Process Simulation Cup (PSC2018)
Increase the Profit of a Bacteria-Based PDO Production Facility

Part 1: The Story
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Is this document for me?

- This document is for you, if you want to
  - get started in the PSC2018
  - understand the minimum about the task

- This document
  - explains how a bacteria-based PDO production plant works
  - introduces the process, which we have modeled for the PSC2018
  - describes a current problem with this process (we made it up!)
  - explains your task to solve the problem
You are working on one of the first world scale Bacteria-Based PDO production facilities!

The plant is grouped into the process units

- Fermentation
- Filtration
- Ion Exchange and
- Distillation

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In the fermentation section specialized E. Coli bacteria convert glucose from cane juice into PDO. This is done in 4 fed-batch fermenters of 400 m³ volume. 3 of them are always in operation.
Micro and Ultra Cross-Flow Filtration Units

In the filtration section cross-flow filtration units are used to remove biomass cell debris and proteins.

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Ion Exchanger Unit

In the ion exchange section salts and rests of proteins are removed with ion exchange columns. The columns are regenerated with caustic soda and sulfuric acid.
Evaporation and Distillation

In the distillation section PDO is purified by thermally separating it from water and rests of glucose.

In the evaporator a first part of the water is separated together with dissolved inert gases and CO₂. A part of the water is condensed and fed back to the previous sections.

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Evaporation and Distillation

In the distillation section PDO is purified by thermally separating it from water and rests of glucose.

The first column purges the remaining glucose via the bottom. In the second column the final PDO quality is achieved at the bottom by vaporizing water. Some PDO is recovered in the overhead condenser.

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We have modeled a bacteria-based PDO production process for you
We have included the calculation of profit in the simulation model

Management view: Any process must be operated at a profit

Utility Costs \(-uc \$/h\)
Feed Costs \(-fc \$/h\)
Effluent Treatment Costs \(-tc \$/h\)
Fixed Costs \(-c \$/h\)

Product Revenues \(+r \$/h\)

Profit \(=p \$/h\)
To give you a challenge, we assume changing bacteria behavior

Due to a change of the bacteria behavior the fermenter output changed and the profit became negative.

The plant’s bio-tech department is still evaluating the problem, but a more immediate course of action is required. They need your help!
We assume that the PDO production is still running, but the downstream costs became too high.

Hint: Operators noticed that the steam consumption increased a lot!

<table>
<thead>
<tr>
<th>Utility and Raw Material Costs</th>
<th>spec. Price</th>
<th>Cost Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>3964 kW-h/h</td>
<td>317.09 $/h</td>
</tr>
<tr>
<td>Steam</td>
<td>276732 kg/h</td>
<td>553.46 $/h</td>
</tr>
<tr>
<td>Cooling Water</td>
<td>16372 m³/h</td>
<td>327.45 $/h</td>
</tr>
<tr>
<td>Feed &amp; Chemicals</td>
<td>3252 $/h</td>
<td>3252.17 $/h</td>
</tr>
<tr>
<td>Waster Water Treatment</td>
<td>41 $/h</td>
<td>41.44 $/h</td>
</tr>
<tr>
<td>Product</td>
<td>5075 $/h</td>
<td>5074.91 $/h</td>
</tr>
<tr>
<td>PROFIT w/o maint., labour, depr., etc.</td>
<td>573 $/h</td>
<td></td>
</tr>
</tbody>
</table>

| Labour                        | 600 $/h    |
| Maintenance                   | 100 $/h    |
| Depreciation                  | 50 $/h     |
| Marketing/Sales/Transport     | 10 $/h     |

**PROFIT** -386.70 $/h
Here is our task for you!

Goal: Find the optimal set of design variables to generate maximum profit!

Approach:

1. We provide the flowsheets. Download them [here](#).

2. Change any of the unlocked design variables and examine their impact on profit.

3. Submit your design variables [here](#).

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1. Read the Detailed Model Description to
   - fully understand what was modeled in CHEMCAD
   - learn how biotechnology processes can be modeled in a flow sheet simulator, especially the metabolic reaction network, the cross-flow filtration unit op, and the thermodynamic models

2. Read the Step-by-Step Instructions if you are new to CHEMCAD or to the use of Data Maps in CHEMCAD