### Optimum operation of an evaporator network in viscose fiber production

The table below shows the assignment of evaporators to different product cycles along with their evaporation capacity:

<table>
<thead>
<tr>
<th>Product Cycle</th>
<th>Evaporators</th>
<th>Evaporation Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td><img src="image1" alt="Evaporator A" /></td>
<td>60 t/h</td>
</tr>
<tr>
<td>B</td>
<td><img src="image2" alt="Evaporator B" /></td>
<td>41 t/h</td>
</tr>
<tr>
<td>C</td>
<td><img src="image3" alt="Evaporator C" /></td>
<td>15 t/h</td>
</tr>
<tr>
<td>D</td>
<td><img src="image4" alt="Evaporator D" /></td>
<td>20 t/h</td>
</tr>
<tr>
<td>E</td>
<td><img src="image5" alt="Evaporator E" /></td>
<td>33 t/h</td>
</tr>
<tr>
<td>F</td>
<td><img src="image6" alt="Evaporator F" /></td>
<td>5 t/h</td>
</tr>
<tr>
<td>G</td>
<td><img src="image7" alt="Evaporator G" /></td>
<td>90 t/h</td>
</tr>
</tbody>
</table>

### The problem

- Recovery of the spinbath is the process with the highest energy demand in viscose production.
- An evaporator network with 29 different evaporators is used for the reconcentration of the solution in different product cycles.
- The efficiency of the evaporators depends on the type, volume flow rate, temperature and fouling effects.

### The solution

- A decision-support system (DSS) for the assignment of evaporators to different product cycles was developed in a cooperation of Lenzing AG and TU Dortmund.
- The optimum operating strategy is visualised for the operator who can accepted or reject it.
- The optimum operating strategy is determined at regular intervals and the responsible person is provided with information about the possible savings.
Optimum operation of an evaporator network in viscose fiber production

The problem

The reconcentration of the spinbath: a complex and energy-intensive task

During the spinning process, water is introduced into the spinbath liquid due to chemical reactions. For the evaporation of the water from different product cycles, Lenzing AG uses a large network of 29 different evaporators. They vary in capacity, connectivity and energy efficiency. Furthermore, the energy efficiency of the evaporators changes over time due to fouling effects and varying operating conditions. By the choice of the best configuration of the evaporators for a given load and fouling state of the evaporators, significant amounts of energy can be saved. The task of the selection of the evaporators was previously handled by the operators based on their skills and experience.

The solution

Coordination of the evaporator network

As a support tool for the operator of the evaporator network a real time decision support system (DSS) was developed and installed in the control room of the plant within CoPro. The following steps are performed in the optimisation procedure before the result is shown via the human machine interface (HMI) of the DSS:

- Determine the parameters of the mathematical models of the evaporators
- Read process data from the OSI PI system
- Solve the optimisation problem
- Show the solution on the HMI

The optimisation algorithm is based on simple mathematical models of the evaporators. The operating behaviour of an evaporator can be described by the evaporator capacity, the specific steam consumption and the absolute steam consumption. The independent variables are the volumetric flow rate of the product cycle, the spinbath temperature, and the condenser temperature. 6 parameters are required for each evaporator model which can be obtained from measurement data by the use of a linear regression algorithm. For the determination of the model parameters, a graphical user interface was developed in a cooperation of Lenzing AG and TU Dortmund to simplify this time-consuming task.

The DSS uses four different software systems. The PI system contains the measurement data, MATLAB is used to set up and solve the optimisation problem, the PI ProcessBook realises the HMI which is used by the operator and the DCS is used for the control of the individual components in the production lines. The MATLAB optimisation is automatically triggered via the PI ProcessBook if certain conditions in a product cycle change (e.g. a change of the overall evaporation capacity). For the calculation of the optimum operating conditions of the evaporator network, constraints (e.g. the available evaporators) have to be considered which are available via the PI system. The result of the optimisation is displayed to the operator via a HMI in the PI ProcessBook. The operator has the possibility to check if the results are feasible and, if so, to accept them. Then the new set points for every evaporator in the cycles are automatically written to the distributed control system (DCS). (Fig. 1, 2)

To optimise the energy efficiency of the evaporator network, the total absolute steam consumption is minimised while fulfilling the evaporation capacity demand of each product cycle. The degrees of freedom are the set points of each evaporator and the allocation of the evaporators to the product cycles, which introduces integer variables. For a fast solution for large networks, the absolute steam consumption is approximated as a linear or quadratic function of the evaporation capacity.

Tests with the DSS during the operation of the evaporator network showed steam savings of up to 2 % depending on the load condition.

The summary

Improved operator support and energy savings

The Lenzing AG site, located in Lenzing, Austria, is a reference factory around the world for producing man-made cellulose fibers. These advanced fibers are broadly employed: from home textiles to medical and technical applications. In the resource and energy intensive viscose fiber production the recovery of the spinbath is one of the technical applications. In resource and energy intensive viscose fiber production the recovery of the spinbath is one of the processes with the highest energy demand. To ensure an energy efficient production process, a real time decision support system (DSS) for the operator of the evaporator network was developed and implemented in the control system of the plant. The test results showed a relevant potential for energy savings, especially at partial load conditions of the evaporator network.

The developers

Dr. Alexander Arnitz  
Process Engineering & Technology  
Global Utility & Infrastructure  
Lenzing AG  
4840 Lenzing, Austria  
a.arnitz@lenzing.com

Yannik-Noel Misz, M.Sc.  
Process Dynamics and Operations Group  
Department of Biochemical and Chemical Engineering  
TU Dortmund  
44221 Dortmund, Germany  
yannik.misz@tu-dortmund.de

Prof. Dr. Sebastian Engell  
TU Dortmund  
sebastian.engell@tu-dortmund.de

Dr. Thomas Röder  
Lenzing AG  
t.roeder@lenzing.com

Further information