

ASPEN ASSIGNMENT - 5

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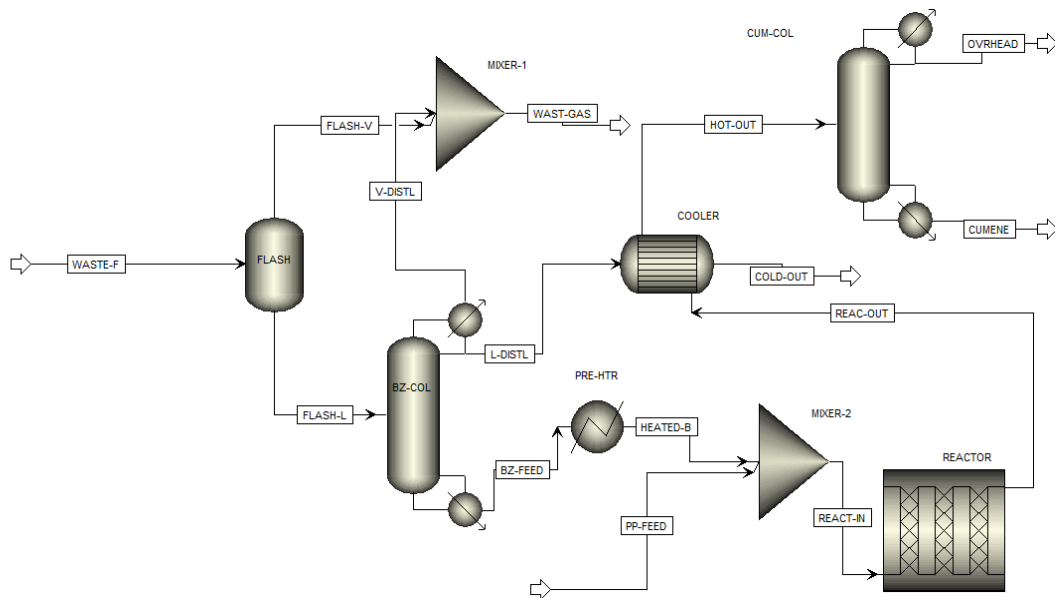
$$a=0, b=5, c=2$$

$$T = a + b + 10*c = 0 + 5 + 20 = 25$$

$$X = 25 \bmod 9 = 7$$

$$Y = 25 \bmod 19 = 6$$

Use ASPEN PLUS to simulate this cumene production process.



Model fidelity

☒ Shortcut
☐ Detailed
☐ Shell & Tube
☐ Kettle Reboiler
☐ Thermosyphon
☐ Air Cooled
☐ Plate

Hot fluid

☐ Shell
☐ Tube

Shortcut flow direction

☒ Countercurrent
☐ Cocurrent
☐ Multipass, calculate number of shells
☐ Multipass, shells in series

Calculation mode **Design**

Exchanger specification

Specification **Cold stream outlet temperature**

Value **F**

Exchanger area **sqm**

Constant UA **cal/sec-K**

Minimum temperature approach **F**

Exit temperature of cooler = 96F (90 + Y)

The specifications of maintaining the waste gas stream (WAST-GAS) has a maximum total flow rate of 37.0 lbmol/hr , to achieve 99% conversion and 99.x% => 99.7% purity of cumene in the output cannot be achieved directly .Varying the parameters such as

- Vapor fraction in the distillate = 0.05 of benzene distillation column to get the waste gas stream below 37 lbmol/hr

Condenser specification

☐ Temperature **C**
☒ Distillate vapor fraction **Mole**

Subcooling specification

Subcooled temperature **C**
☒ Both reflux and liquid distillate are subcooled
☐ Only reflux is subcooled

Utility specification

Utility

Distillate vapor fraction.
Enter a number between 0 and 1

- **Propylene inlet flow rate to get the required purity of cumene i.e., 99.x% => 99.7%**
 - Using Design specifications (DS-1)

- Manipulated variable as flow rate of propylene
- Design variable as mole fraction of cumene

☐ Active

^ Sampled variables (drag and drop variables from form to the grid below)

Variable	Definition
CUMPUR	Mole-Frac Stream=CUMENE Substream=MIXED Component=ISOPR-01

New Delete Copy Paste Move Up Move Down View Variables

^ Edit selected variable

Variable **CUMPUR**

Category

- ☐ All
- ☐ Blocks
- ☒ Streams
- ☐ Model Utility
- ☐ Property Parameters
- ☐ Reactions

Reference

Type **Mole-Frac**

Stream: **CUMENE**

Substream: **MIXED**

Component: **ISOPR-01**

When selected, allows you to define Physical Property Parameters.

Design specification expressions

Spec **CUMPUR**

Target **0.997**

Tolerance **0.0001**

Manipulated variable

Type **Mole-Flow**

Stream: **PP-FEED**

Substream: **MIXED**

Component: **PROPY-01**

Units: **lbmol/hr**

Manipulated variable limits

Lower **100**

Upper **150**

Step size

Maximum step size

Report labels

Line 1 Line 2 Line 3 Line 4

EO input

Open variable

Description

	Variable	Initial value	Final value	Units
▶	MANIPULATED	50.2613	50.2613	KMOL/HR
▶	CUMPUR	0.997018	0.997018	

- **Flow Rate = 50.2613 kmol/hr = 110.807 lbmol/hr**

Flash Type: **Temperature** **Pressure**

State variables:

Temperature: **200** **F**

Pressure: **14.7** **psia**

Vapor fraction:

Total flow basis: **Mole**

Total flow rate: **110.807** **lbmol/hr**

Solvent:

Reference Temperature:

Volume flow reference temperature: **C**

Component concentration reference temperature: **C**

Composition: **Mole-Flow** **kmol/hr**

Component	Value
▶ BENZE-01	
▶ METHA-01	
▶ METHA-02	
▶ ACETY-01	
▶ NITRO-01	
▶ OXYGE-01	
▶ ISOPR-01	
▶ PROPY-01	1

Total: **1**

- Length of the reactor to get required conversion of 99%
 - Using Design specifications (DS-2)
 - Manipulated variable as Reactor length
 - Design variable as conversion of benzene = $(\text{React Inlet concentration} - \text{Reactor outlet concentration}) / \text{reactor inlet concentration}$

☐ Active

^ Sampled variables (drag and drop variables from form to the grid below)

Variable	Definition
▶ REACTIN	Mole-Flow Stream=REACT-IN Substream=MIXED Component=BENZE-01 Units=lbmol/hr
▶ REACTOUT	Mole-Flow Stream=REAC-OUT Substream=MIXED Component=BENZE-01 Units=lbmol/hr
*	

^ Edit selected variable

Variable

Category

☐ All
☐ Blocks
☒ Streams
☐ Model Utility
☐ Property Parameters
☐ Reactions

Reference

Type

Stream:

Substream:

Component:

Units:

Design specification expressions

Spec

Target

Tolerance

Manipulated variable

Type

Block:

Variable:

Sentence:

Units:

Manipulated variable limits

Lower

Upper

Step size

Maximum step size

Report labels

Line 1	Line 2	Line 3	Line 4
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

EO input

Open variable

Description

	Variable	Initial value	Final value	Units
▶	MANIPULATED	3.54594	3.54594	METER
▶	REACTIN	90	90	LBMOL/HR
▶	REACTOUT	0.900337	0.900337	LBMOL/HR

- Length of the reactor = 3.54594 m = 11.633 ft

Reactor dimensions

Length

Diameter

Elevation

☒ Reactor rise

☐ Reactor angle

Valid phases

Process stream

Thermal fluid stream

- After using the above specifications we get

	Units	CUMENE	WAST-GAS	REACT-IN	REAC-OUT	
Molar Density	mol/cc	0.00619536	4.62979e-05	3.35535e-05	0.000160802	
Mass Density	gm/cc	0.74387	0.000984669	0.00195383	0.016832	
Enthalpy Flow	cal/sec	-28345.1	-5259.16	325368	-44997.6	
Average MW		120.069	21.2681	58.2303	104.676	
— Mole Flows	lbmol/hr	89.3659	36.2852	200.807	111.707	
BENZE-01	lbmol/hr	0.266247	0.281348	90	0.900326	
METHA-01	lbmol/hr	1.23198e-10	0.200768	1.41119e-06	1.41119e-06	
METHA-02	lbmol/hr	3.30115e-27	21.2805	8.17415e-13	8.17415e-13	
ACETY-01	lbmol/hr	1.0035e-19	6.52326	4.70417e-10	4.70417e-10	
NITRO-01	lbmol/hr	0	5.99973	1.40666e-22	1.40666e-22	
OXYGE-01	lbmol/hr	0	1.99962	2.30885e-21	2.30885e-21	
ISOPR-01	lbmol/hr	89.0996	0	0	89.0997	
PROPY-01	lbmol/hr	4.05347e-07	0	110.807	21.7073	
— Mole Fractions						
BENZE-01		0.00297929	0.00775378	0.448192	0.00805968	
METHA-01		1.37858e-12	0.00553305	7.0276e-09	1.26329e-08	
METHA-02		3.69398e-29	0.586478	4.07065e-15	7.31747e-15	
ACETY-01		1.12291e-21	0.179777	2.34263e-12	4.21115e-12	
NITRO-01		0	0.165349	7.00502e-25	1.25923e-24	
OXYGE-01		0	0.0551083	1.14978e-23	2.06687e-23	
ISOPR-01		0.997021	0	0	0.797617	
PROPY-01		4.53582e-09	0	0.551808	0.194323	

- Mole fraction of cumene(purity) = 0.997021
- Waste gas stream flow rate = 36.2852 < 37 lbmol/hr
- Conversion of benzene
 - Reactor input = 90 lbmol/hr

- Reactor output = 0.900326 lbmol/hr
- Conversion = $(90 - 0.900326) / 90 = 98.99\% \sim 99\%$

It is found that the temperature for 30 degrees superheating = 206.247 F

Flash specifications

Flash Type: **Temperature**

Pressure: **Pressure**

Temperature: **206.247** **F**

Temperature change: **C**

Degrees of superheating: **C**

Degrees of subcooling: **C**

Pressure: **14.7** **psia**

Duty: **cal/sec**

Vapor fraction:

Pressure drop correlation parameter:

☐ Always calculate pressure drop correlation parameter

Conduct a sensitivity analysis and generate a plot of the variation of the cumene product flow rate with the preheater temperature.

- Using the sensitivity analysis in aspen to generate the required plot

☒ Active ☐ Case study

Manipulated variables (drag and drop variables from form to the grid below)

Variable	Active	Manipulated variable	Units
1	<input checked="" type="checkbox"/>	Block-Var Block=PRE-HTR Variable=TEMP Sentence...	F

New Delete Copy Paste

Edit selected variable

Manipulated variable

Variable: **1**

Type: **Block-Var**

Block: **PRE-HTR**

Variable: **TEMP**

Sentence: **PARAM**

Units: **F**

Manipulated variable limits

☒ Equidistant ☐ Logarithmic ☐ List of values

Start point: **180** **F**

End point: **300** **F**

☐ Number of points: **121**

☒ Increment: **1** **F**

☐ Report labels

^ Sampled variables (drag and drop variables from form to the grid below)

Variable	Definition
CUMFLOW	Mole-Flow Stream=CUMENE Substream=MIXED Component=ISOPR-01 Units=lbmol/hr

New Delete Copy Paste Move Up Move Down View Variables

^ Edit selected variable

Variable CUMFLOW

Category

- ☐ All
- ☐ Blocks
- ☒ Streams
- ☐ Model Utility
- ☐ Property Parameters
- ☐ Reactions

Reference

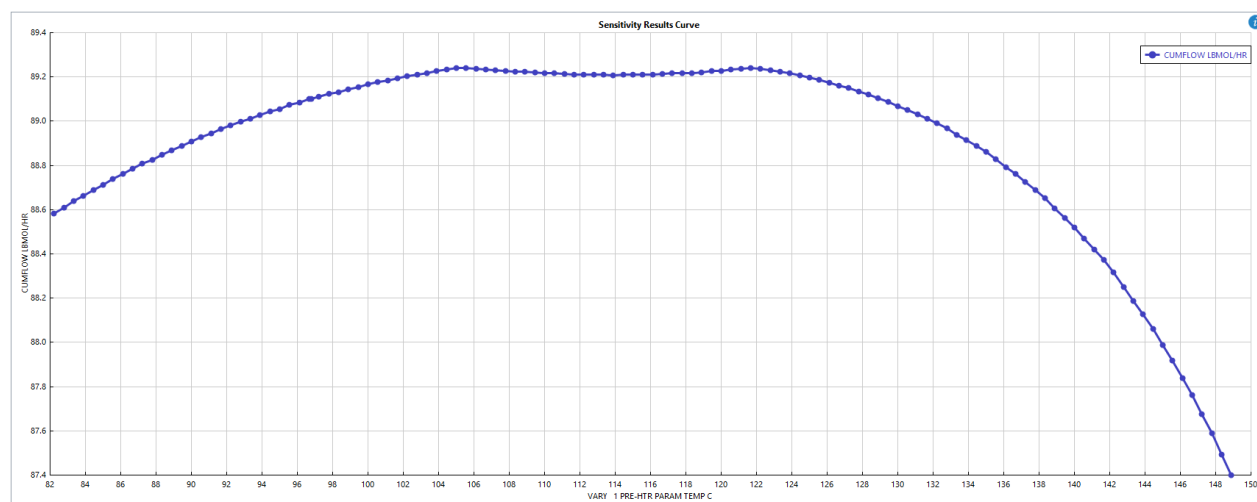
Type Mole-Flow

Stream: CUMENE

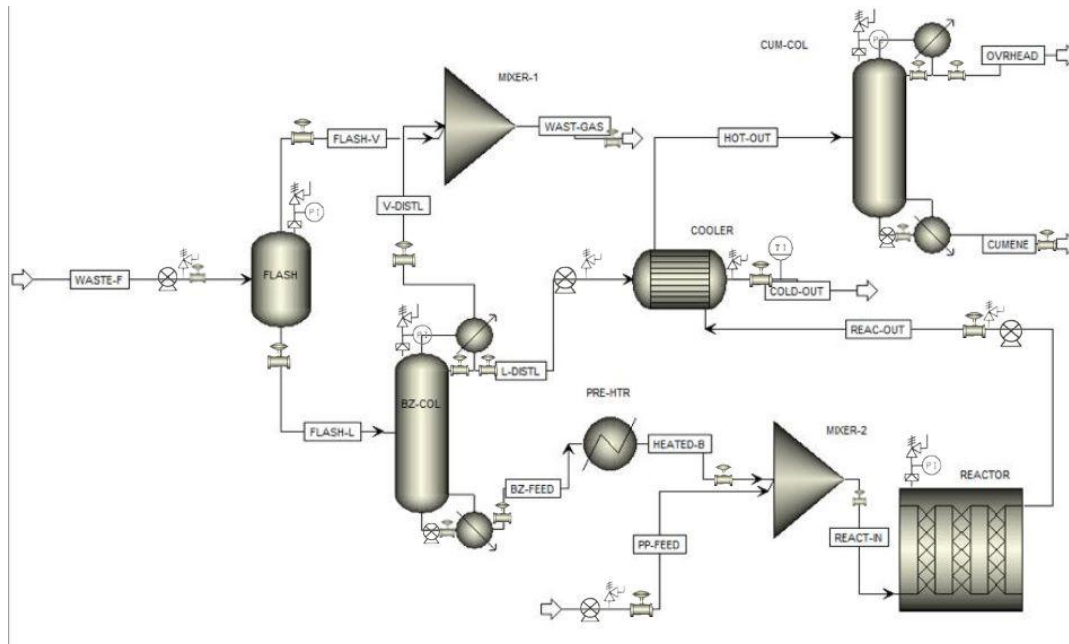
Substream: MIXED

Component: ISOPR-01

Units: lbmol/hr



Create a PFD for the process clearly showing all the pumps that will be needed in the process. The PFD should include the stream table.



The stream table is attached along with the report as a excel file