow 20 MMSCFD & initial pressure 2 barg to be 16 barg. The system is adiabatic & efficiency = 86%. Also determine the temperature increase if Power given 1500 KW?

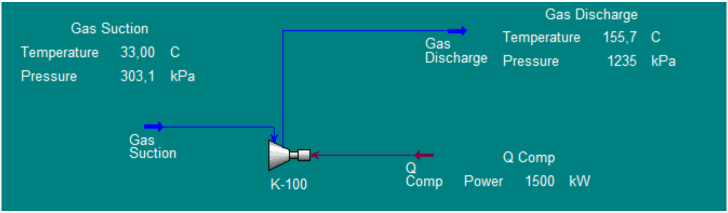
Step:

- Input components & FP = PR.
- Insert blue Stream & rename as GAS Suction with T = 33 ^{o}C & P = 3 barg also 20 MMSCFD molar Flow.
- Input the composition as above
- Insert Compressor, Inlet as GAS Suction, Outlet as Gas

Discharge & energy name with E-100.

- In the Worksheet tab fill P = 16 barg.
- Power can be seen on E-100
- Then delete P out also fill 1500 kW in Heat Flow red stream then increasing temperature & pressure can be seen.

Result:



6. Turbine

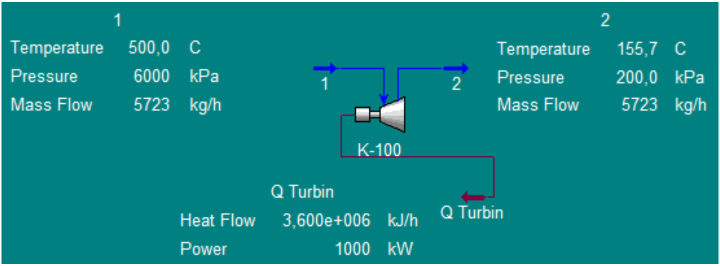
How much the power generated if we have 1000 kg/jam steam at 500 ^oC 6000 kpa & efficiency = 78%. If the pressure output 200 kpa how much kg/h water required to produce 1 MW power?

Step:

- Input Component then FP is PR PR.
- Insert turbin & fill inlet name 1 then outlet name 2 & energy named E-100
- Input condition as the task above & the composition is 1.
- To know the result can be seen in the stream energy (heat flow)

- To see the power can see in the table show.
- To know the mass flow delete first then input energy = 1 MW & can be seen the mass flow water.

Result:



7. **Splitter**

Separate i-Butane from other components at 145 psia top and bottom 153.5 psia. Also i-Butane 5% still in the bottom & n-butane 5% still on top. Use GRAYSON-STREED as FP. Condition operation:

Temperature [F]	140
Pressure [psia]	200
Mass Flow [lb/hr]	100000
Compositions	
Mole Fractions (%)	
Propane	1.40
i-Butane	33.80
n-Butane	64.60
i-Pentane	0.20

Step:

- Input the components & FP
- Insert the blue & fill the composition so the condition operation.
- Insert the Splitter & pick inlet, outlet & energy stream.
- Input split on top:

  Propane : 1

  i-Butane : 0.95

  n-Butane : 0.05

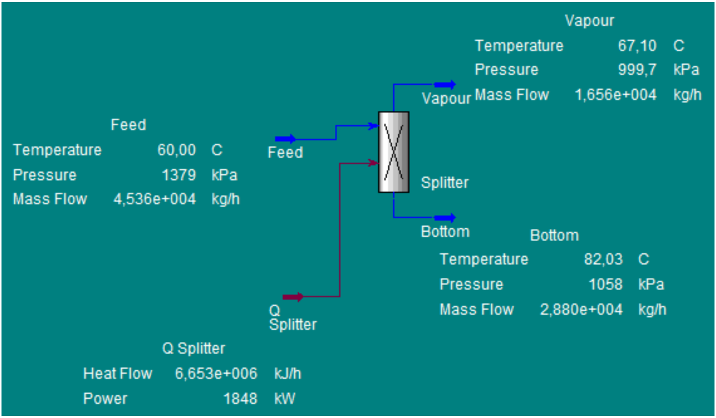
  i-Pentane : 0
- On the Parameter:

  Vapour Fraction : Top = 1

  Bottom = 0

  Pressure as description

- Show Tabel on each Stream



8. **Reactor conversion** **(CH_4 Combustion)**

Composition:

Methane : 0.01 lbmole/hr

Oxygen : 0.02 lbmol/hr

Condition Operation:

25 ^oC & 0 barg.

What is the fraction of component & temperature out after reaction ?

Step:

- Input components of CH_4, O_2, H_2O dan CO_2. Use PR as FP.
- Click **Reactions**
- **Add,** click **Conversion** & input the raw material then product with setting Coeffisien:

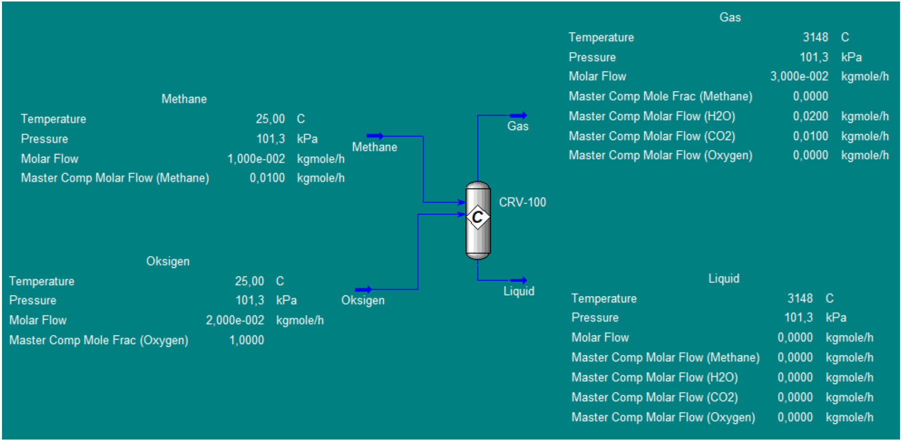
  CH_4 : -1

  O_2 : -2

CO_2 : 1
H_2O : 2

- **Basis**, pick Methane as **Base Component** & **Vapour Phase** in Rxn Phase also **Co** = 100. Then close.
- Clock **Reaction Set then** delete Global Set & **Add Set. Then** active checklist in Active List & then **Add to FP.**
- Enter simulation Environment.
- Insert blue Stream & name Methane also input the composition as 1.
- Condition at 25 ^oC 0 barg & molar flow 0.01 kgmole/hr.
- Insert blue Stream & rename as Oxygen then fill with 1 the composition 1.

- Then fill the same condition operation but molar flow 0.02 kgmole/hr.
- Insert **Reaktor Konversi**
- Inlet (Methane & Oksigen), Vapour Outlet (Gas), Liquid Outlet (Liquid).
- Pick Reactions in the reactor then click Reaction set become Set-1.
- Show tabel of each stream for the variabel Temperature, Pressure, composition of each Component & Molar Flow. Then will be seen T, P, m & Component of each Stream.


Methane
Temperature 25,00 C
Pressure 101,3 kPa
Molar Flow 1,000e-002 kgmole/h
Master Comp Molar Flow (Methane) 0,0100 kgmole/h
Methane
Oksigen
Temperature 25,00 C
Pressure 101,3 kPa
Molar Flow 2,000e-002 kgmole/h
Master Comp Mole Frac (Oxygen) 1,0000
Oksigen
CRV-100
Gas
Liquid
Gas
Temperature 3148 C
Pressure 101,3 kPa
Molar Flow 3,000e-002 kgmole/h
Master Comp Mole Frac (Methane) 0,0000
Master Comp Molar Flow (H2O) 0,0200 kgmole/h
Master Comp Molar Flow (CO2) 0,0100 kgmole/h
Master Comp Molar Flow (Oxygen) 0,0000 kgmole/h
Liquid
Temperature 3148 C
Pressure 101,3 kPa
Molar Flow 0,0000 kgmole/h
Master Comp Molar Flow (Methane) 0,0000 kgmole/h
Master Comp Molar Flow (H2O) 0,0000 kgmole/h
Master Comp Molar Flow (CO2) 0,0000 kgmole/h
Master Comp Molar Flow (Oxygen) 0,0000 kgmole/h

9. Distilattion Column

Pure Ammonia produce from mix Ammonia-Acetone-Water with 16 Stages include reboiler dan condenser total. Feed on Stage 13 & side draw on stage 5.

Data as below:

FEED STREAM INFORMATION		
Pressure	Feed Tray Pressure	
Temperature	473	K
Component		
Ammonia	3702.77	kgmoles/hr
Acetone	17.93	kgmoles/hr
Water	126.55	kgmoles/hr

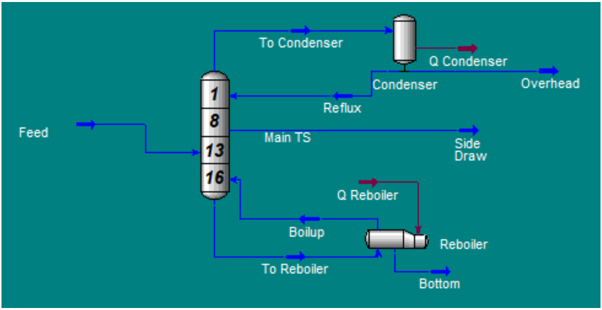
PROCESS INFORMATION		
Condenser pressure	1555	kPa
Pressure drop - Condenser	10	kPa
Reboiler pressure	1589	kPa
ΔP/tray	1.5	kPa
Liquid side draw rate	18	kgmoles/hr
Pressure drop - Reboiler	1.5	kPa
Reflux rate	2500	kgmoles/hr
Overhead product rate	3702	kgmoles/hr

Step:

- Input the component above & NRTL as FP
- Insert blue Stream also the composition.
- Fill the condition temperature 473 K & Pressure 1583 kPa.
- Insert Distillation Column then click Total Condenser and named Q Condenser on the Energy Condenser, Q Reboiler on the Energy Reboiler & Feed as Inlet, Overhead as Ovhd Outlet, Bottom as Bottom Outlet, also Side Draw on Optional Side Draw, & 13 as Inlet Stage & 16 total Stage. Then, Next

- Input 290 psia on the Condenser pressure & 10 Psi on the Condenser Pressure Drop also 300 psia on the Reboiler Pressure. Change dP reboiler to 1.5 kPa. Then, Next 2x & Done. Click Specs & delete all of the Variabel.
- DOF = 3 then have to input 3 Variabel required. Add
- Pick Column Draw Rate rename as OverheadRate & choice Overhead@COL1 on Draw & input 3702 at Spec Value.
- Click Column Draw Rate then change name to Side Draw Rate & pick Side Draw@COL1 in draw also input 18 kgmole/h in Spec Value.

- The last pick Column Reflux Ratio & Condenser in Stage so input 0.6753. Then close.
- As we can see that DOF = 0 and click Run
- Then click Parameter to see Pressure, Temperature & flow of each stage and tray.
- To see the detail distillation column. Column Environment.
- Result:



Logical Operations

1. **Set**
   To fix the value from process variabel which is spesific with other similar variabel (example: Temperature from 2 Stream).

2. **Adjust**
   To variate 1 value of variable independent to comply with any spesification required (Variabel Dependen). It can be use for different variabel / similar. Also can be used for trial iteration & error for the automatic.

3. **Example of SET & ADJUST:**

1. Well with composition of (A & B) ratio 80:20 at 120 ^{o}C 40 barg.

The gas flow rate required from well = 300 MMSCFD with WGR 20 Sbbl/MMSCF, gas flow rate is not including the liquid.

2. Flow of well split to 2 stream which is the one has Std. Gas Flow (MMSCFD) = 100. FP = PR.

Data composition:

	A	B
Component	Mole Fractions, %	
Nitrogen	0.04	0.05
CO2	4.29	1.22
Methane	85.57	84.79
Ethane	2.89	4.71
Propane	2.27	3.17
i-Butane	0.53	0.68
n-Butane	0.63	1.06
i-Pentane	0.34	0.41
n-Pentane	0.22	0.30
n-Hexane	0.52	0.23
n-Heptane	0.45	0.76
n-Octane	0.75	0.71
n-Nonane	0.38	0.28
n-Decane	0.37	0.26
C11+*	0.74	1.37
Properties untuk C11+ adalah :		
Normal Boiling Point	: 300 C	
Molecular Weight	: 200	
Liquid Density	: 800 kg/m^3	

Note:
Std. Gas Flow can't be input directly as Molar Flow (MMSCFD).

Step:

- Input the composition then in to tab Hypothetical for C11
- Click Hypo Manager then add and rename the group
- Click Hydrocarbon as the class.
- Add Hypo 1x then input

Name	: C11
NBP[C]	: 300
MW	: 200
Density	: 800 kg/m^3

- Click Estimate Unknown Props
- Input into Component by **Add hypo**
- Use PR as FP.

- Enter Simulation Environment
- Insert blue Stream (A) & fill the composition. Then, set the condition 120 ºC & 40 barg.
- Insert the blue Stream biru (B) & composition as the data also condition same as A.
- Insert blue Stream (Water) & Composition 1 with same condition of A.
- Insert Mixer & inlet A, B & Water also outlet (Pre Heater)
- Insert Heater with inlet Pre Heater also Energy (Q Heater) & Outlet (Well) with dP 0 psi so Temp. Well 120 ºC.
- It can be seen that all Stream is not OK (Still light blue) due to not have the flow.

Tips:

1. Flow Stream A get from Adjust to get 300 MMSCFD in Stream Well.
2. Flow Stream B get from SET installed between Stream A dan B.
3. Stream water get from Adjust to reach 6000 BWPD on the Stream Well.

Continue Step:

- Insert 2 Adjust & 1 Set.
- SET:

  Target : Std Ideal Liq Vol B

  Object : Stream A

  Multi : 0.25

  Offset : 0 barrel/day
- ADJUST-1 :

Adjusted Variabel
Object : Mass Flow A
Target Variabel
Object : Phase Std Gas Flow (Vapour Phase) Well
Target Value : 300 MMSCFD
Method : Secant
Tolerance : 0.001
Step Size : 9000 kg/h
Minimum : 0
Maksimum : 1 Billion
Max Iterasi : 1 Million

- ADJUST-2:
  Adjusted Variabel
  Object : Mass Flow Air
  Target Variabel
  Object : Phase Liq Vol Flow (Aqueous Phase) Well
  Target Value :6000 barrel/day

Method : Secant
Tolerance : 0.001
Step Size : 9000 kg/h
Minimum : 0
Maksimum : 1 Billion
Max Iterasi : 1 Million

- Input flow on Stream A and Water then the value will differ to be the target.
- Insert the Tee with Inlet (Well) then outlet (to Test Separator) & (to Production Manifold) then stream still in light blue.
- Insert Adjust-3

  Adjusted Variabel

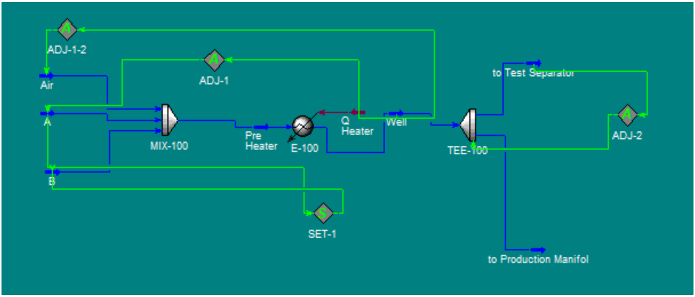
  Object : Flow Ratio [Flow Ratio_1) Tee

  Target Variabel

Object : Phase Std Gas Flow [Vapour Phase] to Test Separator
Target Value : 100 MMSCFD
Method : Secant
Tolerance : 0.01
Step Size : 0.01
Minimum : 0
Maksimum : 1
Max Iterasi : 1 Billion

- Due to is not OK
- Open TEE then Parameter & click Flow Ratio set into 0.1 for to test.
- Double click on Stream to Test Separator then see Properties & also Std Gas Flow become 100 MMSCFD.

Result:



ADJ-1-2
ADJ-1
Air
A
MIX-100
Pre
Heater
E-100
Q
Heater
Well
TEE-100
to Test Separator
ADJ-2
B
SET-1
to Production Manifol

4. **Recycle**

   A plant wants to increase pressure of Gas with ***Gas Compression Plant.*** Gas separate from the liquid with 1 Separator with asumption dP 0 & eficiency compressor 72.5% with increasing pressure into 1000 psia. Then decrease the temperature with cooler dP 10 psi. Temperature set till have composition of 80% methane (mole fraction). Gas outlet then separate with Separator 2 dP 0.

   Data, as below:

Temperature [F]	:	20
Pressure [psia]	:	700
Molar Flow [lbmole/hr]	:	1000
		Mole Fractions
Methane	:	0.35
Ethane	:	0.25
Propane	:	0.10
i-Butane	:	0.10
n-Butane	:	0.10
i-Pentane	:	0.05
n-Pentane	:	0.03
n-Hexane	:	0.02

Question:

1. Which is located the recycle?
2. T out cooler?
3. Flow rate (lbmole/hr) gas product?
4. Flow rate (lbmole/hr) output recycle?

Step:

- Input the component above & use PR as FP.
- Insert blue Stream & input the composition also the condition.
- Insert Separator 1 & inlet (Inlet Gas), Vapour Outlet (Vap) & Liquid Outlet (Liq). Then close.
- Insert Compressor & inlet (Vap), Energy (Q Comp) also Outlet (Feed Cooler).
- Set the efficiency in Parameter (72.5%), input P out 1000 psia.
- Insert Cooler & inlet (Feed Cooler), Energy (Q Cooler) & Outlet (Feed Sep 2). Then input dP 10 psi also feed Temperature Feed 50 ^oF in tab Worksheet.

- Insert separator 2 & inlet (Feed Sep 2), Vapour Outlet (Gas Hasil) and Liquid Outlet (Recycle).
- Insert blue Stream Biru and named Liq Recy then click Define from Other Streams then pick Recyle in the Available Stream.
- Double click on the Separator 1 then inlet add Liq Recy.
- Insert Recycle, inlet (Recycle), Outlet (Liq Recy). Because is not Converged, then
- Insert Adjust & set:

  Adjusted Variabel:

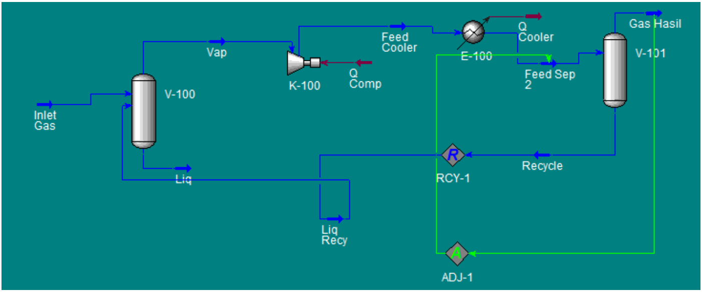
  Object : Feed Sep 2

  Variabel : Temperature

  Target Variabel:

Object : Gas Hasil
Variabel : Master Comp Mole Frac (Methane)
Target Value : 0.8
Tolerance : 1e-3
Step Size : 10 F
Minimum : 1 F
Maximum : 1000 F
Iterasi : 1000

- Result.



5. **Spreadsheet**

   It is used to calculate on the variable process with the formula inside. Such as excel but version HYSYS also can be used for complex mathematical formula & Boolean Logical. Spreadsheet also has full access to all of variable process so the logical unit.

   Example:

   Optimization Crude Oil in to Plant Design No. 4 with setting the pressure in the Separator because if pressure increases the liquid production also is increase. Margin called as the difference between decreasing of liquid again minus the utility cost of reboiler & condenser can be calculated in $/day.

Cost Factors:

1. Recovered liquid = $28/bbl
2. Electric condenser= $0.04/kwhr
3. Gas for reboiler = $2.5/MMBtu
4. Power Factor = 3.412 Btu/kwhr

Step:

- Insert 4 Set
- Setting the Set 3:
  Target Variabel:
  Pressure Stab Vapour
  Source:
  Gas
  Multiplier : 1
  Offset : -10 psi
- Also for Set 4:
  Target Variabel:

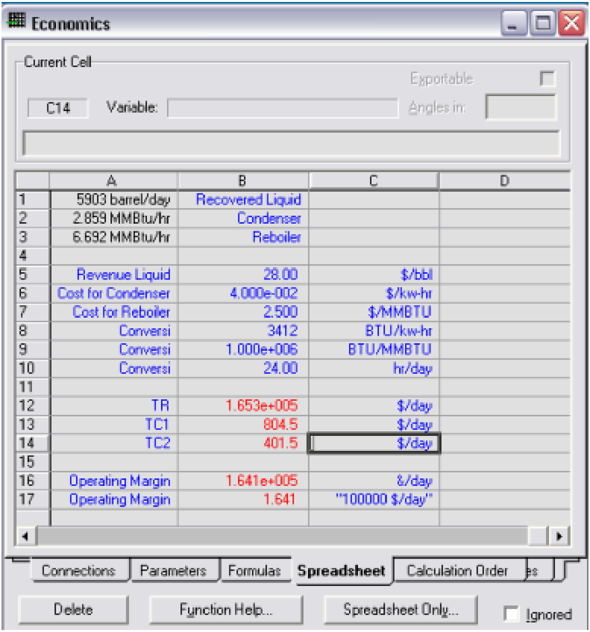
Pressure Bottom
Source:
Gas
Multiplier : 1

- Then 5:
  Target Variabel:
  Pressure Oil
  Source:
  Oil & Water
  Multiplier : 1
- Last is Set 6:
  Target Variabel:
  Pressure Water
  Source:
  Oil & Water
  Multiplier : 1
- Insert Spreadsheet then named with Economics

- Click Add Import then pick Cell A1, Object (Pump Out), Variabel (Std Ideal Liq Vol Flow)
- Click Add Import again on A2, Q Condenser and Heat Flow
- Click Add Import for A3, Q Reboiler and Heat Flow
- Then click on tab Spreadsheet & input information as below:

1. Revenue from Liquid pada Pump Out (TR)
   = \$28/bbl x L bbl/day = 28 L \$/day
   L = Liquid Volume from stream Pump Out
2. Cost of Q Condenser (TC1)
   = (\$0.04/kwhr x kwhr/3412 Btu) x (10^6 Btu/MMBtu)
   x (Q MMBtu/hr) x (24 hr/day) = $0.04 \times 10^6 \times 24 \times Q/3412$ \$/day
   (Q = heat flow Condenser in MMBtu/hr)
3. Cost of Q Reboiler (TC2)
   = (\$2.5/MMBtu) x (Q MMBtu/hr) x (24hr/day)
   = 2.5 x Q x 24 \$/day
   (Q = heat flow Reboiler in MMBtu/hr)
4. Operating Margin = TR – TC1 – TC2

Result:



	A	B	C	D
1	5903 barrel/day	Recovered Liquid		
2	2.859 MMBtu/hr	Condenser		
3	6.692 MMBtu/hr	Reboiler		
4				
5	Revenue Liquid	28.00	$/bbl	
6	Cost for Condenser	4.000e-002	$/kw-hr	
7	Cost for Reboiler	2.500	$/MMBTU	
8	Conversi	3412	BTU/kw-hr	
9	Conversi	1.000e+006	BTU/MMBTU	
10	Conversi	24.00	hr/day	
11				
12	TR	1.653e+005	$/day	
13	TC1	804.5	$/day	
14	TC2	401.5	$/day	
15				
16	Operating Margin	1.641e+005	&/day	
17	Operating Margin	1.641	"100000 $/day"	

- Input Databook then Insert and pick Pressure LP Crude.
- Insert again Mass Flow Stab Feed, Stab Vapor & Stab Bottom.
- Insert Heat Flow Q Conderser & Q Reboiler.
- Insert Std Ideal Liq Vol Flow Pump Out
- Last Insert B12, B13, B14 & B17 Economics.
- Click Case Studies & pick Pressure LP Crude Ind and beside that Dep. then click View
- Pick Independent Variables Setup & input Low 275, High 375 & Step Size 5. Then Start,
- To know the result click Result and will be an option of Graph.

- Click Setup to choose variable you want to see.
- Checklist only B17 then click Result.

6. **Balance**

   It used to provide Heat & Material Balance. There are 6 types of Balance Operation. To get Solve, only 1 variable shall to input between temperature / pressure output (neither).

   Example:

   Create 1. Balance Heat and Material Balance

   Compositions:

   Methanol : 40%

   Acetic Acid : 40 %

   Water : 10%

M-Acetate : 10%

Condition Operation :

Tin : 164.6 F

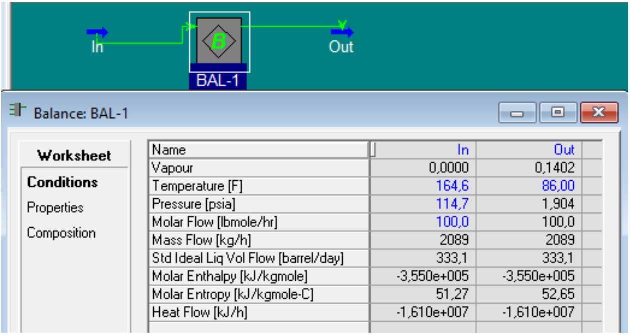
Tout : 86 F

Pin : 100 psig

Molar Flow : 0.9107 MMSCFD

- Input component and FP using PR
- Insert 2 blue Stream Biru then fill the condition & composition.
- Insert Balance & use Component Mole & Heat Flow Balance Type.

- We can see that Heat Flow & Mass & Molar Flow will be similar in the input & output.



Name	In	Out
Vapour	0,0000	0,1402
Temperature [F]	164,6	86,00
Pressure [psia]	114,7	1,904
Molar Flow [lbmole/hr]	100,0	100,0
Mass Flow [kg/h]	2089	2089
Std Ideal Liq Vol Flow [barrel/day]	333,1	333,1
Molar Enthalpy [kJ/kgmole]	-3,550e+005	-3,550e+005
Molar Entropy [kJ/kgmole-C]	51,27	52,65
Heat Flow [kJ/h]	-1,610e+007	-1,610e+007

Plant Design

1. **Crude Stabilizer Plant**
   Stream of Well is choked down to 300 psia then goes to separator & Oil from Separator flows to stabilization tower after heated by 250 ºF. Stabilizer has T condenser 120 F & Reboiler 100 F. Product tower bottom till 150 F & pump till 1000 psia. Then result of top compressed into 1000 psia. Pressure drop in HE = 5 psi for each section & 10 for Stabilizer. Simulate it!

Composition well:

Component	Mole Fraction	MW	Density (lb/ft3)
C1	0,097		
C2	0,110		
C3	0,150		
i-C4	0,090		
n-C4	0,085		
i-C5	0,050		
n-C5	0,045		
n-C6	0,048		
C7F	0,060	98,000	45,902
C9F	0,065	125,000	48,209
C11F	0,061	159,000	50,080
C14F	0,056	202,000	52,575
C18F	0,039	258,000	54,446
H_2O	0,044		

Step:

- Input the component
- Click tab Hypothetical for C7F sampai C18F

- Click Hypo Manager then add also name the group
- Pick Hydrocarbon as the component class.
- Add Hypo 5x then input Name, MW, Density.
- Click Estimation Unknown Props
- Blue is our input & red is result
- Close 2x then add group/hypo one on one. FP uses PR
- Enter Simulation
- Insert blue Stream and input the Composition at 150 ^{o}F & 800 psia with flow rate 10000 lbmol/hr. Then close
- Insert Valve (Name it) Choke Valve & fill Inlet (Crude) So Outlet (LP Crude).

- Pressure drop = 500 psi then close.
- Insert 3-Phase Separator with Inlet (LP Crude), Vapour (Gas) Light Liquid (Oil) & Heavy Liquid (Water). Then close.
- Insert Heater and named with (Preheat Exchanger) then inlet = Oil, Energy = Q heater & Outlet Stab Feed.
- Parameter with dP 5 psi & Tout 250 F. Then close.
- Insert Splitter & named with Stabilizer also Inlet Stab Feed, Top Outlet = Stab Vapour & bottom = Stab Bottom so Energy = Q Stab.
- Splits:

  C1 : 1

C2	: 1
C3	: 0.95
C4	: 0.05
H_2O	: 1

Besides that = 0.

- Parameter:

T Vapour	: 120 F
P Vapor	: 290 psia
Fraction Bot	: 0
P bottom	: 300 psia

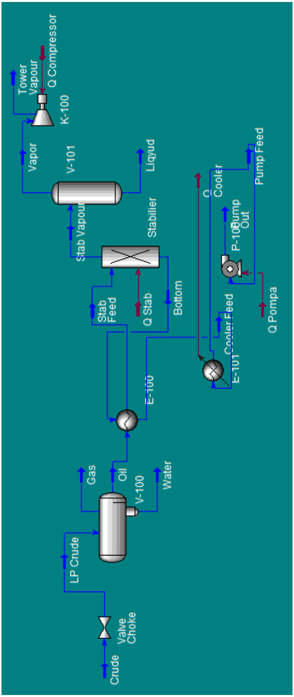
Then close.

- Insert Separator with inlet (Stab Vapour), Vapour Outlet (Vapor) & Liquid Outlet (Liquid). Then close.
- Insert Compressor with inlet Vapour, Energy Q Compressor dan Outlet (Tower Vapour)

- Parameter then click Adiabatic Effisiensi 72% at P Tower Vapour 1000 psia. Then Close.
- Delete Pre Heat Exchanger also the Q Heater due to get Stream Bottom from Stabilizer to heat Oil that will be feed to stabilizer.
- Insert HE with Tube inlet (Oil), tube outlet (Stab Feed), shell inlet (Bottom) & shell outlet (Cooler Feed).
- Parameter input dP 5 psi for tube & shell also change HE model to *Weighted*. Then close.
- Insert Cooler with inlet (Cooler Feed), Energy (Q Cooler) & Outlet (Pump Feed).

- Parameter & dP 10 psi at 150 F then named temperature out. Click close.
- Insert Pump with inlet (Pump Feed), outlet (Pump Out) & Energy (Q Pump).
- Parameter & dP 715 psi with adiabatic efficiency 76.5%. Then close.

Result:


Crude
Valve Choke
LP Crude
V-100
Gas
Oil
Water
E-100
Stab Feed
Q Stab
Bottom
Stabilier
Stab Vapour
V-101
Vapor
Liqyud
K-100
Tower Vapour
Q Compressor
Cooler Feed
E-101
Q Cooler
Pump Feed
P-100
Pump Out
Q Pompa

2. **Continue of Case 1**
   From case 1 want to separator operated as adiabatic at 300 psia & hydrocarbon liquid contain 0.1% (molar) water. Change Separator 3 phase into 2 phase then Splitter. To get spesification of water content in the water on the feed stabilizer. Use adjusts to variety water fraction in the oil stream. Use Set to control the condition of product flow from dari Splitter at 300 psia & use set to specified temperature output because have to same with flow of oil + water.

Step:

- Use case 1
- Delete 3-phase Separator then insert 2-Phase Separator & Splitter.
- Separator named then input LP Crude as Inlet & Gas as Vapour Outlet as Oil & Water on the Liquid Outlet. Then close.
- Splitter named with Separator 2 then input Stream Oil & Water as Inlet & Oil on Overhead Outlet also click Water on Bottom Outlet. Input Q-Sep 2.
- Input 300 psia on Pressure Oil & Water in Parameter. Then close.
- Insert Adjust & 2 Set
- Set 1:

  Target Variabel:

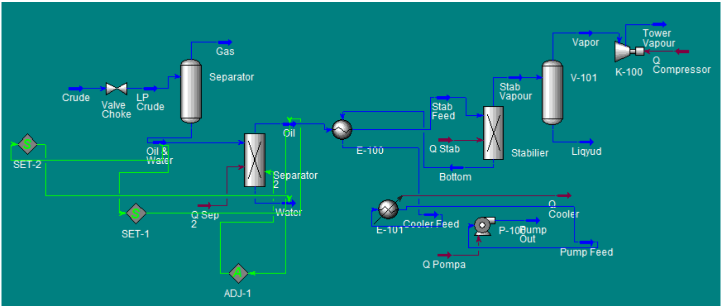
Temperature Oil
Source:
Oil & Water
Multiplier : 1
Offset : 0 F

- Set 2:
  Target Variabel:
  Temperature Water
  Source:
  Oil & Water
  Multiplier : 1
  Offset : 0 F
- Adjust:
  Adjust Variabel:
  Object : Separator 2
  Variabel : Overhead Fraction Water
  Target Variabel:
  Object : Oil

Variabel : Master Comp Mole Frac Water
Target Value: 0.001

- Lalu Parameter:
  Toleransi : 1e-6
  Step Size : 1e-2
  Minimum : 0
  Maximum : 1
  Iterasi : 1e6
  Then close.
- Splitter edit Splittere & input 1 on the all of components except H_2O.
- From Worksheet composition of Oil will be shown H_2O = 0.001.

Result:



Gas
Separator
Crude
Valve Choke
LP Crude
Oil & Water
SET-2
Oil
Separator 2
Q Sep 2
Water
SET-1
ADJ-1
E-100
Stab Feed
Q Stab
Bottom
Stab Vapour
Stabilier
Vapor
V-101
Liqyud
Tower Vapour
K-100
Q Compressor
E-101
Cooler Feed
Q Cooler
P-100
Pump Out
Pump Feed
Q Pompa

3. **Continue Case 2**

   Model required of distillation column has 8 stages theoretic (except condenser & reboiler) at P kondenser 290 psia and dP 10 psi. Temperature bottom 360 ^{o}F, feed from stage 4 with same temperature feed 250 ^{o}F & temperature condenser 120 ^{o}F. Product liquid bottom has 25 psia.

   Step:

- Continue Case 2 then insert Distillation Column
- Delete Separator 1 & Stabilizer also the Stream Vapour, Liquid & Qstab
- On the Distillation Column, pick Full Reflux & named with

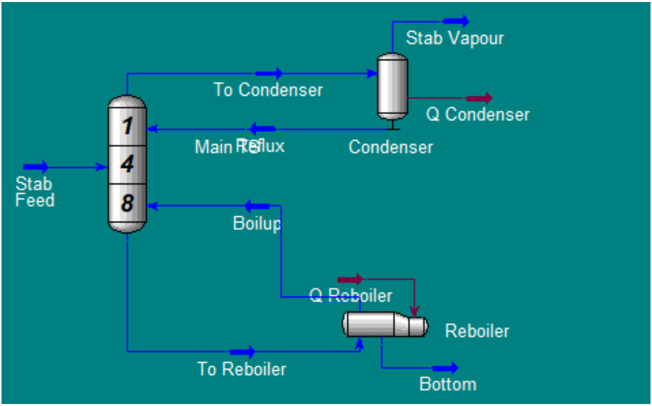
(Stabilizer), Q-Condenser for Condenser Energy & Q-Reboiler for Reboiler Energy then Stab Vapour for Ovhd , Bottom for Bottoms & input Stab Feed on Inlet Stream then pick stage 4 for the feed & 8 for total Stages. Then Next.

- It will shown 290 psia above, 0 psi middle & 300 psia bottom. Then Next 2x.
- Click Done.
- Click Specs
- Delete all variabel in Column Specification by click Tab Delete for each Variabel then DOF = 2. It means we have to add 2 Variabel. Then Add

- Click Column Temperature then Add Specs, input Condensor as Stage at 120 ^{o}F in Spec Value. Then close.
- DOF = 1,
- Pick Column Vapour Pressure Spec then pick Reboiler Stage at 25 psia in Spec Value. Then close.
- Click Run and Converged. Close, in the parameter field can be seen the result.
- Click Column Environment to see the detail
- Click the erlenmeyer to back to Environment / CTRL + T
- Click Parent Environment & will be back to Home.

- Insert Stream Stab Vapour into inlet Compressor & Outlet as Tower Vapour also Energy (Q Compressor). Then close

Result:



4. **Multi Stage Separation**
   Separate feed with 1050 psia & 135 ^oF to gas dan liquid. 3 stage separator of pressure 260, 90 dan 20 psia to stabilize crude. Heater is used before 2nd stage to fulfill spec crude vapor pressure 15 psia at 100 F. Gas in to 3rd stage compresor centrifugal at 750 psia output. Output of each compressor want to 100 F and liquid recycled to 1 of stages. Liquid stage 1 recycled to low pressure separator, but 2nd 3rd liquid scrubber recycled to intermediet pressure separator. Assumed dP 5 psi on each cooler & heater

with adiabatic compresor = 0.72.

Data, as below:

Component	Flow Rate	MW	Density	NBP
	lbmole/hr		lb/ft^3	deg F
C1	4688			
C2	950			
C3	800			
i-C4	171			
n-C4	429			
i-C5	154			
n-C5	238			
CO2	467			
C6*	429	89	43.92	174
C7*	679	100	46.66	222
C8*	533	113	47.72	268
C9*	500	124	48.72	307
C10+	2635	163	50.28	422

Step:

- Input component & click hypothetical. FP = PR.

- Insert blue stream & input the composition.
- Insert separator with name Flash 1, Inlet (Feed), Vapour Outlet (Vap F1) & Liquid Outlet (Liq F1).
- Set parameter & input dP 790 psi.
- Insert Heater & inlet (Liq F1), Energy (Q Heater) also Outlet (Outlet Heater)
- Set parameter with dP 5 psi T outlet 200 ^{o}F.
- Insert Mixer then named Mixer 1 & inlet (Outlet Heater) then Outlet (Feed F2).
- Insert Separator with name Flash 2, inlet (Feed F2), Vapour

Outlet (Vap F2), & Liquid Outlet (Liq F2).

- Set parameter & dP 175 psi.
- Insert Mixer named Mixer 2 then inlet (Liq F2) & Outlet (Feed F3).
- Insert Separator then name it Flash 3, inlet (Feed F3), Vapour Outlet (Vap F3) & Liquid Outlet (Crude).
- Set parameter dP 60 psi.
- Insert Compressor with name Comp 1, inlet (Vap F3), Outlet (Outlet C1) & Energy (Q Comp1).
- Set parameter, 72% Adiabatic Eficiency & fill P Outlet C1 80 psia.

- Insert Mixer with name Mixer 3, inlet (Outlet C1 dan Vap F2) & Outlet ketik Feed Cool1.
- Insert Cooler with name Cool 1, inlet (Feed Cool1), Energy (Q Cool1), & Outlet (Feed F4).
- Set parameter dP 5 psi & 100 F on Feed F4
- Insert Separator with name Flash 4, inlet (Feed F4), Vapour Outlet (Vap F4) & Liquid Outlet (Liq F4).
- Insert Compressor with name Comp 2, inlet (Vap F4), Energy (Q Comp2) & Outlet (Outlet C2).
- Set parameter Adiabatic Eficiency 72% then input Outlet C2 260 psia.

- Insert Mixer with name Mixer 4, inlet (Outlet C2 & Vap F1) & Outlet (Feed Cool2).
- Insert Cooler with name Cool 2, inlet (Feed Cool2), Energy (Q Cool2) & Outlet (Feed F5).
- Set parameter dP 5 psi & 100 F on Tout.
- Insert Separator with name Flash 5, inlet (Feed F5), Vapour Outlet (Vap F5) & Liquid Outlet (Liq F5)
- Insert Compressor with name Comp 3, inlet (Vap F5), Energy (Q Comp3) & Outlet (Feed Cool3)
- Set parameter with adiabatic efisiensi 72% & input pressure Feed Cool3 750 psia.

- Insert Cooler with name Cool 3, inlet (Feed Cool3), Energy (Q Cool3) & Outlet (Feed F6).
- Set parameter dP 5 psi 100 ^oF on Tout.
- Insert Separator with name Flash 6, inlet (Feed F6), Vapour Outlet (Gas) & Liquid Outlet (Liq F6)
- Insert Mixer with name Mixer 5, inlet (Liq F5 dan Liq F6) & Outlet (Liq Return).
- Insert 2 Stream with name Recycle 1 & Recycle 2. Then, Define 1st with Liq Return & 2nd define with Liq F4.
- Input Recycle 1 in inlet Mixer 1 & Recyle 2 in inlet Mixer 2.

- Insert Recycle with name RCY 1, inlet (Liq Return) & Outlet (Recyle 1)
- Insert Recyle again with name RCY 2, inlet (Liq F4) & Outlet (Recycle 2).
- Flowsheet already complete. Then, use Adjust to produce crude 15 psia 100 ºF. But, before show table, we show variabel crude vapor pressure in Utility Stream Crude.
- Click Stream Crude then click Attachments & Utilities
- Click Create & pick Cold Properties then close.
- Input Adjust & set:
  Adjusted Variabel:

Object : Outlet Heater Temperature

Target Variabel:

Object Filter : Utilities

Variabel : Cold Properties True VP at 100 F

Target Value : 15 psia

Tolerance : 1e-2

Step Size : 18

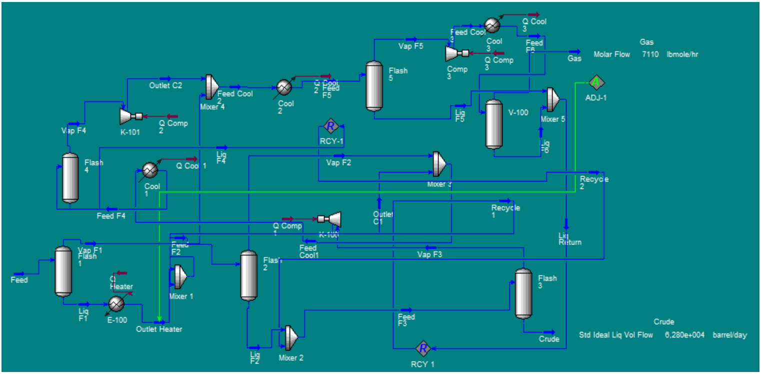
Minimum : 0

Maximum : 1000 F

Iterasi : 1000

- Then we can see on the stream Crude that True Vapor Pressure 100 F = 14.92 psia and Flow Rate Gas 7110 lbmole/hr. Flowrate Crude 62800 barrel/day.

Result:



Gas
Molar Flow 7110 lbmole/hr
Crude
Std Ideal Liq Vol Flow 6,280e+004 barrel/day

5. **Natural Gas Pipeline**

   Determine & evaluate requirement data such as Flow Rates, Pipeline Conditions, Compression Requirements, etc.

   Data, as below:

Component	Mole Fraction
C1	0.8912
C2	0.0583
C3	0.0189
i-C4	0.0013
n-C4	0.0023
i-C5	0.0003
n-C5	0.0002
N_2	0.0075
CO_2	0.0200

Flow = 2500 MMSCFD
T = 35 F
P = 2200 psia

Pipeline Information:

ID	= 40.025 in
OD	= 42 inRoughness
Heat Transfer Coef	= 0.5 Btu/Hr/ft^2/F

Fuel Conversion Factors

Fuel Effisiensi = 108840 SCFD/ MMBtu/Hr

1)

Node	X (miles)	Y	Z (ft)	$T_{Ambient}$ (°F)
Node1	0.0	0	10.0	30.0 (Node 1 – Node 2)
Node2	80.0	0	650.0	30.0 (Node 2 – Node 3)
Node3	160.0	0	2500.0	34.0 (Node 3 – Node 4)
Node4	220.0	0	3200.0	40.0 (Node 4 – Node 5)
Node5	270.0	0	1500.0	–

2) **Estimated Compression Fuel Requirement :**

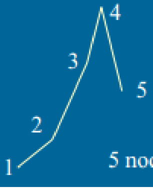
Fraction of Pipeline outlet to fuel = 0.1

3) **Compressor Data :**

Discharge Pressure = 2,200 psia

Number of Stages = 1

Adiabatic Efficiency = 78.5%



5 nodes = 4 segments

Step:

- Insert component and use PR as FP then Enter Simulation.
- Insert blue stream with name (Gas Feed) & fill the composition & condition.

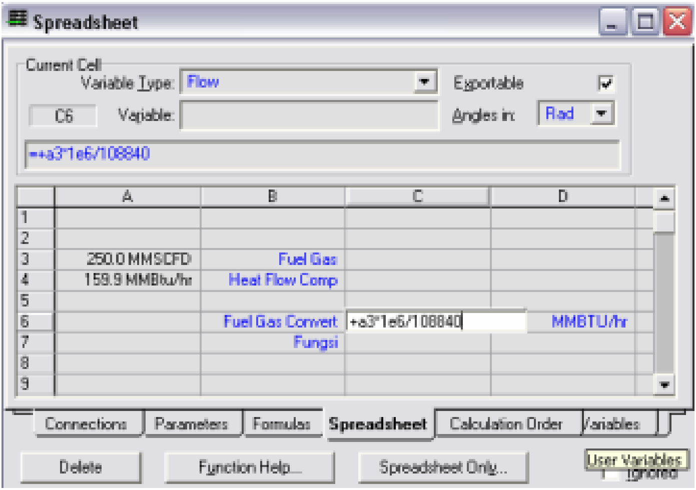
- Insert Pipe Segment then inlet (Gas Feed), Outlet (Pipeline Out) & Energy (Q Losses).
- Click Rating & click Append Segment 4x. Then, input the data and pick Rating also Segment HTC in Heat Transfer.
- Input Ambient Temp. & HTC. Then, close.
- Insert Tee then inlet (Pipeline Out), fill Outlet (To Valve) & (+Fuel)
- Set Parameter & input Fuel (0.1)
- Insert Valve, inlet (To Valve) & Outlet (Compressor Feed) then 10 psi for dP .
- Insert compressor, fill inlet (Compressor Feed), Energy (Q

Comp) & Outlet (Compressor Out)

- Set parameter, fill with 78.5% on Adiabatic Effisiency then Pressure Outlet 2200 psia.
- Insert Spreadsheet & Add import with:

  Cell (A3), Object (Fuel), Variabel Description (Molar Flow) & A4, Q Comp & Heat Flow.

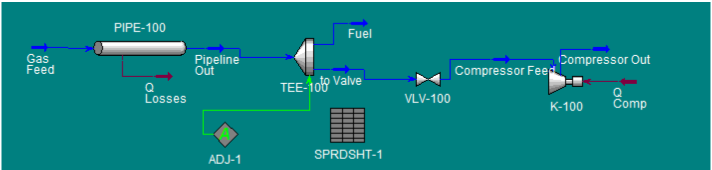
- Set Spreadsheet then fill it as below



- Fill in C7 = C6-A4. Close.
- Insert Adjust then set: *Adjusted Variabel:*

Object : Tee
Variabel : Flow Ratio (Flow Ratio 2)
Target Variabel:
Object : SpreadhseetC7
Variabel : C7
Target Value = 0
Toleransi : 1e-3
Step Size : 0.2
Minimum : 0
Maximum : 1
Iterasi : 1000

- Show table and see the result



Compositions						
	Gas Feed	Pipeline Out	Fuel	to Valve	Compressor Feed	Compressor Out
Comp Mole Frac (Methane)	0,8912	0,8912	0,8912	0,8912	0,8912	0,8912
Comp Mole Frac (Ethane)	0,0583	0,0583	0,0583	0,0583	0,0583	0,0583
Comp Mole Frac (Propane)	0,0189	0,0189	0,0189	0,0189	0,0189	0,0189
Comp Mole Frac (i-Butane)	0,0013	0,0013	0,0013	0,0013	0,0013	0,0013
Comp Mole Frac (n-Butane)	0,0023	0,0023	0,0023	0,0023	0,0023	0,0023
Comp Mole Frac (i-Pentane)	0,0003	0,0003	0,0003	0,0003	0,0003	0,0003
Comp Mole Frac (n-Pentane)	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002
Comp Mole Frac (Nitrogen)	0,0075	0,0075	0,0075	0,0075	0,0075	0,0075
Comp Mole Frac (CO2)	0,0200	0,0200	0,0200	0,0200	0,0200	0,0200