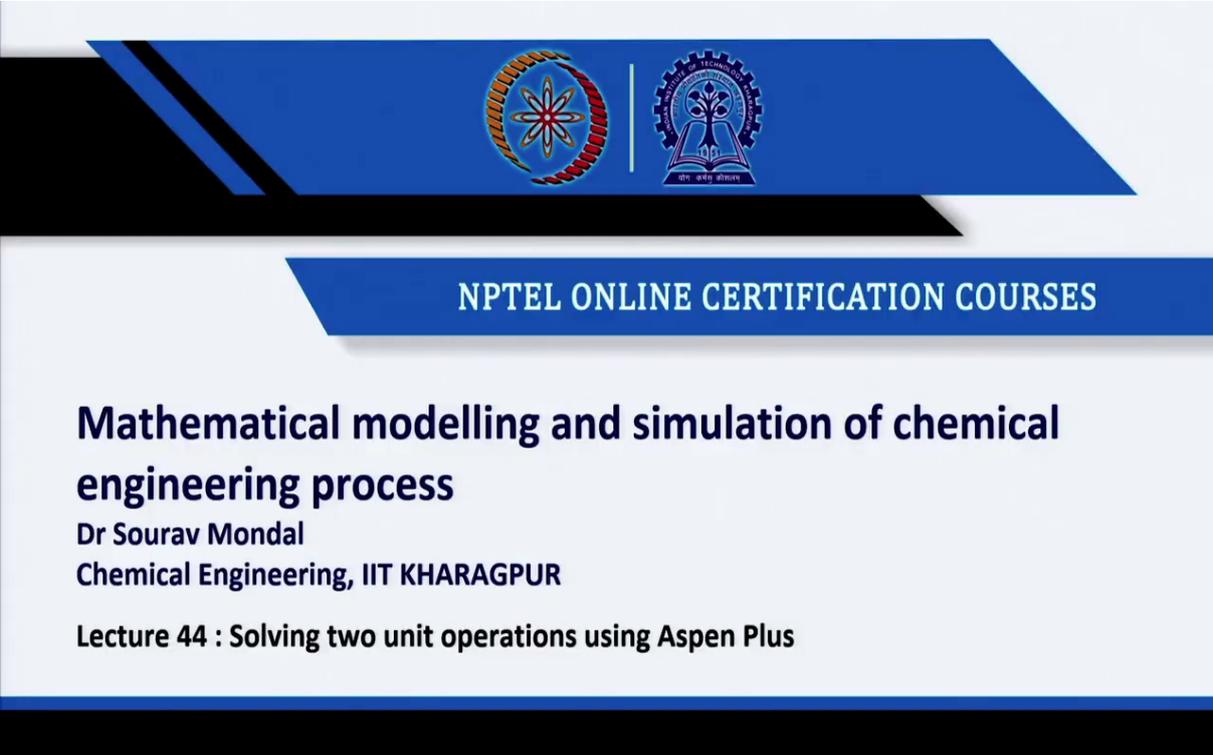


**Mathematical Modelling and Simulation of Chemical Engineering Process**  
**Professor Doctor Sourav Mondal**  
**Department of Chemical Engineering**  
**Indian Institute of Technology, Kharagpur**  
**Lecture 44**  
**Solving two-unit operations using Aspen Plus**

Hello everyone. In this class we are going to talk about again another demonstration involving two units. So, far we have been focusing only on the distillation column and try to and we have explored the variations of the you know distillate fractions using changing the feed stage or changing the or adding an entrainer etcetera but it is mostly using one unit. So, in this one we are going to see two units or more than two units also.

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The image shows a banner for NPTEL Online Certification Courses. At the top, there are two logos: the Indian Institute of Technology (IIT) Kharagpur logo on the left and the NPTEL logo on the right. Below the logos, the text "NPTEL ONLINE CERTIFICATION COURSES" is displayed in white on a blue background. Underneath, the course title "Mathematical modelling and simulation of chemical engineering process" is written in bold black text. Below the title, the instructor's name "Dr Sourav Mondal" and his affiliation "Chemical Engineering, IIT KHARAGPUR" are listed. Finally, the lecture title "Lecture 44 : Solving two unit operations using Aspen Plus" is shown at the bottom of the banner.

## CONCEPTS COVERED

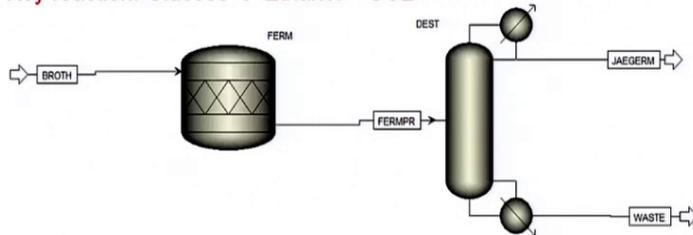
❖ Two units connected in sequence

❖ Reactor and separators



### Problem 1: Simple reaction followed by separation

Key reaction:  $\text{Glucose} \rightarrow \text{Ethanol} + \text{CO}_2$



Total feed flow 1 kg/hr

Broth:  $x_{\text{Water}}=0.5$ ,  $x_{\text{Glucose}}=0.5$ ,  $T_{\text{Broth}}=25^\circ\text{C}$

Jägermeister:  $x_{\text{Jaegerm}}=0.3\%(\text{w/w}) = (0.37\% \text{v})$



So, the first example problem that we are going to study here and of course we will also explore apart from distillation column reactors and other separators flash vaporizers and all. The first problem that we are going to study is glucose fermentation. So, in this case you are having we are having this fermenter which is essentially a reactor as you can see which is fed with the Broth this Broth mixture.

So, the Broth mixture is actually mixture of glucose and water and you allow that fermentation to happen and after the fermentation you get ethanol and you know CO<sub>2</sub>. So, now to and also some unreacted water and unreacted glucose etcetera everything is there. So, that is then again fed to the you know this distillation column to get or to have this improved you know this ethanol from this distillation column. So, it is just to separate the water etcetera from the system.

(Refer Slide Time: 2:00)

Total feed flow 1 kg/hr  
 Glucose: 0.5 mass fr.  
 Water: 0.5 mass fr.  
 Temp. 25 C

Reactor Conditions:  
 RStoic reactor type  
 Reactor temp: 25 C  
 Pressure 1.5 bar  
 Equilibrium conversion: 0.9 of Glucose

Column conditions:  
 Number of stages 5  
 Condenser Total

Op. conditions:  
 Reboiler duty: 0.3 kW  
 Reflux ratio 0.3 mass fraction

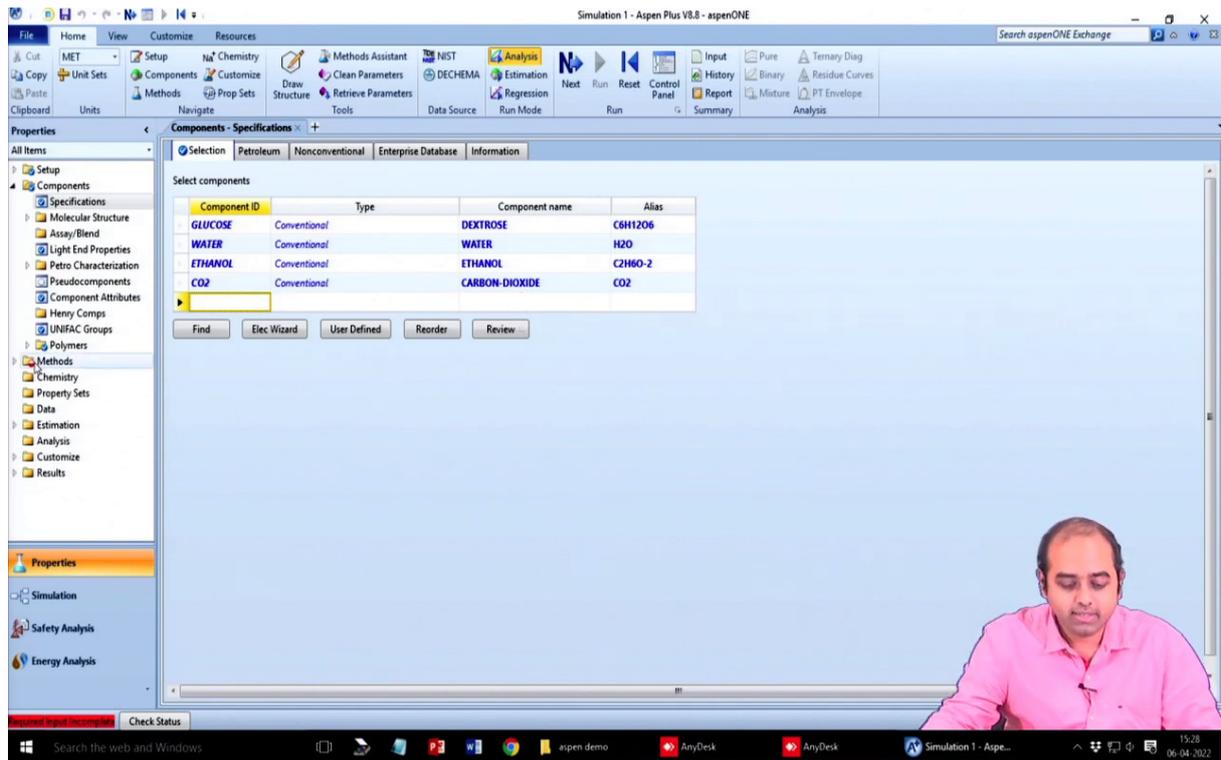
Feed stage: above stage 3  
 Product stream phase: Liquid  
 Condenser / top stage pr: 1 bar

Key reaction:  
 Glucose → Ethanol + CO<sub>2</sub>  
 $C_6H_{12}O_6 \rightarrow 2 C_2H_5OH + 2 CO_2$

So, now let us try to design the problem here, thus you can see that the specifications are mentioned that the total feed flow rate is 1 kg per hour glucose I mean this is like equimolar mass fraction temperature is 25 we choose because the reaction chemistry is known very well-known we choose the RStoic stoichiometric type reactor, reactor temperature 25 pressure is slightly higher 1.5 bar.

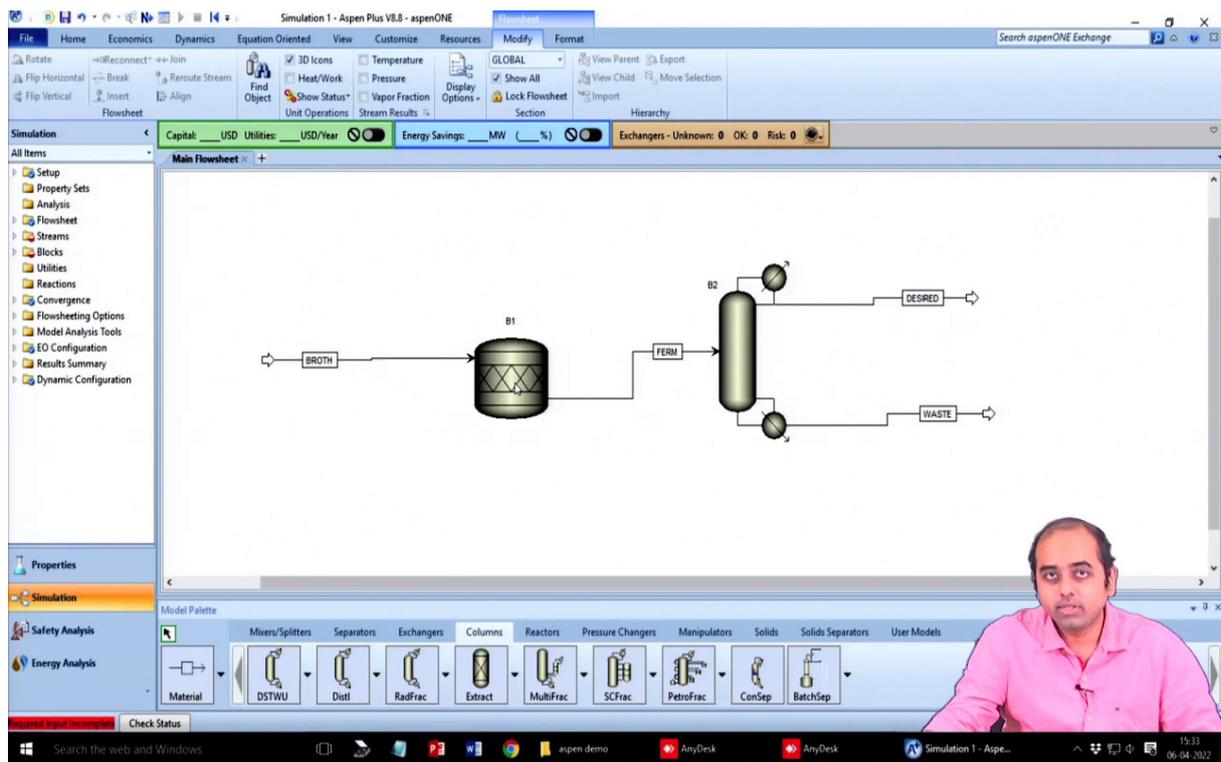
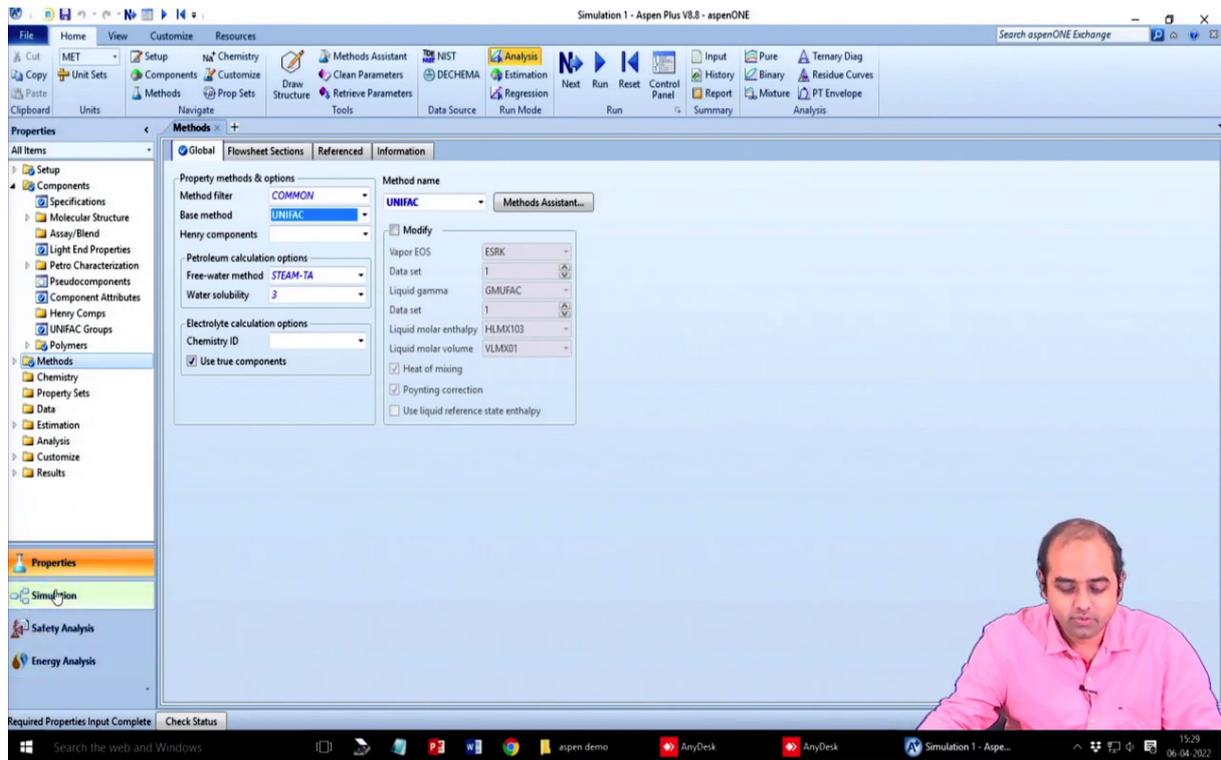
Equilibrium conversion we allow up to 90 percent of the glucose. In the column, or the distillation column, we see that the total five stages con total condenser and Reboiler duty, Reflux ratio everything is mentioned feed stage is above stage three and the product stream ledge is liquid condenser at the top stage pressure is 1 bar.

(Refer Slide Time: 2:56)



So, let us try to frame this frame the process flow sheet and specify these conditions and work out this problem. So, I have selected this is a new file and as I have said we will choose with the blank simulation, create. So, the first step is to define the chemicals, in this case it is glucose water CO<sub>2</sub> and ethanol. Define the units as metric system let us say, first component is glucose. So, glucose is selected chemical name is dextrose C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>. Then we have water, then we have ethanol and we have CO<sub>2</sub> carbon dioxide, all are standard chemicals that is why they are easily detected by writing their name or their short chemical formulas.

(Refer Slide Time: 3:58)



Next is to define the methods. So, we will quickly go through these steps because this is something which we have elaborated detail in the previous class. So, the base method will choose let us say UNIFAC or UNIVAC whatever, next we will move to the simulation because now all the required you know properties input is complete, you can see next we go to the simulation and then try to frame the process flow sheet.

So, the important unit operations are the reactor. So, we will take the stoichiometric reactor just drag it there or click and click it here to paste and, in the column, we will choose, maybe RADFRAC why not, next is the stream connections. So, one reactor stream feed to the reactor now this is the important bit in this case for the distillation the input to the distillation is the output of the reactor.

So, this is an internal stream. So, now we will not be specifying the feed conditions of the distillation column as opposed to the previous class where we have specified what is the feed composition etcetera but now this feed composition to the distillation is actually the output of the this reactor. So, unless we solve the reactor we will not be knowing. So, this is a sequential solution where the solution of the reactor or the output of the reactor will act as a feed to the distillation column.

So, there is no explicit information or user information needed for the feed stream to the reactor which will be taken from the output of the reactor. So, for the distillation column the user need not to specify the feed conditions. Like what is the feed composite that is unknown there is a part of the internal solution. So, let us connect these two streams the output or the product stream of the reactor as the feed stream to the distillation column.

So, make sure this connection is done properly because it will if it is done properly it will not show any red column and this connection is done properly. So, if you want to change the connection if you want to have a different connection then you can of course delete it and do it once again another option is there also to so select the stream and then click and see that if you can if you wish to reconnect either source or destination.

So, if there is a complex network let us say and I do not want to you know delete a particular stream. So, again I have to specify the connection etcetera but I want to change it is destination then only the destination will be deactivated and you can connect it again. Similarly, you can you know have the reconnection of the source if it is by mistake connected to a different place. Source means the start point and destination in end points of the stream.

So, for complex problem this becomes quite crucial. So, other streams are the from the distillation top and the bottom. So, let us define the rename the feed stream to the reactor as Broth, this is like fermenter output FERM let us write a FERM. This is like the top of the distillation column which is like our desired product desire and this is the waste because this will be mostly water glucose etcetera. So, this flow sheet is done. It is visible properly. So, this is block B 1 this is block B 2 let us not confuse with that.

(Refer Slide Time: 8:25)

Simulation 1 - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation Capital: \_\_\_USD Utilities: \_\_\_USD/Year Energy Savings: \_\_\_MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet B1 (RStoic)

Specifications Reactions Combustion Heat of Reaction Selectivity PSD Component Attr. Utility Information

Operating conditions

Flash Type Temperature Pressure

Temperature 25 C

Pressure 1.5 bar

Duty cal/sec

Vapor fraction

Valid phases Vapor-Liquid

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models

Simulation 1 - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation Capital: \_\_\_USD Utilities: \_\_\_USD/Year Energy Savings: \_\_\_MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet B1 (RStoic)

Specifications Reactions Combustion Heat of Reaction Selectivity PSD Component Attr. Utility Information

Reactions

Run No. Specification type Edit Stoichiometry

Reaction No. 1

Reactants

Component	Coefficient
GLUCOSE	-1

Products

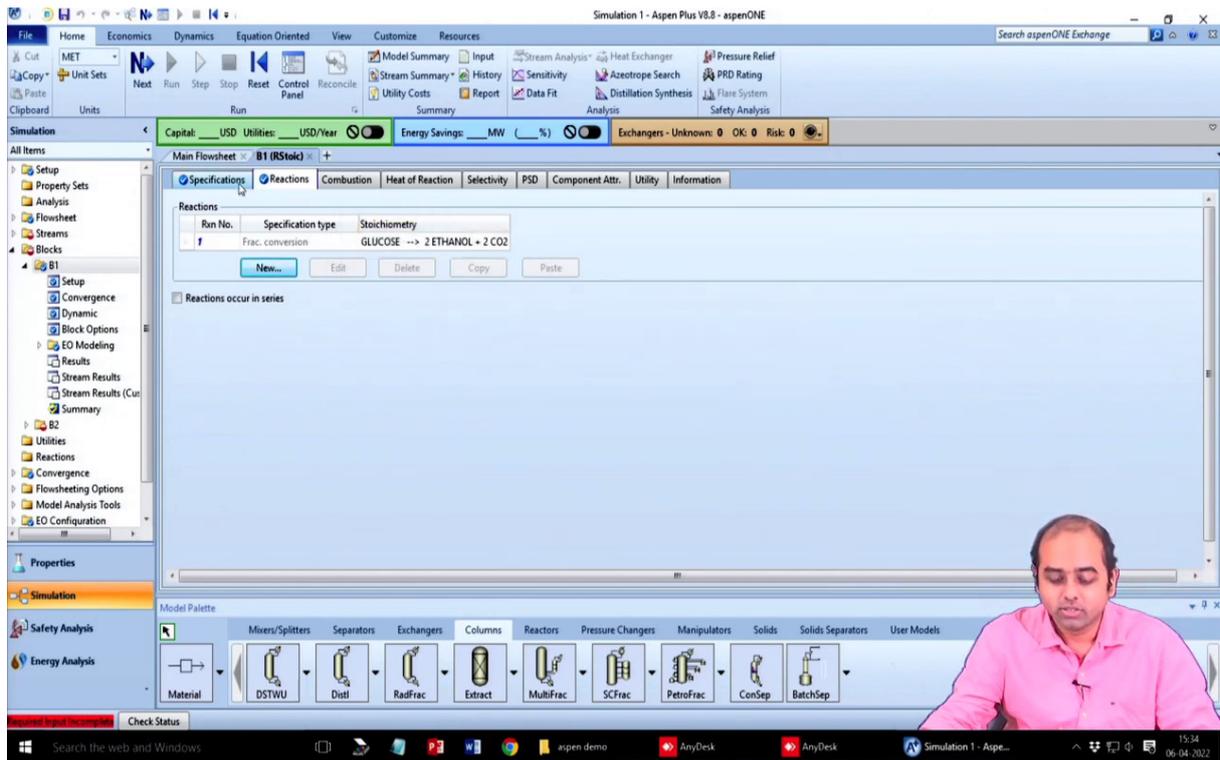
Component	Coefficient
ETHANOL	2
CO2	2

Products generation

Molar extent kmol/hr

Fractional conversion 0.9 of component GLUCOSE

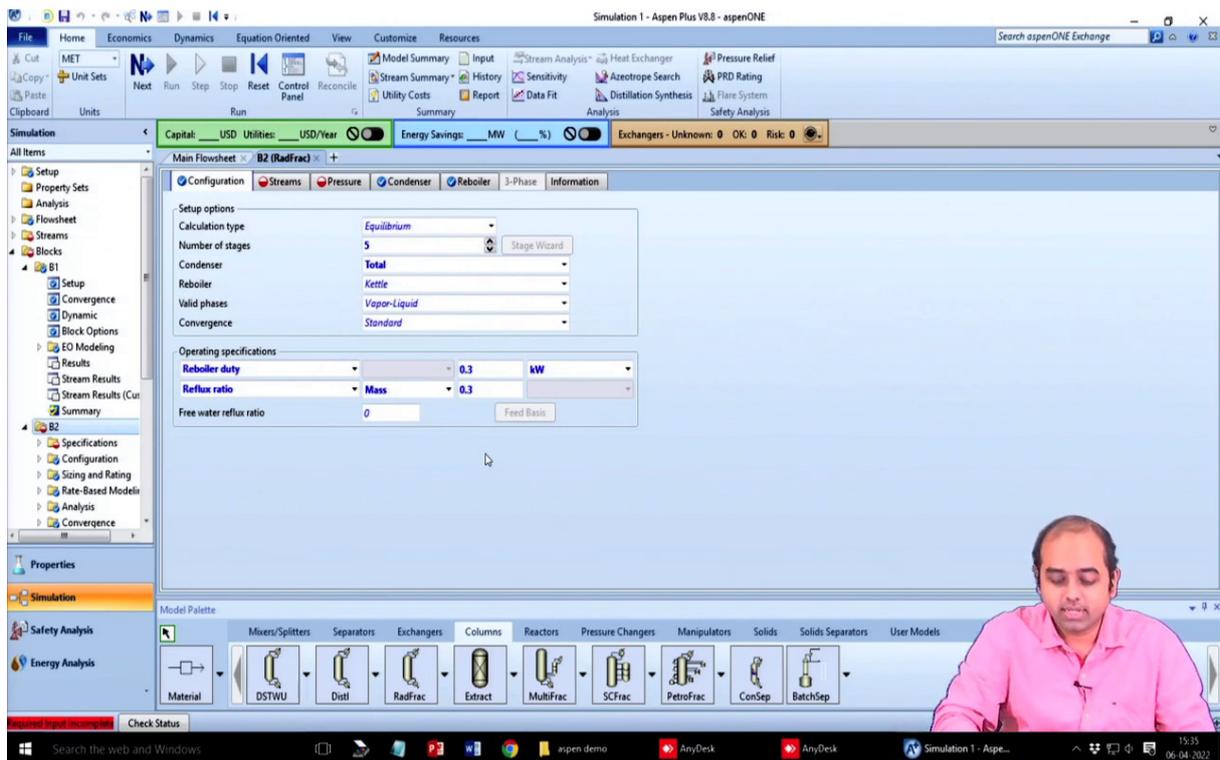
Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models



So, now is the time to define the reactor conditions and the distillation conditions. So, for the reactor you have to define the temperature and the pressure. So, the reactor temperature is let us define in centigrade 25 pressure let us define in bar that is 1.5 bar and let us define the reactions. So, it is only one reaction in this case. So, reaction 1 component is glucose, water and the product is ethanol and CO<sub>2</sub>. So, we have to write please remember we have to write balanced reaction. So, here the coefficient should be 2, 2 and this is 1.

So, water is not taking part of the reaction. So, let us remove it. So, it is only conversion of glucose to ethanol and water but sorry ethanol and CO<sub>2</sub> but water is there with the stream but not in part in the reaction. So, let us not write water here. Fractional conversion we write 90 percent of glucose. So, this will set the reaction conditions or the reactions for this problem. So, the reaction is defined. So, that is all the definitions that is needed for the reactor.

(Refer Slide Time: 10:12)



Now, let us go to the distillation column you know the required definitions, first is the number of stages as for the problem only five stage condenser total type and then it is said that we define the reflux ratio in terms of mass that is point 3 is there in the problem statement itself and instead of the distillate rate the Reboiler duty is mentioned and the Reboiler duty is given in terms of you can choose your units, units are very vary and the software has paid a lot of attention on the selection of the different types of units. So, units are very important.

(Refer Slide Time: 10:55)

Simulation 1 - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation: Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet: B2 (RadFrac)

Configuration Streams Pressure Condenser Reboiler 3-Phase Information

Feed streams

Name	Stage	Convention
FERM	3	Above-Stage

Product streams

Name	Stage	Phase	Basis	Flow	Units	Flow Ratio	Feed Specs
DESIRED	1	Liquid	Mole		kmol/hr		Feed basis
WASTE	5	Liquid	Mole		kmol/hr		Feed basis

Pseudo streams

Name	Pseudo Stream Type	Stage	Internal Phase	Reboiler Phase	Reboiler Conditions	Pumparound ID	Pumparound Conditions	Flow	Units
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Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models

Material, DSTWU, Dist, RadFrac, Extract, MultiFrac, SCFrac, PetroFrac, ConSep, BatchSep

Simulation 1 - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation: Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet: B2 (RadFrac)

Configuration Streams Pressure Condenser Reboiler 3-Phase Information

View: Top / Bottom

Top stage / Condenser pressure: 1 bar

Stage 1 / Condenser pressure: 1 bar

Stage 2 pressure (optional)

- Stage 2 pressure: atm
- Condenser pressure drop: atm

Pressure drop for rest of column (optional)

- Stage pressure drop: atm
- Column pressure drop: atm

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models

Material, DSTWU, Dist, RadFrac, Extract, MultiFrac, SCFrac, PetroFrac, ConSep, BatchSep

Simulation 1 - Aspen Plus V8.8 - aspenONE

Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main FlowSheet: BROTH (MATERIAL)

Specifications

Flash Type: Temperature Pressure

State variables

Temperature: 25 C

Pressure: 1 bar

Vapor fraction

Total flow basis: Mass

Total flow rate: 1 kg/hr

Solvent

Reference Temperature

Volume flow reference temperature: K

Component concentration reference temperature: K

Composition

Component	Value
GLUCOSE	0.5
WATER	0.5
ETHANOL	
CO2	
Total	1

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models

Simulation 2.apwz - Aspen Plus V8.8 - aspenONE

Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main FlowSheet

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models

So, you select the unit appropriately. Then the stream. So, the feed stream the fermenter which is the output of the reactor is above the third stage pressure of the condenser that is 1 bar. So, all the specifications are set now it is time to only define the input stream. So, the input stream is defined by I mean with the temperature and the pressure. So, input stream is temperature is 25 centigrade. Pressure is let us say 1 bar. Total flow rate is 1 kg and

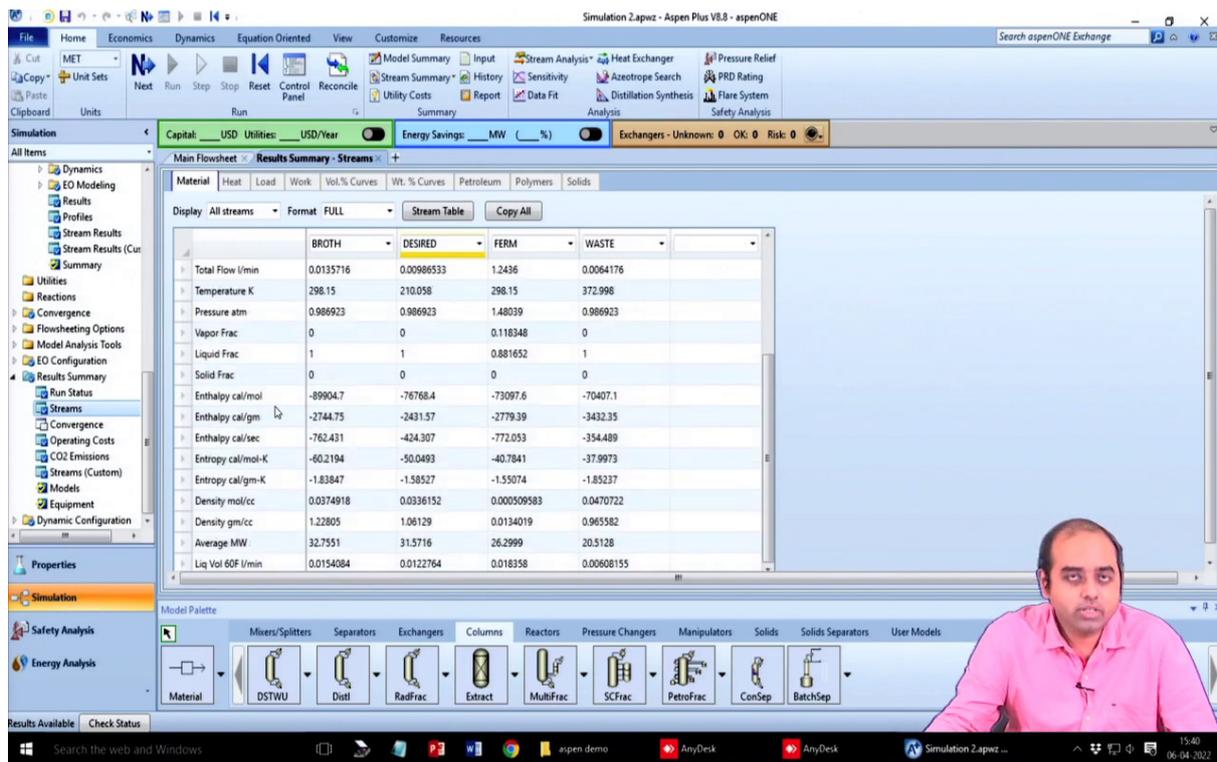
composition let us say mass fraction glucose is 0.5 and water is 0.5, 1 kg per hour total flow basis mass, so kg per hour.

So, this is all set as far as the stream definition is concerned. So, now we have specified the pressure of the feed stream as one but in the reactor is 1.5. So, no issues it will you know be pressurized as it goes into the stream. So, if there is a difference in the pressure is too much then you might need a compressor otherwise it will be difficult to make it pressurize in the reactor, I mean physically this is what happens same will happen here also.

(Refer Slide Time: 12:37)

The screenshot shows the Aspen Plus V8.8 interface with the 'Results Summary - Streams' window open. The 'Stream Table' is displayed, showing the following data:

	BROTH	DESIRED	FERM	WASTE
Substream: MIXED				
Mole Flow kmol/hr				
GLUCOSE	0.00277535	6.6756e-22	0.000277535	0.000277535
WATER	0.0277542	0.00991587	0.0277542	0.0178383
ETHANOL	0	0.00498607	0.00499562	9.5587e-06
CO2	0	0.00499562	0.00499562	9.3888e-11
Total Flow kmol/hr	0.0305295	0.0198975	0.038023	0.0181254
Total Flow kg/hr	1	0.628197	1	0.371803
Total Flow l/min	0.0135716	0.00986533	1.2436	0.0064176
Temperature K	298.15	210.058	298.15	372.998
Pressure atm	0.986923	0.986923	1.48039	0.986923
Vapor Frac	0	0	0.118348	0
Liquid Frac	1	1	0.881652	1
Solid Frac	0	0	0	0
Enthalpy cal/mol	-89904.7	-76768.4	-73097.6	-70407.1



So, once everything is done let us save it and then let us try to run the simulation. So, no resetting is required because we have not run it before. So, there is no change in the. So, there is no solution actually available. So, changing the input to get the new solution is not applicable here because there is no existing solution present. So, you run it. So, once the run is complete it will show that the results is available check status.

So, no error message summary this is done. So, now we see the streams. So, if you see the streams, you will see that in the in the case of the glucose sorry not glucose the ethanol stream which is the desired product is more in the desired fraction compared to the waste fraction. So, waste is the bottom of the distillation column and desired is the top product of the distillation column.

So, we see that in the top the flow rate of ethanol is actually more than the bottom and this is what we are looking forward to is it and this is the desired product and the water in the waste or the bottom is actually more compared to the top. So, it is not more but still it is more. So, you might need another distillation column to separate further or to improve or increase the number of stages or whatever but essentially ethanol is mixed with CO2 this is what you see it here but since CO2 is will be in the gaseous state at 1 bar pressure you can easily separate the you know liquid ethanol from the CO2 this is just a phase extraction.

So, that is not a concern of a worry again CO<sub>2</sub> is more volatile that is why it is not there in the waste stream. So, in the waste stream you mostly see your unreacted glucose and water and in the desired stream you have this water but it also have a lot of ethanol. So, ethanol is diluted by water in the top stream but insignificant amount of glucose. So, you can just you can also look into the rest of the enthalpy-entropy values you can also try to you know modify this to get the you know this what you call the values of the mole fractions, mass fractions and all those things it is also possible that in the summary these things are also tabulated.

(Refer Slide Time: 15:45)

The screenshot shows the Aspen Plus V8.8 interface with the 'Results Summary - Streams (Custom)' window open. The window displays a table of stream properties for four streams: BROTH, DESIRED, FERM, and WASTE. The table includes columns for Units, To, Substream, Phase, Component Mole Flow, Mole Flow, Mass Flow, Volume Flow, Temperature, Pressure, Vapor Fraction, Liquid Fraction, Solid Fraction, and Molar Enthalpy. A man in a pink shirt is visible in the bottom right corner of the screenshot.

	Units	BROTH	DESIRED	FERM	WASTE
To		B1		B2	
Substream		MIXED			
Phase		Liquid	Liquid	Mixed	Liquid
Component Mole Flow					
GLUCOSE	KMOL/HR	0.00277535	6.6756e-22	0.000277535	0.000277535
WATER	KMOL/HR	0.0277542	0.00991587	0.0277542	0.0178383
ETHANOL	KMOL/HR	0	0.00498607	0.00499562	9.5587e-06
CO <sub>2</sub>	KMOL/HR	0	0.00499562	0.00499562	9.3888e-11
Mole Flow	KMOL/HR	0.0305295	0.0198975	0.038023	0.0181254
Mass Flow	KG/HR	1	0.628197	1	0.371803
Volume Flow	L/MIN	0.0135716	0.00986533	1.2436	0.0064176
Temperature	K	298.15	210.058	298.15	372.998
Pressure	ATM	0.986923	0.986923	1.48039	0.986923
Vapor Fraction		0	0	0.118348	0
Liquid Fraction		1	1	0.881652	1
Solid Fraction		0	0	0	0
Molar Enthalpy	CAL/MOL	-89904.7	-76768.4	-73097.6	-70407.1

Simulation 2.apwz - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation: Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet | Results Summary - Streams (Custom) | Control Panel

COMPUTATION ORDER FOR THE FLOWSHEET:  
 B1 B2  
 -->Calculations begin ...

Block: B1 Model: RSTOIC  
 Block: B2 Model: RADFRAC

Convergence iterations:

OL	ML	IL	Err/Tol
1	1	4	1225.3
2	1	2	360.29
3	1	3	130.45
4	1	3	56.230
5	1	2	10.417
6	1	2	1.3457
7	1	2	0.66588E-01

-->Simulation calculations completed ...

\*\*\* No Warnings were issued during Input Translation \*\*\*

\*\*\* No Errors or Warnings were issued during Simulation \*\*\*

-->Generating results ...

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models

Results Available | Check Status



Simulation 2.apwz - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation: Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet | Setup | Control Panel

Global | Description | Accounting | Diagnostics | Information

Title: [ ]

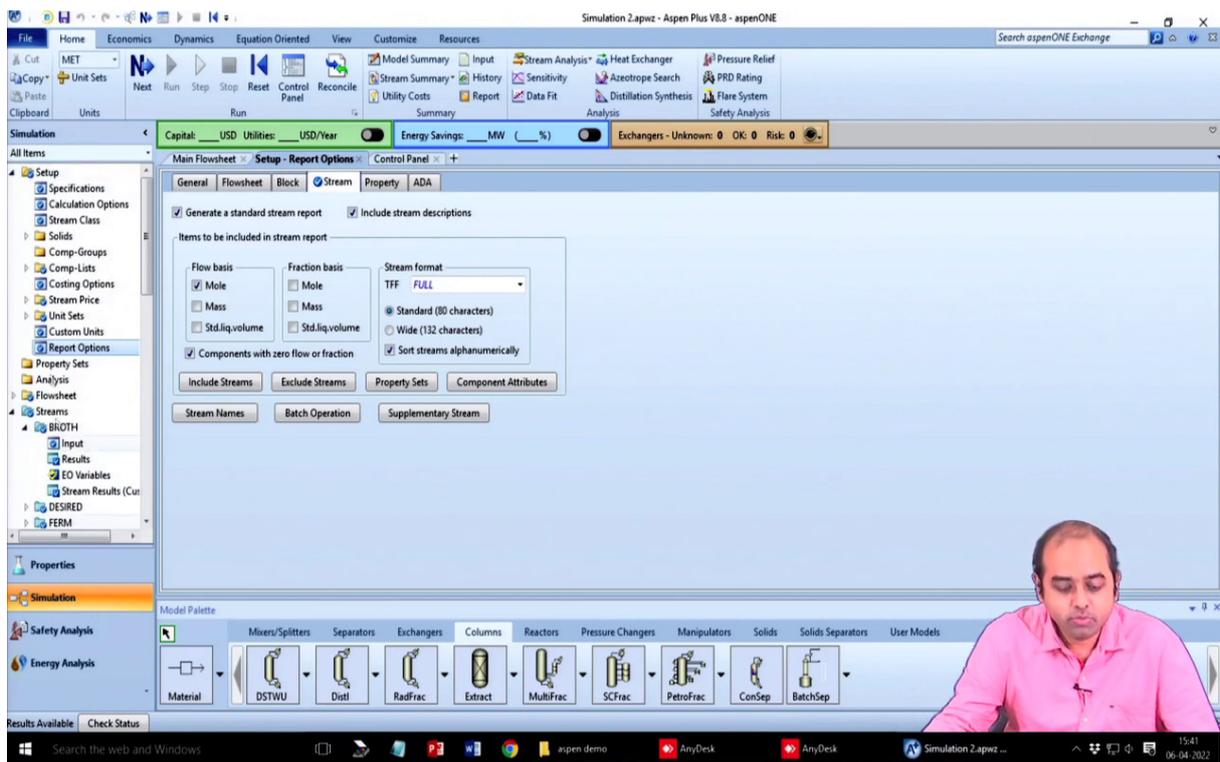
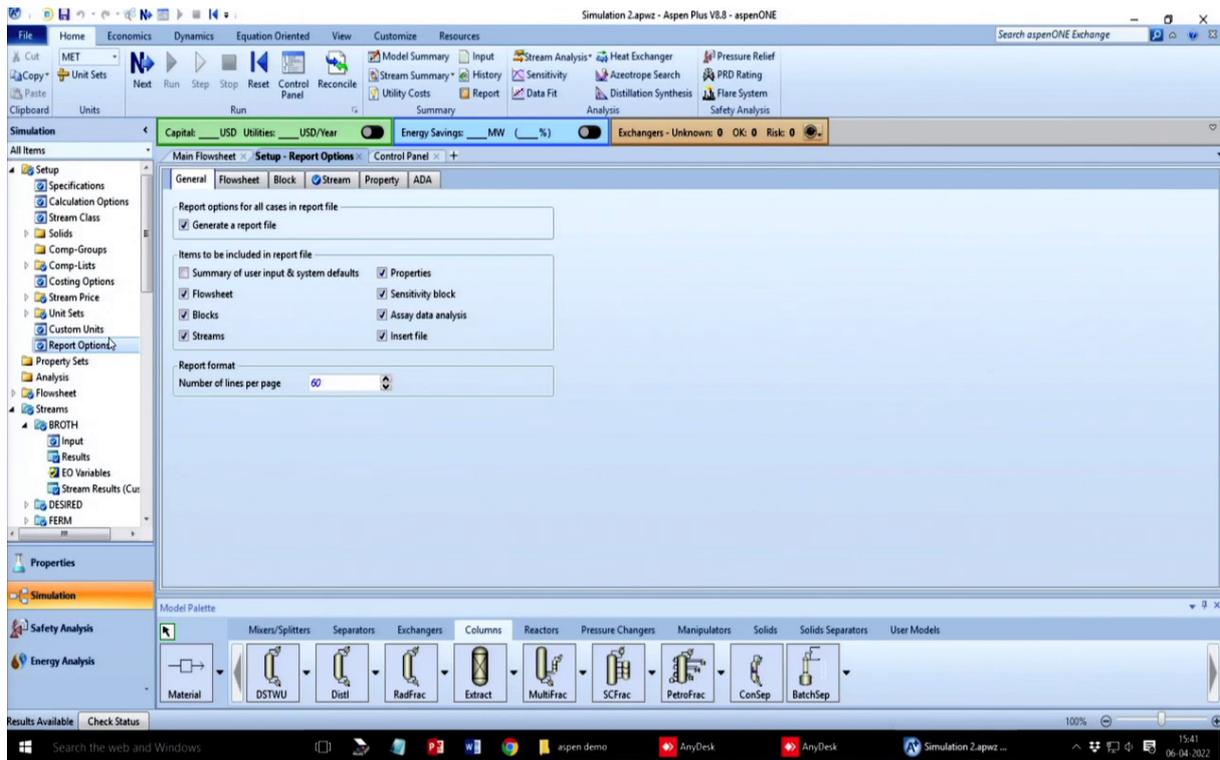
Global unit set: MET

Global settings:

- Input mode: Steady-State
- Stream class: CONVEN
- Flow basis: Mole
- Ambient pressure: 1 atm
- Ambient temp.: 283.15 K
- Valid phases: [ ]
- Free water: No
- Operational year: 8766 hr

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models

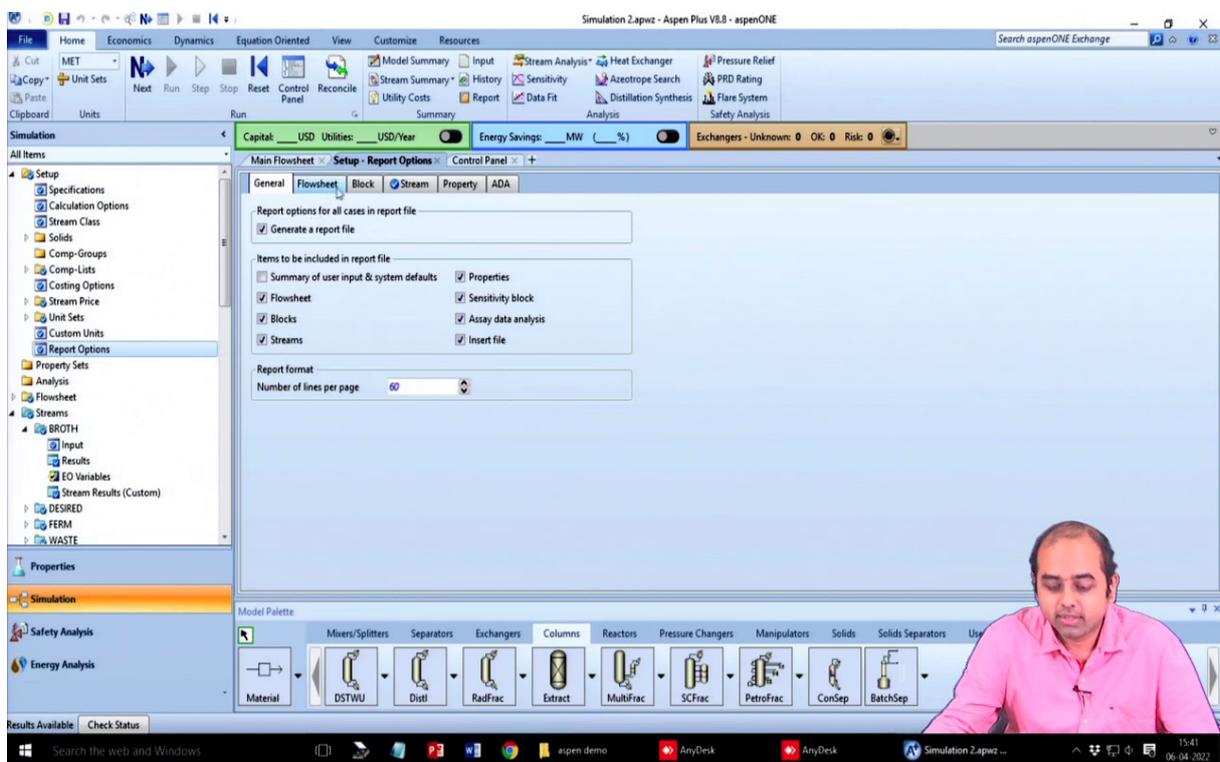
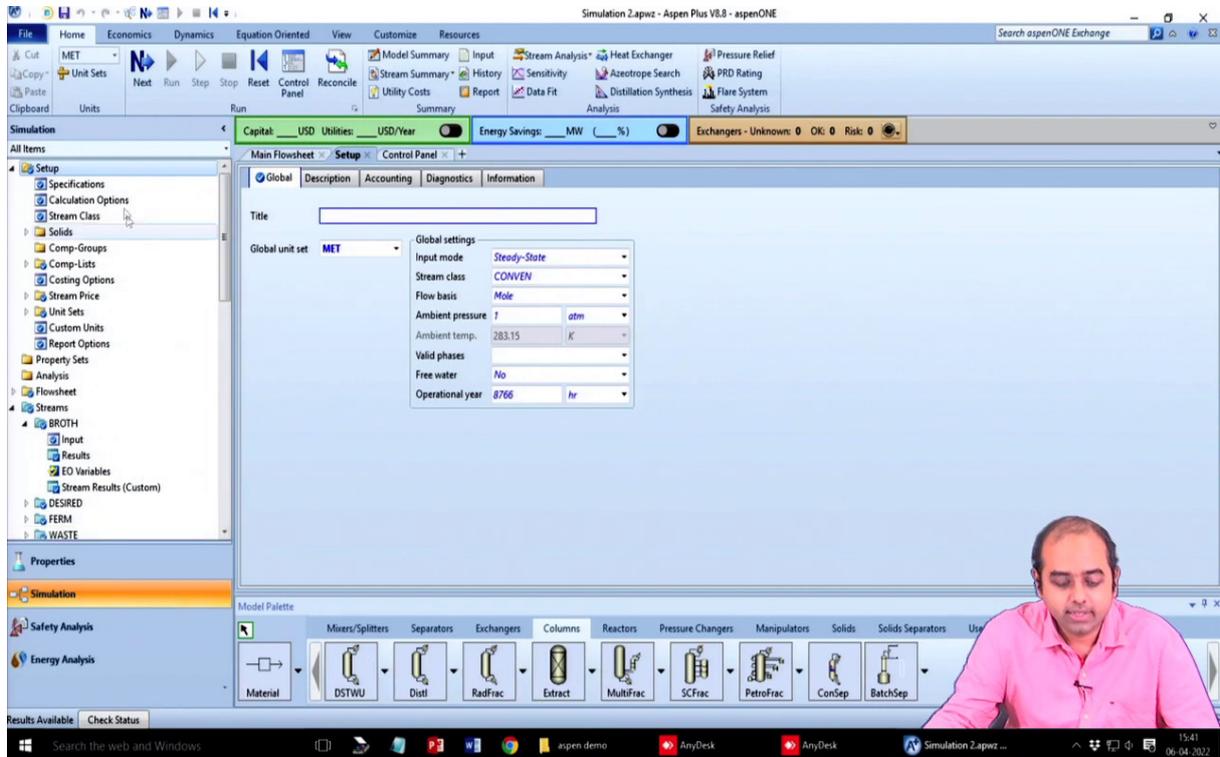
Results Available | Check Status



Liquid fraction then you have the vapor fraction because CO<sub>2</sub> is there. So, that will basically there will be some amount of vapor fraction. So, this is what we see that the component mole flow in terms of kilo mole per hour we can also change it to mole I cannot get the mass flow I was actually looking for the mass flow let me see how to bring the mass flow. So, please note

this option that if you want to change some of the report options in this simulation block at the beginning there is the setup node.

(Refer Slide Time: 16:48)



Simulation 2.apwz - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation: Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet - Setup - Report Options - Control Panel

General Flowsheet Block Stream Property ADA

Items to be included in report file

- Total mass and energy balances around the flowsheet
- Component mass balances around the flowsheet
- Descriptions of all flowsheeting options
- Convergence block
- Calculation sequence
- Design specification
- Calculator block
- Constraint
- Optimization
- Transfer block

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, etc.

Simulation 2.apwz - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation: Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet - Setup - Report Options - Control Panel

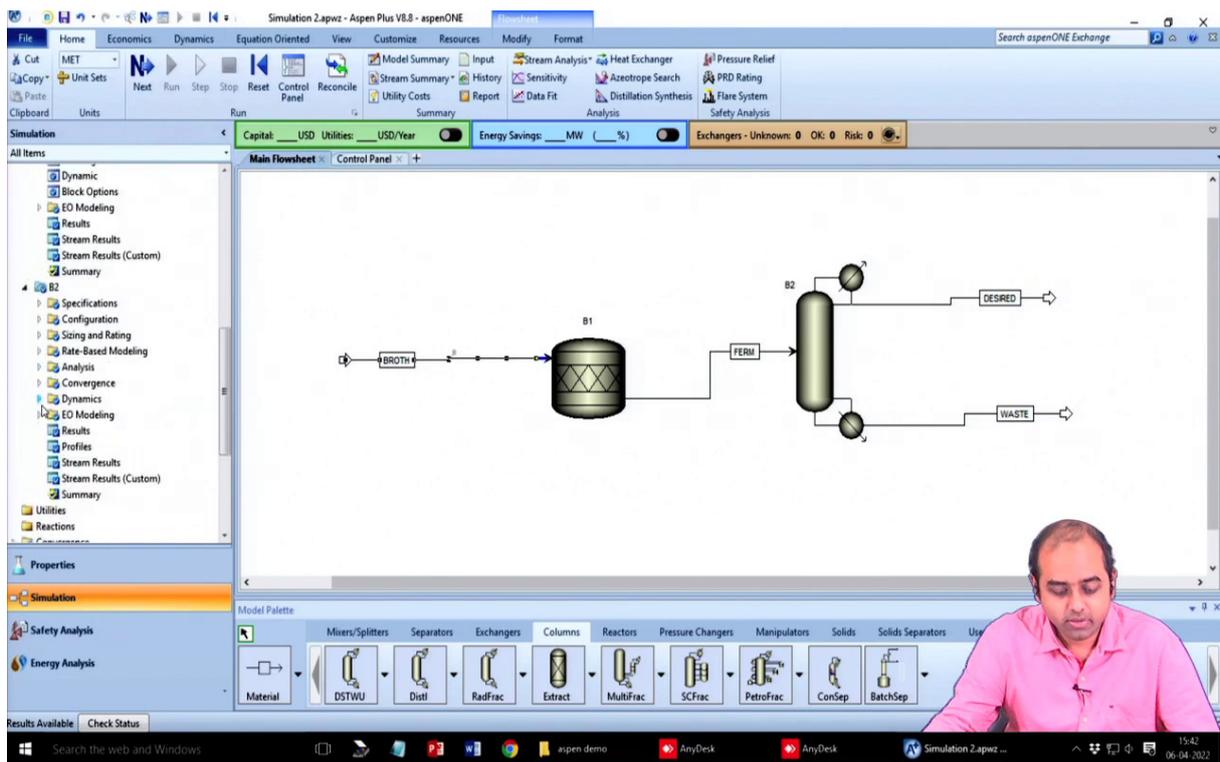
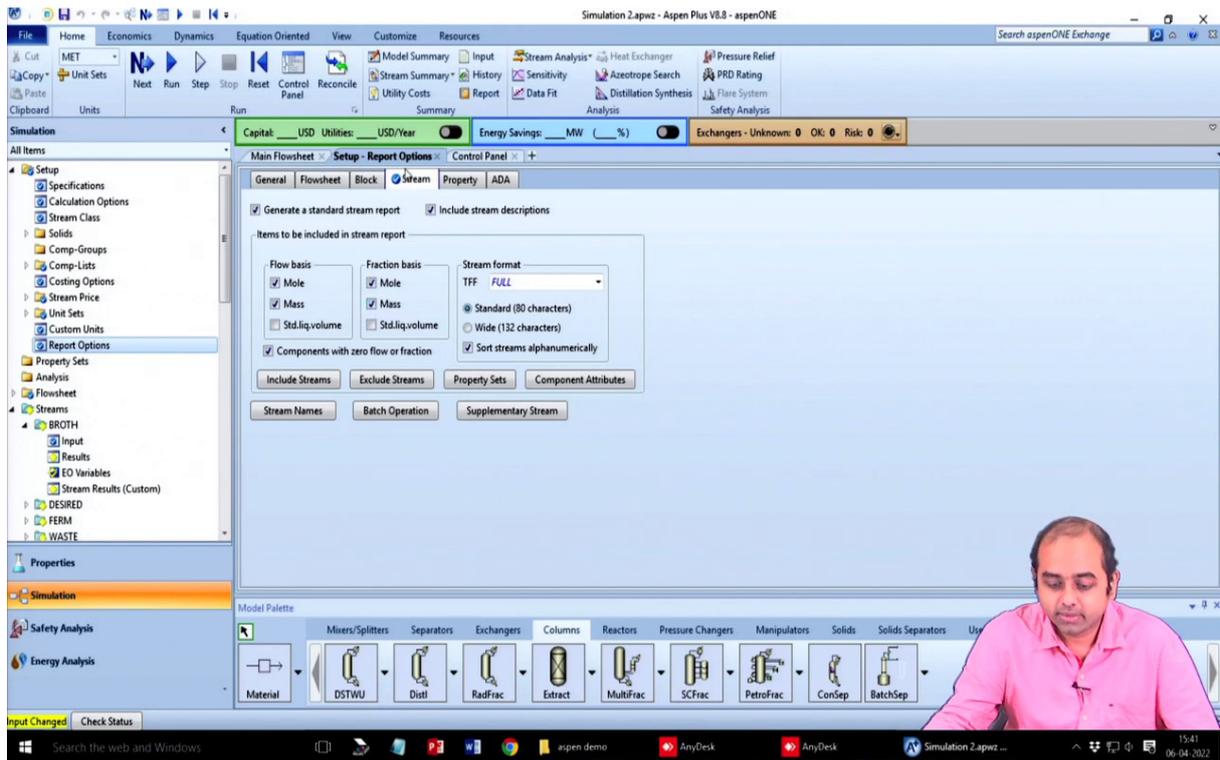
General Flowsheet Block Stream Property ADA

Items to be included in block reports

- Total mass and energy balance
- Summary of user input & system defaults
- Component balances
- Block results
- Begin each block report on a new page
- Sort blocks alphabetically

Buttons: Include Blocks, Exclude Blocks

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, etc.



So, in this setup there is something known as the report option. So, if you click on this report option and it will show general then flow sheet then block etcetera and then there is a stream option. So, now in the stream option if you see that in this case only flow basis is mentioned as mole I can also click the mass option and fraction also I can set the mole and the mass. So, all these will now be included in the report. So, let us see that. So, I have to change it and

rerun the calculation once again because I have selected some new features to be tabulated in the report let us reinitialize and rerun, running is complete.

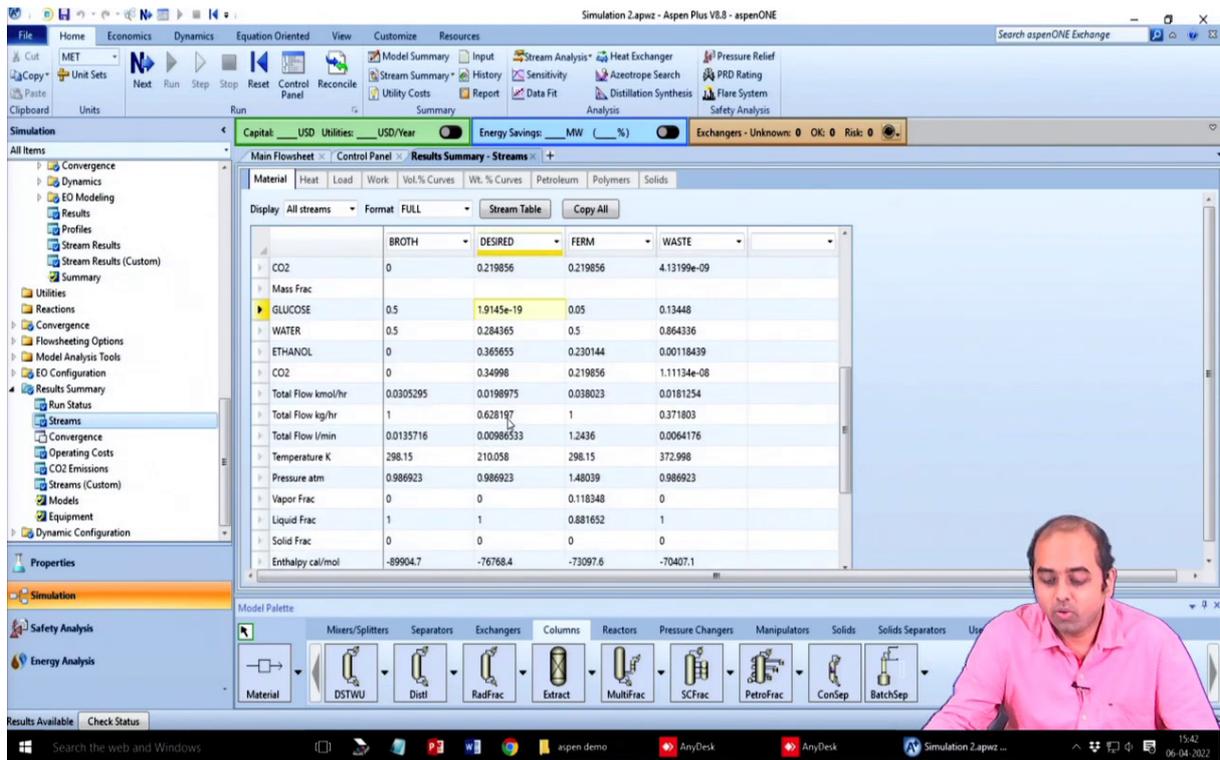
(Refer Slide Time: 17:36)

The screenshot shows the Aspen Plus V8.8 interface with the 'Results Summary - Streams' window open. The 'Stream Table' is displayed for 'Mole Flow kmol/hr'. The table has columns for 'Substream: MIXED', 'BROTH', 'DESIRED', 'FERM', and 'WASTE'. The rows list various components: GLUCOSE, WATER, ETHANOL, and CO2. The values are as follows:

Substream: MIXED	BROTH	DESIRED	FERM	WASTE
Mole Flow kmol/hr				
GLUCOSE	0.00277535	6.6756e-22	0.000277535	0.000277535
WATER	0.0277542	0.00991587	0.0277542	0.0178383
ETHANOL	0	0.00498607	0.00499562	9.5587e-06
CO2	0	0.00499562	0.00499562	9.3888e-11
Mole Frac				
GLUCOSE	0.0909068	3.355e-20	0.00729913	0.0153118
WATER	0.909093	0.498346	0.729932	0.984161
ETHANOL	0	0.250587	0.131384	0.000527364
CO2	0	0.251067	0.131384	5.1799e-09
Mass Flow kg/hr				
GLUCOSE	0.5	1.2027e-19	0.05	0.05
WATER	0.5	0.178637	0.5	0.321363
ETHANOL	0	0.229703	0.230144	0.00044036

The screenshot shows the Aspen Plus V8.8 interface with the 'Results Summary - Streams' window open. The 'Stream Table' is displayed for 'Mass Flow kg/hr'. The table has columns for 'Substream: MIXED', 'BROTH', 'DESIRED', 'FERM', and 'WASTE'. The rows list various components: WATER, ETHANOL, CO2, GLUCOSE, and Total Flow. The values are as follows:

Substream: MIXED	BROTH	DESIRED	FERM	WASTE
WATER	0.909093	0.498346	0.729932	0.984161
ETHANOL	0	0.250587	0.131384	0.000527364
CO2	0	0.251067	0.131384	5.1799e-09
Mass Flow kg/hr				
GLUCOSE	0.5	1.2027e-19	0.05	0.05
WATER	0.5	0.178637	0.5	0.321363
ETHANOL	0	0.229703	0.230144	0.00044036
CO2	0	0.219856	0.219856	4.13199e-09
Mass Frac				
GLUCOSE	0.5	1.9145e-19	0.05	0.13448
WATER	0.5	0.284365	0.5	0.864336
ETHANOL	0	0.365655	0.230144	0.00118439
CO2	0	0.34998	0.219856	1.11134e-08
Total Flow kmol/hr	0.0305295	0.0198975	0.038023	0.0181254
Total Flow kg/hr	1	0.628197	1	0.371803



So, now if I go to the reports sorry the results summary and click on this stream I guess now you can see that what is the same mole fraction is represented and mass flow which is what is very important because we have defined most of the things in terms of mass. So, is the mass flow that you can see is also you know specified now as well as the mass fraction. So, glucose mass fraction is very low in the desired stream and water is around 30 percent but the important is the ethanol.

So, ethanol is around 36 percent compared to 0.001 percent in the bottom. So, that you get maximum recovery of your ethanol and this one actually separates the you know glucose etcetera from here the next you can add another in distillation column for further separation of ethanol and water mixture the top of the distillation column can you can have it into another distillation column for further purification of your ethanol and water that is possible.

(Refer Slide Time: 18:43)

Simulation 2.apwz - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources Modify Format

Model Summary Input Stream Analysis Heat Exchanger Pressure Relief  
 Stream Summary History Sensitivity Azeotrope Search PRD Rating  
 Utility Costs Report Data Fit Distillation Synthesis Flare System  
 Analysis Safety Analysis

Simulation Capital: USD Utilities: USD/Year Energy Savings: MW Exchangers - Unknown: 0 OK: 0 Risk: 0

All Items  
 Convergence  
 Dynamics  
 EO Modeling  
 Results  
 Profiles  
 Stream Results  
 Stream Results (Custom)  
 Summary  
 Utilities  
 Reactions  
 Convergence  
 Flowsheeting Options  
 Model Analysis Tools  
 EO Configuration  
 Results Summary  
 Run Status  
 Streams  
 Convergence  
 Operating Costs  
 CO2 Emissions  
 Streams (Custom)  
 Models  
 Equipment  
 Dynamic Configuration

Properties  
 Simulation  
 Safety Analysis  
 Energy Analysis

Main Flowsheet: Control Panel | Results Summary - Streams

Model Palette  
 Mixers/Splitters Separators Exchangers Columns Reactors Pressure Changers Manipulators Solids Solids Separators  
 Material DSTWU Distl RadFrac Extract MultFrac SCFrac PetroFrac ConSep BatchSep

Results Available Check Status

Search the web and Windows aspen demo AnyDesk AnyDesk Simulation 2.apwz ... 15:43 06-04-2022

Simulation 2.apwz - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources Modify Format

Rotate Reconnect Temperature GLOBAL View Parent Export  
 Flip Horizontal Break Heat/Work Pressure Show All View Child Move Selection  
 Flip Vertical Break Reroute Stream Find Object Show Status Vapor Fraction Display Options Lock Flowsheet Import Hierarchy  
 Flowsheet Unit Operations Stream Results Section

Simulation Cap Flowsheet Display Options

All Items  
 Convergence  
 Dynamics  
 EO Modeling  
 Results  
 Profiles  
 Stream Results  
 Stream Results (Custom)  
 Summary  
 Utilities  
 Reactions  
 Convergence  
 Flowsheeting Options  
 Model Analysis Tools  
 EO Configuration  
 Results Summary  
 Run Status  
 Streams  
 Convergence  
 Operating Costs  
 CO2 Emissions  
 Streams (Custom)  
 Models  
 Equipment  
 Dynamic Configuration

Properties  
 Simulation  
 Safety Analysis  
 Energy Analysis

Set default styles for flowsheet

Results display on Process Flowsheet window  
 Units of measurement: MET  
 Units operations  Heat/Work: %Of

Streams  
 Temperature: %Of  
 Pressure: %Of  
 Vapor fraction: %2f  
 Mole flow rate: %Of  
 Mass flow rate: %3f  
 Volume flow rate: %Of  
 Heat/Work: %Of

User-Defined Global Stream Data

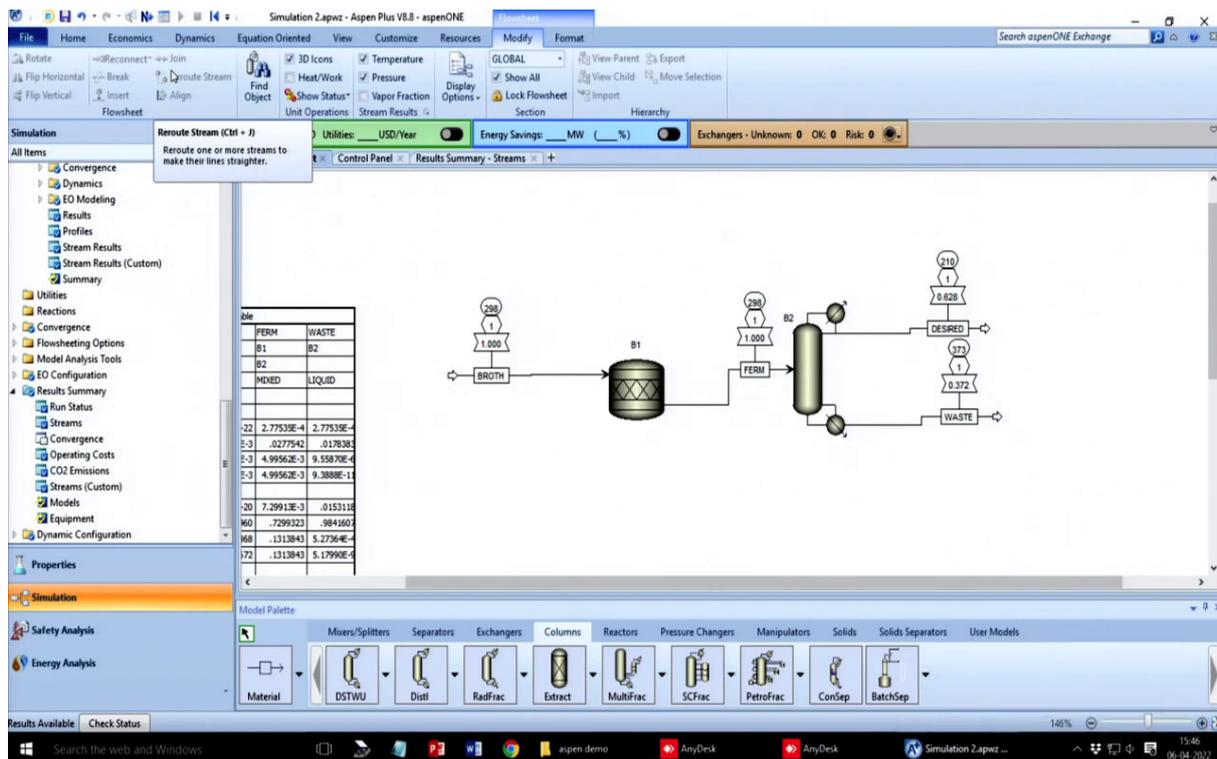
Label	Prop-Set	Format	Color	Icon
Custom1		%2f	Black	
Custom2		%2f	Blue	
Custom3		%2f	Green	
Custom4		%2f	Red	
Custom5		%2f	Purple	
Custom6		%2f	Olive	

Status display on Process Flowsheet window  
 Show error  Show warning  Show inactive

Model Palette  
 Mixers/Splitters Separators Exchangers Columns Reactors Pressure Changers Manipulators Solids Solids Separators  
 Material DSTWU Distl RadFrac Extract MultFrac SCFrac PetroFrac ConSep BatchSep

Results Available Check Status

Search the web and Windows aspen demo AnyDesk AnyDesk Simulation 2.ap... Flowsheet Displ... 15:43 06-04-2022



So, this is a problem that I thought that I should you know show to all of you as how do we connect two-unit operations. This stream table can be also pasted if I click on the stream table into the main flow sheet I mean many fabricators may want some standard you know calculations or results of this simulation. So, you can paste this on the stream this table also there is an option to, if you go in the top there is a flow sheet there is something known as modify and format.

So, and there is an also option of the view but I think there is one more option which I want to show to you that is regarding the, not here, yes. So, see if you click on the flow sheet option if you click on this modify there are these options of specifying the temperature pressure vapor fraction. So, if I click on these temperatures these according to the PFD or the P and ID diagram specifications these will be listed.

So, temperature is listed as a circle then pressure is left listed as a hexagon vapor fractions or liquid fractions can also be listed down for example I can also write down the mass flow rate here. So, these properties of the different streams that you get in the output will also be listed down here in the main flow sheet you can include these information's and you can also specify that how many number of decimal places are you interested to display.

So, three decimal places for the mass flow and rest is, as you know this is in kelvin temperature pressure is in bar and the mass flow is in sorry yes the mass flow or the mass

fraction is the mass flow units is in kg per hour. So, this is one problem I am going to also talk about the problem of multiple flash units.

(Refer Slide Time: 21:23)

**Problem 2A: Single stage flash**

Flash of acetone + water mixture

Total feed flow: 100 kg/hr  
Feed conditions: 50 C and 1 atm  
Mass fraction of acetone: 0.5

Flash conditions: 75 C and 1 atm

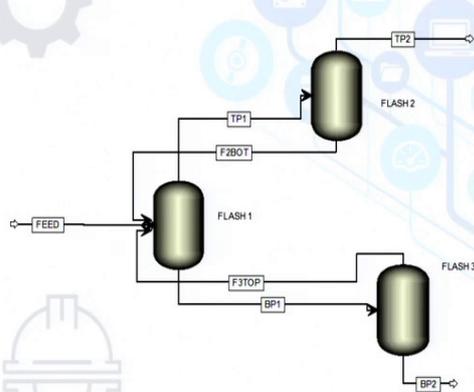
The slide features a schematic of a single-stage flash unit labeled 'FLASH1'. A 'FEED' stream enters the top of the cylindrical vessel. Two output streams exit from the bottom: 'TPI' (Top Product Inlet) and 'BPI' (Bottom Product Inlet). To the left of the schematic is a T-xy diagram for ACETONE/WATER. The y-axis is 'Temperature, C' ranging from 55 to 105. The x-axis is 'Liquid/vapor mole fraction, ACETONE' ranging from 0.0 to 1.0. The diagram shows two curves: a blue curve for the liquid phase and a green curve for the vapor phase. The liquid curve starts at approximately 85°C for a mole fraction of 0.0 and levels off around 60°C. The vapor curve starts at 100°C for a mole fraction of 0.0 and levels off around 60°C. A vertical dashed line is drawn at a mole fraction of 0.5, showing the temperature of the feed (50°C) and the flash temperature (75°C). The NPTEL logo is visible in the bottom left corner.

So, this is a single stage flash and then we will have you know again some more further flash we will add two stage flash we will do. So, in this flash we put a mixture of you know acetone and water all the specifications are given to you and then to further enrich. So, let us say in the top you will get more of acetone on the bottom you will get more of water. So, this again then we will try to enrich using another you know set of you know flash and then we will have some recycle streams into this system.

So, let us try to work this out work this problem. So, the first problem states that you know please note down all the this specifications of the flash total fluid flow rate is 100 kg per hour it is equivalent amounts of acetone and you know water by mass is present feed conditions is 50 degree and one atmosphere and this I have made the t x y diagram and you can see that at 50 degrees there could be a significant separation of this sorry that is the feed condition and the flash condition is 75. So, at 75 you can see there are distinct you know variation of the vapor and the liquid fractions of acetone. So, it can be very nicely separated at 75.

(Refer Slide Time: 23:00)

## Problem 2B: Two stage flash



Flash of acetone + water mixture

Total feed flow: 100 kg/hr  
Feed conditions: 50 C and 1 atm  
Mass fraction of acetone: 0.5

Flash1 conditions: 75 C and 1 atm

Flash 2 condition: 60 C and 1 atm

Flash 3 condition: 90 C and 1 atm



So, this  $t \times y$  diagram helps you to identify what should be the appropriate you know this temperature choice for the flash or for a distillation column and in the next case we will keep the same settings but we will have two additional flash to further purify the acetone or to further purify you know this whatever we are getting from the bottom flash. So, again it suggests that if you are adding one more flash unit to the top.

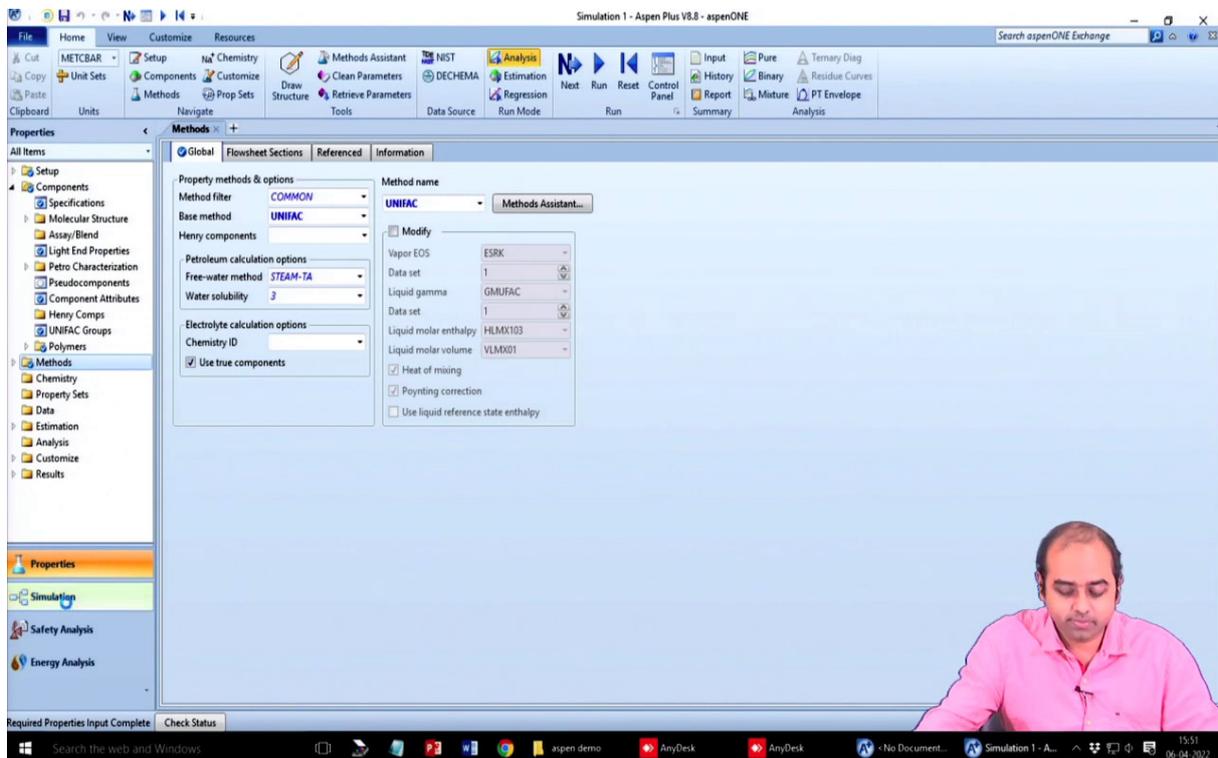
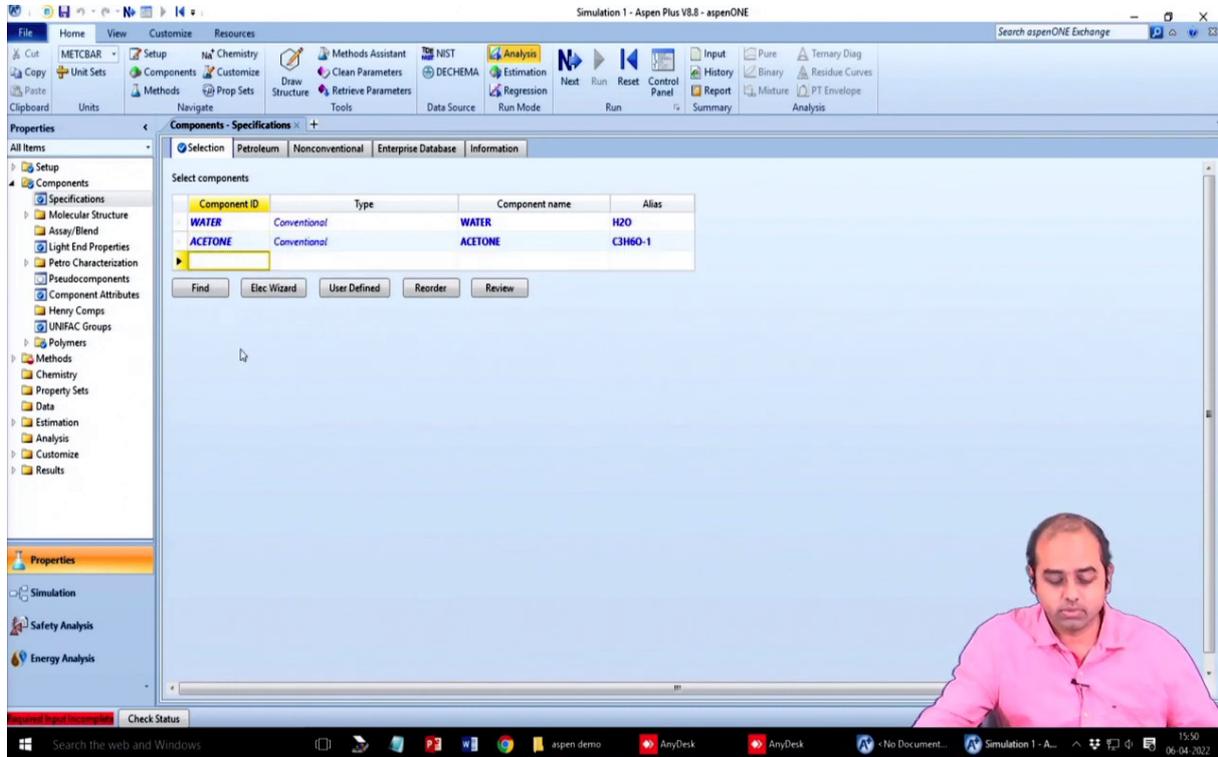
So, it means that this TP2 will be further enriched with acetone and to improve the chances what we do is that the bottom which is mostly water of the second stage flash is again recycled back. So, we do not waste any amount of acetone that may be present there we are recycling it back similarly for the bottom flash the top product is again enriched with acetone and water. So, that is something is again recycled back.

So, that we do not waste it and the bottom most BP2 is enriched with water. So, TP2 and BP2 I mean this you know outlets from the second stage after this recycling steel streams is further more enriched compared to a single stage flash and you know that the flash conditions has to be also changed. So, the bottom is more the bottom flash or the flash three that you see the second stage bottom side is actually contains more water.

So, we need to increase the temperature. So, that to obtain more amounts of acetone that is why the flash three condition is 90 the flash 2 which is the second stage of this flash after the first flash will contain more amounts of acetone. So, probably there we need lower

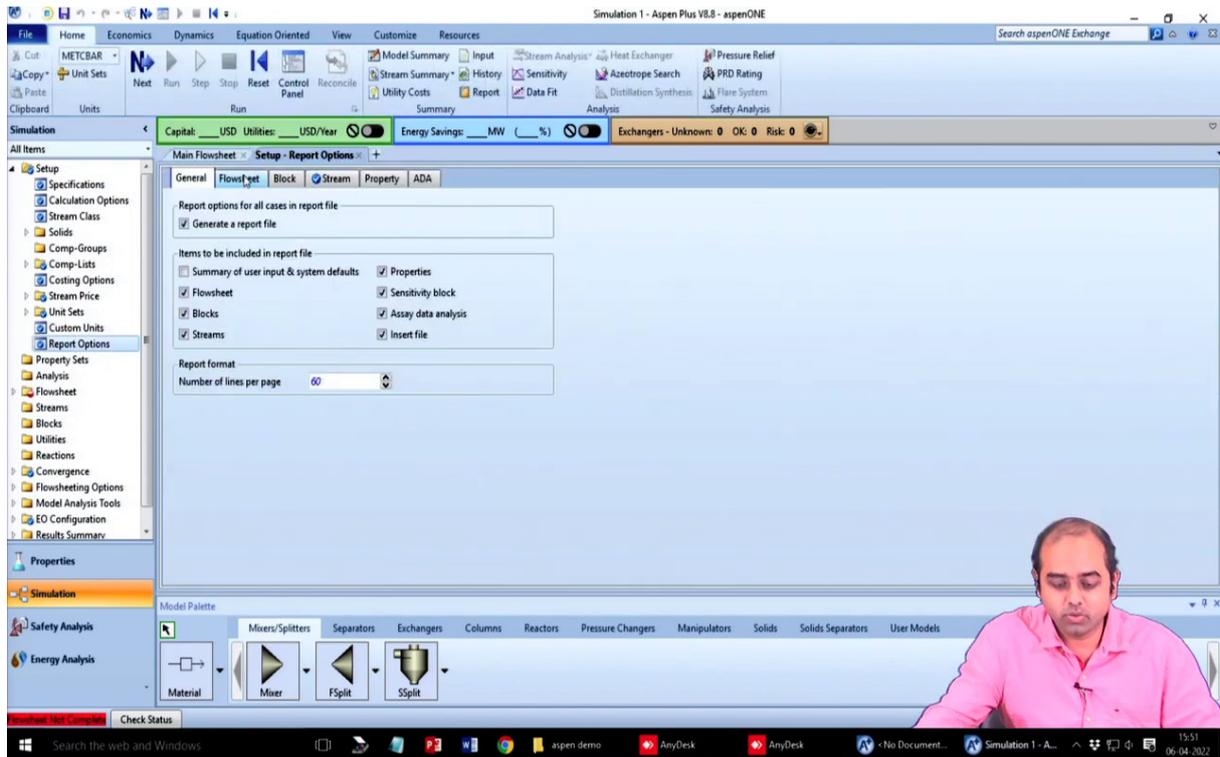
temperature than the first stage flash. So, that is why I have selected that as 60 degrees. So, this is the subsequent of the follow up problem on the single stage flash let us try to work it out in the aspen platform.

(Refer Slide Time: 24:50)



So, this is a blank simulation I have started I have to specify first the you know components in this case components are only water and acetone. So, I write water and acetone. Methods I will select the base method as UNIFAC you can also choose the other ones but you must be sure that what is something you are choosing and what are the limitations of that method. So, this is the required property inputs are complete next we go to the simulation.

(Refer Slide Time: 25:32)



Simulation 1 - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation: Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet Setup - Report Options

General Flowsheet Block Stream Property ADA

Generate a standard stream report  Include stream descriptions

Items to be included in stream report

<input type="checkbox"/> Mole	<input type="checkbox"/> Mole	Stream format
<input checked="" type="checkbox"/> Mass	<input checked="" type="checkbox"/> Mass	TFF FULL
<input type="checkbox"/> Std.liq.volume	<input type="checkbox"/> Std.liq.volume	<input checked="" type="radio"/> Standard (80 characters)
		<input type="radio"/> Wide (132 characters)
<input checked="" type="checkbox"/> Components with zero flow or fraction		<input checked="" type="checkbox"/> Sort streams alphanumerically

Include Streams Exclude Streams Property Sets Component Attributes

Stream Names Batch Operation Supplementary Stream

Model Palette: Material, Mixer, FSplit, SSplit

Simulation 1 - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation: Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet Setup - Report Options

Model Palette: Material, Flash2, Flash3, Decanter, Sep, Sep2

Simulation 1 - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation: Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet Setup - Report Options FLASH1 (Flash2)

Flash specifications

Flash Type: Temperature Pressure

Temperature: 75 C

Pressure: 1 atm

Duty: col/sec

Vapor fraction:

Valid phases: Vapor-Liquid

Model Palette: Mixers/Splitters Separators Exchangers Columns Reactors Pressure Changers Manipulators Solids Solids Separators User Models

Material Flash2 Flash3 Decanter Sep Sep2

15:52 06-04-2022

Simulation 1 - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation: Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet Setup - Report Options Streams

Name	Type	Status	Description
BP1	MATERIAL	Results Not Available	
FEED	MATERIAL	Required Input Incomplete	
TP1	MATERIAL	Results Not Available	

Model Palette: Mixers/Splitters Separators Exchangers Columns Reactors Pressure Changers Manipulators Solids Solids Separators User Models

Material Flash2 Flash3 Decanter Sep Sep2

15:52 06-04-2022

Simulation 3.apwz - Aspen Plus V8.8 - aspenONE

Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Specifications

Flash Type: Temperature Pressure

State variables

Temperature: 50 C

Pressure: 1 atm

Vapor fraction

Total flow basis: Mass

Total flow rate: 100 kg/hr

Solvent

Reference Temperature

Volume flow reference temperature: C

Component concentration reference temperature: C

Composition

Mole-Flow kmol/hr

Component	Value
WATER	0.5
ACETONE	0.5
Total	1

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models

Simulation 3.apwz - Aspen Plus V8.8 - aspenONE

Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Results Summary - Streams

	BP1	FEED	TP1
Substream: MIXED			
Mole Flow kmol/hr			
WATER	0.567387	1.31414	0.746755
ACETONE	0.0289329	1.31414	1.28521
Mass Flow kg/hr			
WATER	10.2216	23.6746	13.453
ACETONE	1.68043	76.3254	74.645
Mass Frac			
WATER	0.858812	0.236746	0.152705
ACETONE	0.141188	0.763254	0.847295
Total Flow kmol/hr	0.59632	2.62828	2.03196
Total Flow kg/hr	11.9021	100	88.0979
Total Flow l/min	0.21908	2.09037	952.156
Temperature C	75	50	75
Pressure bar	1.01325	1.01325	1.01325

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models

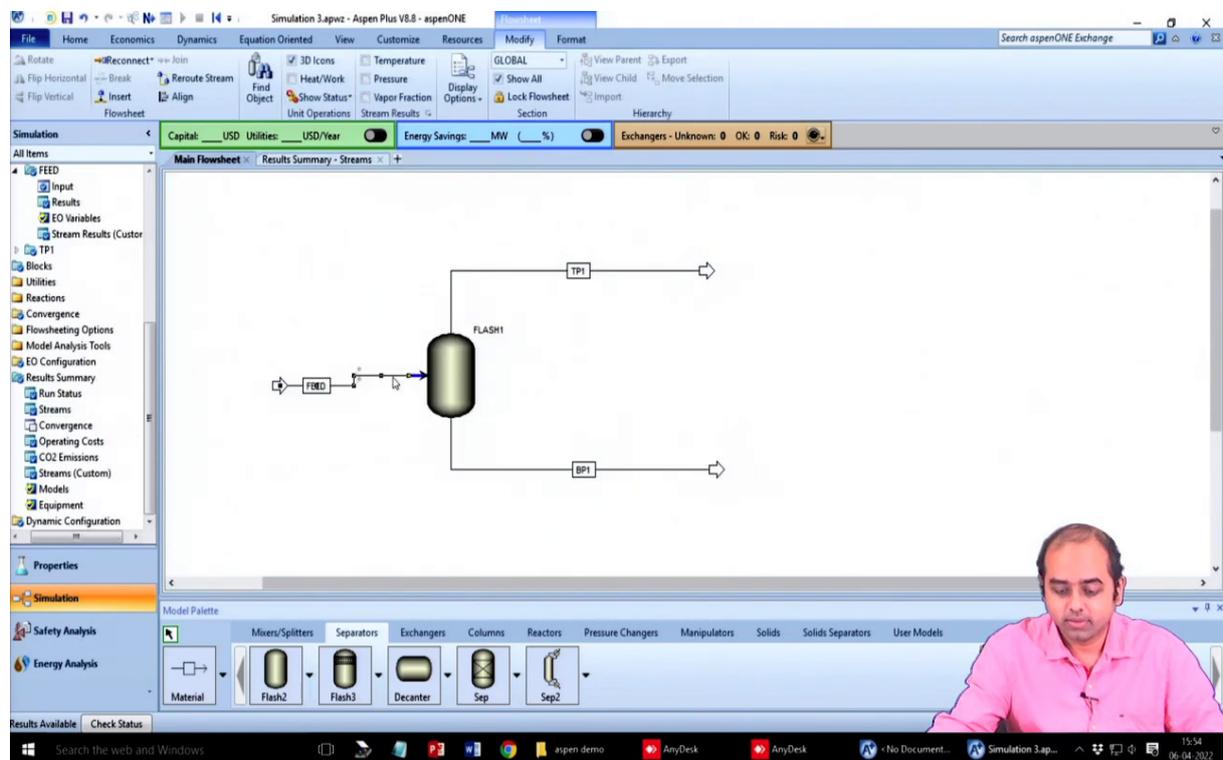
So, in the simulation let us hide this top ribbon in the beginning only itself let us specify the report options to include all the you know mass and the mass fractions because we are dealing with mass everything here. So, that those things are specified in the beginning now coming to the flow sheet. So, let us include one flash. So, flash is included in the separator it is not part of the column.

So, it is flash two only two outlet streams next week sorry we connect the streams. So, one inlet, outlet. So, this one let us rename the streams as feed, this is like top product 1, this is like bottom product 1, let us define this as flash 1, single flash. So, first define the flash 1 conditions temperature we specify as 75 and pressure is 1 atmosphere streams sorry I click the feed streams only feed stream needs to be specified for this problem.

So, the feed stream temperature let us say we specify some temperature of the feed stream you can set it to be preheated close to the flash temperature let us say 70 degrees bring it close to the flash or 50 degrees because that is what it is specified pressure is 1 atmosphere and total flow rate in terms of mass is 100 kg per hour and this is 0.5, 0.5 water and acetone both are equivalent.

So, this completes the required input you see the bottom message required input is completed. So, before running let us save this simulation let us run it and try to see the results, results are available since we have already selected the mass flow and the mass fraction these results are highlighted here. So, the feed stream here is not showing the mass fraction as we have specified in the problem. So, that is something we need to check.

(Refer Slide Time: 29:01)



Simulation 3.apwz - Aspen Plus V8.8 - aspenONE

Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet - Results Summary - Streams - FEED (MATERIAL)

Specifications

Flash Type: Temperature Pressure

State variables

Temperature: 50 C

Pressure: 1 atm

Vapor fraction: [blank]

Total flow basis: Mass

Total flow rate: 100 kg/hr

Solvent: [blank]

Reference Temperature

Volume flow reference temperature: C

Component concentration reference temperature: C

Composition

Component	Value
WATER	0.5
ACETONE	0.5
Total	1

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models

Simulation 3.apwz - Aspen Plus V8.8 - aspenONE

Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet - Results Summary - Streams - FEED (MATERIAL)

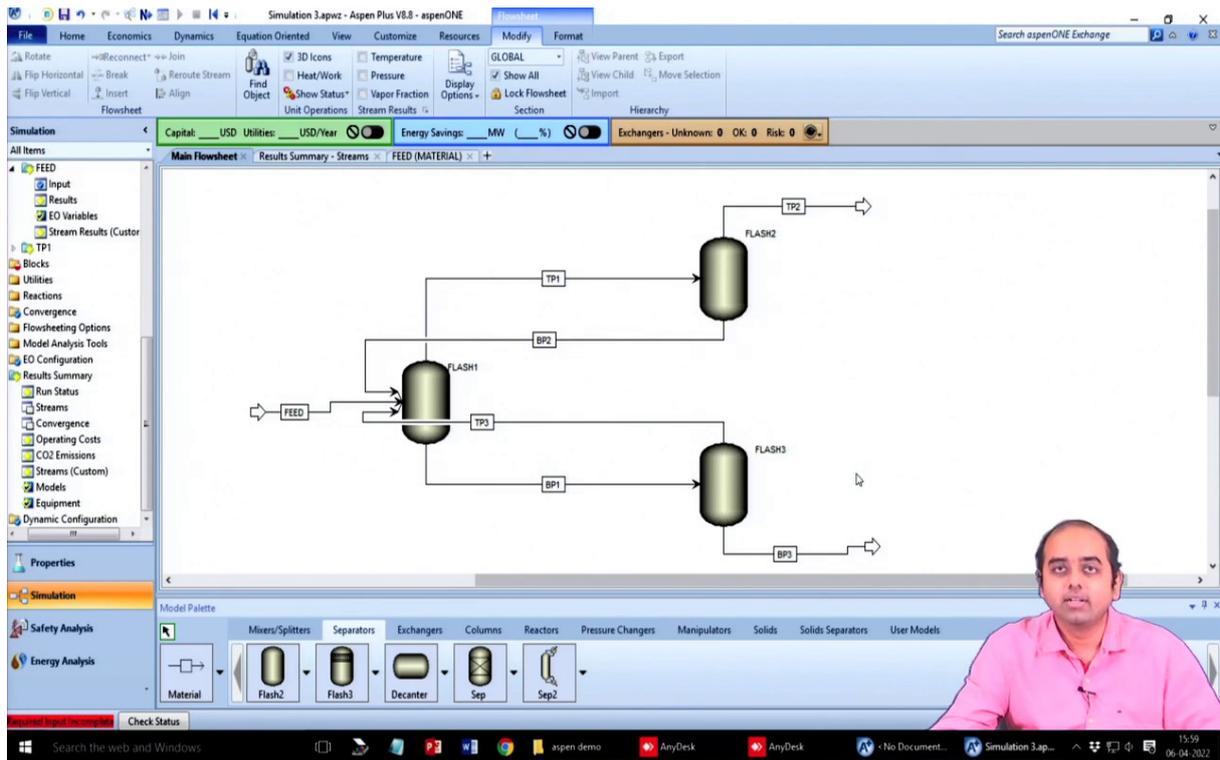
Display: All streams Format: FULL Stream Table Copy All

	BP1	FEED	TP1
ACETONE	0.119564	0.860881	0.741317
Mass Flow kg/hr			
WATER	42.2402	50	7.75978
ACETONE	6.94426	50	43.0557
Mass Frac			
WATER	0.858812	0.5	0.152705
ACETONE	0.141188	0.5	0.847295
Total Flow kmol/hr	2.46425	3.6363	1.17205
Total Flow kg/hr	49.1845	100	50.8155
Total Flow l/min	0.905334	1.96507	549.211
Temperature C	75	50	75
Pressure bar	1.01325	1.01325	1.01325
Vapor Frac	0	0	1
Liquid Frac	1	1	0
Solid Frac	0	0	0

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models

So, we will go back and we will see the feed stream input and if you see it here it is mentioned that the composition is provided terms of mass flow which is bit of incorrect we need to specify the mass fraction. So, now it is the appropriate definition or the proper setting of the problem let us reset it that is why in the results you do not see the mass fraction to a 0.5 and 0.5 for the field stream, run it again let us go to the feed stream summary.





So, I want to improve the recoveries you can click this stream table. So, this will be you know pasted in the flow sheet. So, that is there we zoom out you will see that this table is there now let us work with the adding another you know flash to the top and the bottom and adding the bottoms to be recycling of the top flash.

So, let us works add some more flash to flash streams I have added just click the flash button and click in the flow sheet it will add that let us rename this as flash 2, this has flash 3. Now, please note that this stream needs to be connected as the input to this flash but since we have added this new flash you know stream sorry new flash block this stream is not connected. So, instead of deleting the stream and connecting once more let us try to reconnect the destination.

So, you see this reconnect sorry right click then you click reconnect destination. So, this if I clicked this stream will be collected there. So, you connecting destination similarly this one also reconnect destination. So, if I select the destination that is the inlet of the flash 3 it will connect it there. So, this is where the top and the bottom streams are connected back. Now let us try to connect another stream for the top output and here as the bottom output similarly here also and this stream we are recycling it back to the feed this is added back similarly this one I need to reconnect the destination because I want to connect it here.

So, let us change little bit like this. So, three streams are now, this name is hidden. So, I am just trying to shift the name. So, this is the possible recycling. So, from the top of as I said the top of flash 3 contains more amount of acetone which we want to recover similarly the bottom of flash 2 contains very low amount of acetone but that is something we want to again recycle it back to reuse or to use it as much as possible.

So, now you have two recycling streams in this problem. So, it is not a you know unidirectional computation part of the solution of flash 2 and flash 3 goes to the input of flash 1 is not it let us rename these streams. So, this one let us rename as BP2 because bottom product of flash 2 this one as TP3 top product of flash 3 this one is top product of flash 2 and this one is bottom product of flash 3 and also define the condition.

(Refer Slide Time: 34:16)

The screenshot displays the Aspen Plus V8.8 software interface. The main window shows the configuration for a 'FLASH3 (Flash2)' unit. The 'Specifications' tab is selected, showing the following settings:

- Flash specifications
- Flash Type: Temperature - Pressure
- Temperature: 90 C
- Pressure: 1 atm
- Duty: (blank) cal/sec
- Vapor fraction: (blank)
- Valid phases: Vapor-Liquid

The 'Model Palette' at the bottom of the window contains icons for various unit operations: Material, Flash2, Flash3, Decanter, Sep, and Sep2. A person is visible in the bottom right corner of the screen, likely the presenter.

The screenshot displays the Aspen Plus V8.8 software interface. The main window shows a process flowsheet titled "Main Flowsheet" with the following components and streams:

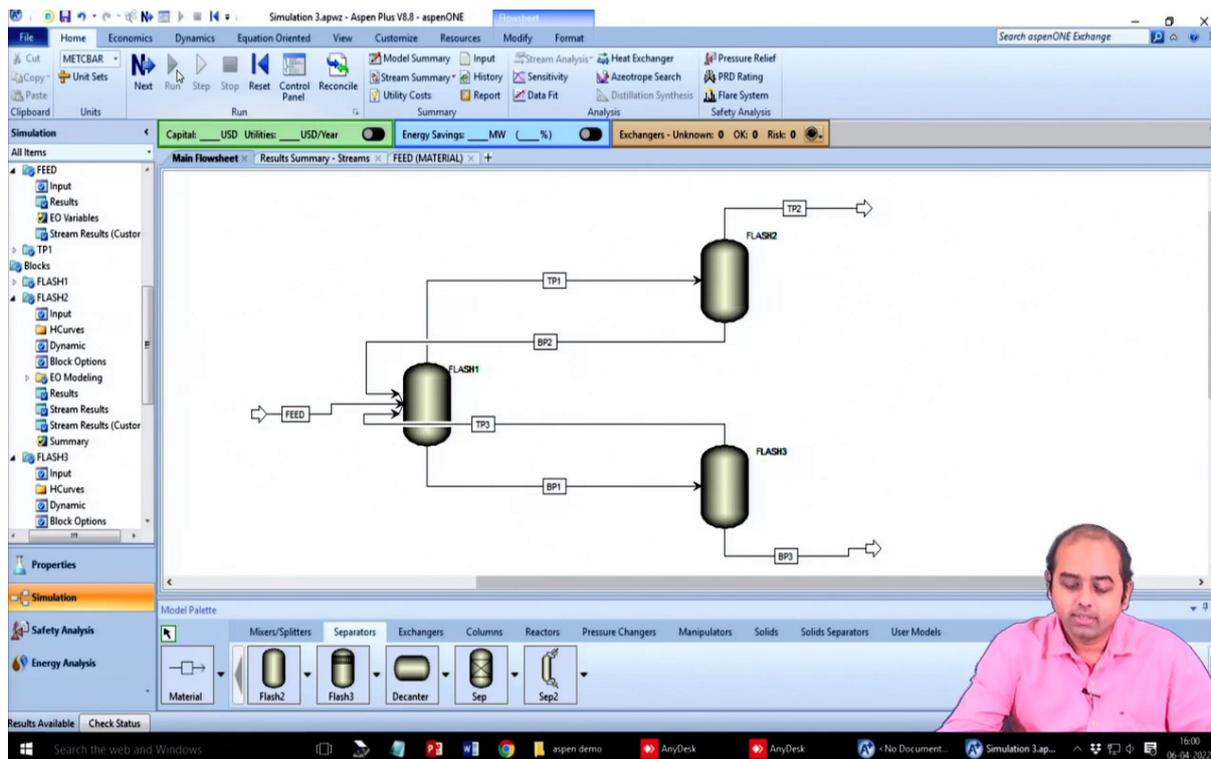
- Streams:** FEED (input), TP1, TP2, TP3, BP1, BP2, BP3 (intermediate and output streams).
- Units:** FLASH1, FLASH2, and FLASH3 (flash distillation units).
- Connections:** FEED feeds into FLASH1. FLASH1 has two outputs: TP1 (top product) and TP3 (bottom product). TP1 feeds into FLASH2. FLASH2 has two outputs: TP2 (top product) and BP2 (bottom product). TP3 feeds into FLASH3. FLASH3 has one output: BP1 (bottom product).

The interface includes a menu bar (File, Home, Economics, Dynamics, Equation Oriented, View, Customize, Resources), a toolbar with simulation controls (Run, Stop, Reset, Control Panel, Reconcile), and a Properties pane on the left. The bottom status bar shows the date 06-04-2022 and time 16:00.

This screenshot shows the "Specifications" tab for the "FLASH3 (Flash2)" unit in Aspen Plus V8.8. The following parameters are visible:

- Flash specifications:**
  - Flash Type: Temperature Pressure
  - Temperature: 90 C
  - Pressure: 1 atm
  - Duty: cal/sec
  - Vapor fraction: (empty field)
- Valid phases:** Vapor-Liquid

The interface also shows the "Model Palette" at the bottom, which includes icons for various process units like Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, and User Models. The bottom status bar shows the date 06-04-2022 and time 16:00.



So, in this case the temperature would be slightly lower because this is the top one where more amounts of acetone will be handled pressure is 1 atmosphere, that is flash 2 and flash 3 needs higher temperature because here the water fraction will be more and pressure is again 1. So, this completes the specification no further stream conditions are needed because these two streams are part of the internal calculations now as the feed anyway they are also part of the output stream and these are also input streams from the first flash BP1 and TP1 to the second flash. So, now all the required inputs are complete. So, let us try to you know reset the problem, save it and then run it.

(Refer Slide Time: 35:16)

Simulation 3.apwz - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources

Simulation: Capital: USD Utilities: USD/Year Energy Savings: MW Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet | Results Summary - Streams | FEED (MATERIAL) | Control Panel

```

Block: FLASH1 Model: FLASH2
Block: FLASH2 Model: FLASH2
Block: FLASH3 Model: FLASH2

> Loop SOLVER01 Method: MEGSTEIN Iteration 8
Converging tear streams: BP2 TP3
6 vars not converged, Max Err/Tol 0.93803E+01

Block: FLASH1 Model: FLASH2
Block: FLASH2 Model: FLASH2
Block: FLASH3 Model: FLASH2

> Loop SOLVER01 Method: MEGSTEIN Iteration 9
# Converged Max Err/Tol 0.36767E+00
->Simulation calculations completed ...

*** No Warnings were issued during Input Translation ***

*** No Errors or Warnings were issued during Simulation ***

->Generating results ...
  
```

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models



Simulation 3.apwz - Aspen Plus V8.8 - aspenONE

File Home Economics Dynamics Equation Oriented View Customize Resources Modify Format

Simulation: Capital: USD Utilities: USD/Year Energy Savings: MW Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet | Results Summary - Streams | FEED (MATERIAL) | Control Panel

Model Palette: Mixers/Splitters, Separators, Exchangers, Columns, Reactors, Pressure Changers, Manipulators, Solids, Solids Separators, User Models



Simulation 3.apwz - Aspen Plus V8.8 - aspenONE

Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet | Results Summary - Streams | FEED (MATERIAL) | Control Panel

Material	BP1	BP2	BP3	FEED	TP1	TP2	TP3
ACETONE	0.146082	0.705965	0.030973	0.860881	1.53527	0.82988	0.115107
Mass Flow kg/hr							
WATER	51.6089	13.1566	47.0859	50	16.0705	2.9135	4.52291
ACETONE	8.8444	40.9677	1.79891	50	89.1686	48.1995	6.6854
Mass Frac							
WATER	0.858812	0.243081	0.963201	0.5	0.152705	0.0570012	0.403532
ACETONE	0.141188	0.756919	0.036799	0.5	0.847295	0.942999	0.596468
Total Flow kmol/hr	3.01081	1.43567	2.64464	3.6363	2.42732	0.991604	0.366166
Total Flow kg/hr	60.0934	54.1242	48.8848	100	105.239	51.113	11.2083
Total Flow l/min	1.10613	1.14755	0.887329	1.96507	1.13742	442.209	179.935
Temperature C	75	60	90	50	75	60	90
Pressure bar	1.01325	1.01325	1.01325	1.01325	1.01325	1.01325	1.01325
Vapor Frac	0	0	0	0	1	1	1
Liquid Frac	1	1	1	1	0	0	0
Solid Frac	0	0	0	0	0	0	0

Simulation 3.apwz - Aspen Plus V8.8 - aspenONE

Capital: USD Utilities: USD/Year Energy Savings: MW (%) Exchangers - Unknown: 0 OK: 0 Risk: 0

Main Flowsheet | Results Summary - Streams | FEED (MATERIAL) | Control Panel

Material	BP1	BP2	BP3	FEED	TP1	TP2	TP3
Mass Frac							
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Pressure bar	1.01325	1.01325	1.01325	1.01325	1.01325	1.01325	1.01325
Vapor Frac	0	0	0	0	1	1	1
Liquid Frac	1	1	1	1	0	0	0
Solid Frac	0	0	0	0	0	0	0
Enthalpy cal/mol	-6687.4	-62899.7	-66956.3	-65566.7	-53097.9	-51986.1	-55066.4
Enthalpy cal/gm	-3350.56	-1668.44	-3622.3	-2384.2	-1224.69	-1008.54	-1798.97
Enthalpy cal/sec	-55929.5	-25084.1	-49187.6	-66227.9	-35801.6	-14319.4	-5600.95
Entropy cal/mol-K	-37.6077	-53.2674	-35.6924	-45.3392	-32.9762	-42.2316	-20.0189

So, if you click on this control panel you will see what are the different steps or you know iterations that has been done and it took almost nine iterations to get a convergence. Recycling streams of course needs a lot of iterations. So, calculation is done results are available. So, let us see the results now result summary we go to the streams. So, let us put the feed in the first one this alphabetical order, let us not worry.

So, mass fraction you see the first column that is TP1 the top product of the first column you have acetone 84.7 almost 85 percent but the top product of the second flash that is the upper one is 95 percent. So, it is improving and the bottom product of the first flash has water of almost 86 percent but the bottom product of the third flash that is the lower is 96 percent. So, the water is getting you know I mean it means that the acetone is getting lower and lower with subsequent number of flash.

So, this is the same way I mean the multi stage distillation operation also works. So, in the multi stage distillation we all I mean the purpose of having multiple stage is to enrich it and these recycling streams in this case of the flash is nothing but sort of the you know reflux actually for a multi stage process. So, this is like a two-stage distillation column is not it, individual flash units can be considered when they are present in sequence can be considered as to be part of the distillation column.

So, you can also connect some more flash and try to see that how the acetone fraction can be enriched you can also explore what happens if you do not recycle back these streams and how does the composition changes. So, these are the things that you can work out you can also work out the you know this sensitivity trying to vary the input feed sorry the input you know the composition or changing the temperature how much it is sensitive to the temperatures of all the three flash that is something can also be worked out.

So, I hope this gives you a quite a good understanding of the multiple units when you have more than one units how the calculations are actually coupled or combined and what essentially the how the internal streams are involved in the part of the calculation rather than they are standalone solution streams or user defined streams. Here we have seen two problems today one is involving a reactor and then another one is involving some flash units.

So, in the next class essentially we will talk about a complex network this Haber-Bosch process of ammonia synthesis and there we will discuss something related to the convergence problem or how convergence issues can be handled in such complex problem or such complex network problems involving a lot of in you know units as well as lot of you know this recycling streams thank you I hope all of you enjoyed this class.