PSC2018 Task Phase Seven – Final

Status: Active

19.11.2018-31.01.2019

Based on your findings, the purchase department has ordered a third blower which was now installed. This means, that you can increase the aeration rate even further!

In addition, you are allowed to manipulate all process variables. It's up to you to find the global optimum for your PDO facility and make it the number one bio-refinery!

Unlocked Design variables:

All design variables are unlocked!

Input Bounds (higher upper bound for F01, rest unchanged):

6500 kg/h < F01 < 120000 kg/h

Input Step Size (unchanged):

F01: 1 kg/h
F02: 1 kg/h
F03: 1 kg/h
F04: 1 kg/h

D01: 1 kg/h
D02: 0.01
D03: 0.01
D04: 1 °C
D05: 1 kg/h
D06: 0.01 bar
D07: 0.01
D08: 0.01
D09: 1°C
D10: 0.01 bar
D11: 0.01
D12: 1°C
D13: 0.01 bar
D14: 0.01
D15: 1°C

Initial Values (unchanged):

F01: 39903 kg/h
F02: 3000 kg/h
F03: 1000 kg/h
F04: 500 kg/h

D01 = 15000 kg/h
D02 = 0.9
D03 = 0.05
D04 = 150 °C
D05 = 50 kg/h
D06 = 0.05 bar
D07 = 0.85
D08 = 0.06
D09 = 30°C
D10 = 0.04 bar
D11 = 0.01
D12 = 250°C
D13 = 0.03 bar
D14 = 0.01
D15 = 120°C

Input Constraints:

D02+D03 < 1

Output Constraints (no changes to phase 6):

Stream 40 Massflowrate > D01 + D05
Stream 39 Vapor Fraction < 0.01
Stream 35 Temperature > 18°C
Stream 38 Temperature > 18°C
Stream 32 Temperature < Stream 31 Temperature
D07 > Stream 25 Vapor Fraction (equivalent to) Stream 29 Vapor Fraction > Stream 25 Vapor Fraction

PSC2018 Task Phase Six

Start: 25.09.2018- 19.11.2018

Wow, these bacteria need a lot of air! You found a technician that tuned the compressors in order to give you up to 80.000 kg/h now! You also noticed that the amount of living and dead biomass increased considerably due to your optimizations. Therefore, this is a good moment to look at the filtration process. You should adjust the parameters of the flow distribution to the cross-flow filtration units in order to further increase the profit.

Unlocked Design variables:

F01 (Air) F02 (Cane Juice) F03 (Ammonia) and F04 (Acetic Acid) from the fermenter section and D01 (Water for Dilution) D02 (Ration to MF1) D03 (Ratio to MF2) and D04 Pre-Heater Temp.) from the downstream section.

All other design variables are locked!

Locked Design variables (no changes to phase 4 beside D01-D04):

D05 = 50 kg/h
D06 = 0.05 bar
D07 = 0.85
D08 = 0.06
D09 = 30°C
D10 = 0.04 bar
D11 = 0.01
D12 = 250°C
D13 = 0.03 bar
D14 = 0.01
D15 = 120°C

Input Bounds (higher upper bound for F01):

6500 kg/h < F01 < 80000 kg/h
1000 kg/h < F02 < 10000 kg/h
1 kg/h < F03 < 5000 kg/h
1 kg/h < F04 < 5000 kg/h

1 kg/h < D01 < 40000 kg/h
0.01 < D02 < 0.99
0.01 < D03 < 0.99
75°C < D04 < 170°C

Input Step Size:

F01: 1 kg/h
F02: 1 kg/h
F03: 1 kg/h
F04: 1 kg/h

D01 = 1 kg/h
D02 = 0.01
D03 = 0.01
D04 = 1 °C

Initial Values:

D01 = 15000 kg/h
D02 = 0.9
D03 = 0.05
D04 = 150 °C

Input Constraints:

D02+D03 < 1

Output Constraints (no changes to phase 4):

Stream 40 Massflowrate > D01 + D05
Stream 39 Vapor Fraction < 0.01
Stream 35 Temperature > 18°C
Stream 38 Temperature > 18°C
Stream 32 Temperature < Stream 31 Temperature
D07 > Stream 25 Vapor Fraction (equivalent to) Stream 29 Vapor Fraction > Stream 25 Vapor Fraction

PSC2018 Phase Five

Start: 09.07.2018-24.09.2018

It is quite impressive what you have achieved by manipulating the feed mixture for the bioreactor! It points out that the rule of thumb “The biggest lever in bioprocesses is the optimization of the bioreactor, forget about the downstream!” somehow applies here…

You might have expected it, but now the time has come to give you full access to the bioreactors feed. Be careful when reducing the air stream, your bacteria will not like to be suffocated ☺

Unlocked Design variables:

F01 (Air) F02 (Cane Juice) F03 (Ammonia) and F04 (Acetic Acid). All other design variables are locked!

Locked Design variables (no changes to phase 4):

D01 = 15000 kg/h

D02 = 0.9

D03 = 0.05

D04 = 150 °C

D05 = 50 kg/h

D06 = 0.05 bar

D07 = 0.85

D08 = 0.06

D09 = 30°C

D10 = 0.04 bar

D11 = 0.01

D12 = 250°C

D13 = 0.03 bar

D14 = 0.01

D15 = 120°C

Input Bounds:

6500 kg/h < F01 < 65000 kg/h

1000 kg/h < F02 < 10000 kg/h

1 kg/h < F03 < 5000 kg/h

1 kg/h < F04 < 5000 kg/h

Input Step Size:

F01: 1 kg/h

F02: 1 kg/h

F03: 1 kg/h

F04: 1 kg/h

Input Constraints (no changes to phase 4):

-

Output Constraints (no changes to phase 4):

Stream 40 Massflowrate > D01 + D05

Stream 39 Vapor Fraction < 0.01

Stream 35 Temperature > 18°C

Stream 38 Temperature > 18°C

Stream 32 Temperature < Stream 31 Temperature

D07 > Stream 25 Vapor Fraction (equivalent to) Stream 29 Vapor Fraction > Stream 25 Vapor Fraction

PSC2018 Phase Four

Start: 01.06.2018-09.07.2018

Congratulations! You optimized the downstream process. Not only that you brought the economic balance of the plant from a loss of 380 $/h to a profit of almost 200 $/h, your measures also saved plenty of electricity, steam, and cooling water. **ChemE's are heroes!** Now you know what that means, as you have been named one at your company.

But your job is not finished yet. Your next project is the fermentation section. Go and tackle these lazy bacteria! Be aware that the downstream process remains at its (almost optimal) operating conditions. You are free to feed the E.Coli's with more cane juice and ammonia, or even with less if you think that it's better.

However, don't forget that these feeds have a considerable cost and that the fermentation tanks only have a volume of 400 m^3. If you exceed this volume during the batch cycle, the overflow is purged!

We are sure that you can increase the plant's profit even further. Time to roll up your sleeves!

Unlocked Design variables:

F02 (Cane Juice) and F03 (Ammonia).

Locked Design variables:

Some variables from the downstream process get new default values!

F01 = 39903.2 kg/h
F04 = 500 kg/h

D01 = 15000 kg/h
D02 = 0.9
D03 = 0.05
D04 = 150 °C
D05 = 50 kg/h
D06 = 0.05 bar
D07 = 0.85
D08 = 0.06
D09 = 30°C
D10 = 0.04 bar
D11 = 0.01
D12 = 250°C
D13 = 0.03 bar
D14 = 0.01
D15 = 120°C

Input Bounds:

1000 kg/h < F02 < 10000 kg/h
1 kg/h < F03 < 5000 kg/h

Input Step Size:

F02: 1 kg/h
F03: 1 kg/h

Input Constraints:

Output Constraints:

Same as in the last phase.

Stream 40 Massflowrate > D01 + D05
Stream 39 Vapor Fraction < 0.01
Stream 35 Temperature > 18°C
Stream 38 Temperature > 18°C
Stream 32 Temperature < Stream 31 Temperature
D07 > Stream 25 Vapor Fraction (equivalent to) Stream 29 Vapor Fraction > Stream 25 Vapor Fraction

PSC2018 Phase Three

Start Date: 09.04.2018-01.06.2018

The management is very happy with your success on increasing plant's profit. You convinced them that you can even be more successful when they allow you to change the flowrates along the process, as the utility consumptions are directly coupled to these rates.

And here you go! Adjust the flows which are fed back to the filtration section and to the ion exchanger section. The total amount of recycled material should not exceed 40.000 kg/h! The quantity of the purge stream is then given by the overall mass balance. Try to keep it small ☺

Unlocked Design variables:

D01 (Water for Dilution) and D05 (Recycle). Existing design variables and constraints remain and are given in *italic*.

Filtration Section

Name	UnitOp	Variable	Value	Unit	Lower Bound	Upper Bound	Constraint	
Water for Dillution	40	Output 1	20000	kg/h	1	40000	< F40	D01
Ratio to MF1	14	Output 1	0.9	-	0.01	0.99		D02
Ratio to MF2	14	Output 2	0.05	-	0.01	0.99		D03
Ratio to UF1	14	Output 3	0.05	-	0	1	0>Out3>1	
Pre-Heater Temp.	3	Tout	150	°C	75	170		D04

Ion Exchanger

Name	UnitOp	Variable	Value	Unit	Lower Bound	Upper Bound	Constraint	
Recycle	40	Output 2	1000	kg/h	1	40000	< F40	D05

Input Bounds:

As given in the Excel table.

Input Step Size:

D01: 1
D05: 1

D06: 0.01
D07: 0.001
D08: 0.01
D09: 0.1
D10: 0.001
D11: 0.01
D12: 0.1
D13: 0.001
D14: 0.01
D15: 0.1

Input Constraints:

D13 < D10
D10 < D06
D08 > D06

Output Constraints:

Stream 40 Massflowrate > D01 + D05

Stream 39 Vapor Fraction < 0.01
Stream 35 Temperature > 18°C

Stream 38 Temperature > 18°C
Stream 32 Temperature < Stream 31 Temperature
D07 > Stream 25 Vapor Fraction (equivalent to) Stream 29 Vapor Fraction > Stream 25 Vapor Fraction

PSC2018 Phase Two

Duration: 01.03.2018 – 08.04.2018

You did it, you steered the process back to the profit zone. Operation personal and management are impressed and want to give you more flexibility now: The distillation section is yours!

However, you must consider several constraints:

1. There is no intermediate pump and thus the pressure must decrease from the evaporator to the second column.
2. The cooling water entrance temperature is 15°C and thus now temperatures below 18°C are allowed in the condensers.
3. The vapor fraction of the stream in front of the recycle pump must be below 0.01 mol/mol to avoid damage due to cavitation.
4. The partial condenser is designed as a cooler and thus it cannot be used to heat the vapor coming from the compressor.

Unlocked Design variables:

All variables from the Distillation Section

Distillation Section									
Name	UnitOp	Variable	Value	Unit	Lower Bound	Upper Bound	Constraint		
Evaporator Pressure	25	Pout	0.1	bar	0.01	5			D06
Evaporator Vapor Fraction	30	VFout	**0.1**	-	0.01	1	>VF25		**D07**
Vapor Compressor Pressure	31	Pout	0.11	bar	0.01	5	>P30		D08
Partial Condenser Temp.	32	Tout	20	°C	18	50	<T31		D09
1.Distillation Pressure	34	Top P	0.07	bar	0.01	2	<P34		D10
1.Distillation R/D	34	R/D	1	-	0.01	20			D11
1.Distillation T Bottom	34	TB	155	°C	50	250			D12
2.Distillation Pressure	35	Top P	0.03	bar	0.01	2	<P35		D13
2.Distillation R/D	35	R/D	2	-	0.01	20			D14
2.Distillation T Bottom	35	TB	120	°C	50	250			D15

Input Bounds:

As given in the Excel table

Input Step Size:

D06: 0.01
D07: 0.001
D08: 0.01
D09: 0.1
D10: 0.001
D11: 0.01
D12: 0.1
D13: 0.001
D14: 0.01
D15: 0.1

Input Constraints:

D13 < D10
D10 < D06
D08 > D06

Output Constraints:

Stream 39 Vapor Fraction < 0.01
Stream 35 Temperature > 18°C
Stream 38 Temperature > 18°C
Stream 32 Temperature < Stream 31 Temperature
D07 > Stream 25 Vapor Fraction (equivalent to) Stream 29 Vapor Fraction > Stream 25 Vapor Fraction

PSC2018 Phase One

Duration: 23.02.2018-01.03.2018

Presently, you are only able to change the outlet vapor fraction of the evaporator, as this equipment was identified by experienced engineers to be the less critical equipment to play with. Fortunately, you have a good simulation model of the process in CHEMCAD. Now, it is your chance to demonstrate your process simulation talent and make the production profitable again!