Model-based operator support for improved energy efficiency in viscose production

Results from the CoPro Lenzing use case

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LENZING Group
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The Lenzing Group 2017

- World market leader in man made cellulose fibers
- Sales: EUR 2.26 bn
- Fiber sales volumes: 1 Mio tons
- Employees: 6488

Innovative by nature
To maintain a certain spinbath composition and to extract the co-product Na$_2$SO$_4$

The Spinbath Recovery Cycle
The challenge with the evaporator network

A single evaporator at Lenzing
The challenge with the evaporator network

<table>
<thead>
<tr>
<th>Evaporators</th>
<th>Target output</th>
</tr>
</thead>
<tbody>
<tr>
<td>EV1 EV2 EV3 EV4 EV5 EV6 …</td>
<td>20 t/h</td>
</tr>
<tr>
<td>Cycle 1</td>
<td>15 t/h</td>
</tr>
<tr>
<td>Cycle 2</td>
<td>42 t/h</td>
</tr>
<tr>
<td>Cycle 3</td>
<td></td>
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### The Lenzing evaporator network
- 29 different evaporators
- 9 different product cycles
- Target evaporation output per cycle is fixed
### The challenge with the evaporator network

#### Evaporators

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<tr>
<td>Cleaning / Maintenance</td>
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#### Production constraints

- Only specific combinations are possible
- Each evaporator can only serve one cycle per time
- Cleaning and maintenance reduce the network availability
The challenge with the evaporator network

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- **Optimization potential**
  - Manual **load allocation** by operator based on experience is **complicated** and **time consuming**
  - Not shifting load to more efficient evaporators can **cost energy**
  - Hundreds of **various combinations** possible

- **Goal**: operation at **minimum overall energy consumption**
The Solution: Model-based Decision Support System (DSS)

For our operators in the control room to find the most energy efficient load allocation for our evaporator network

DSS Key Features:
1. Multiple data-based evaporator regression models
2. Optimization algorithm with live connection to process data in matlab
3. HMI for Visualization and settings in OSIsoft PI
Evaporator modelling

**Capacity** and **efficiency** depends on:
- Cycle flowrate $F$
- Flow temperature $T$
- Condenser temperature $T_K$
- Fouling

Data-based modelling approach
- Evaporation capacity
  \[ EC = a_1 T + a_2 F + a_3 T_{mk} + f_{fouling,1} \]
- Specific steam consumption
  \[ SC = b_1 T + b_2 F + b_3 T_{mk} + f_{fouling,2} \]
- Absolute steam consumption
  \[ AC = EC \cdot SC \]
Optimization task and constraints

**Simplified formulation as MIQP:**

\[
\min \sum_e \sum_i EC_{i,e} \cdot SC_{i,e}
\]

<table>
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<tr>
<th>Cycle i</th>
<th>Evaporator e</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>V1</td>
</tr>
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<td>x_{1,1}</td>
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<tr>
<td>2</td>
<td>0</td>
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Information and constraints from live process data

- Target EC
- State of every evaporator
  - Current load and allocation
  - Fouling and steady state
  - Max. EC
Modelling and network optimization

Data historian/ Process data

Data treatment

Process information

Least-Squares Optimization

Online analysis

Plant state

Constraints

Fouling state

Model parameters

Optimization

Results

Single run

Model structure

Decision Support Interface
HMI for the operators in control

Digitized Operations Workshop Frankfurt 2018
Results so far

- Advanced DSS implemented in control room August 2018
- 1.8 % more efficient operation
- Steam savings around 1200 t/month
- ≈250,000 €/year savings
- v2.0 update with semi automatic control currently under development
Thanks for your attention
DIGITIZED OPERATIONS for SUSTAINABLE PROCESS INDUSTRIES

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CoPro – LENZING Group

www.copro-project.eu
www.lenzing.com

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