Heat-exchanger systems in the viscose fiber production

LENZING AG operates the world largest fully-integrated viscose fiber production plant with a production capacity of about 284,000 t/year in Lenzing (Austria). LENZING’s viscose fibers are made from wood and their production is a multi-stage chemical-technological process. The key stage in terms of energy and resource efficiency belongs to the spinbath recovery cycle. The recovery cycle itself is a sequence of basic but energy-demanding operations (e.g. evaporation). These procedures are carried out in multi-unit networks which involve the spinbath passing through sets of heat exchangers to rise up its temperature either for water evaporation or for reaching the required setpoint after concentration recovery.

An efficient operation of such heat-exchanger systems in real time, as well as a suitable maintenance scheduling, are a key for the resource efficiency in the recovery section.

Overall system efficiency depends on the operation:
- Flows and temperatures affect the heat transfer.
- Fouling in the equipment reduces the heat transfer.
- Large combinatorial problem to find the more convenient allocation of sources to heat exchangers in real time.

Challenges

**Network operation**
- Eleven heat exchangers to heat up the concentrated spinbaths and four to heat up cleaning water.
- Four heat sources characterized by flow availability and temperature.
- Eight heat exchangers can switch the heat source (the spinbath streams are fixed).
- Reconfigurable network layout: possibility of parallel v serial stream connections.
- Spinbath temperature setpoints to be fulfilled.
- Ten heat exchangers to cool the heat sources before entering the waste-water treatment plant.
- Cooling sources also get a cost due to the operating cost of the cooling towers.

**Maintenance**
- Heat exchangers suffer from fouling due to deposition of organic material.
- Different cleaning procedures are possible to get rid of the fouling.
- Overall cleaning capacity is limited by available personnel.
- Fiber production is continuous, so the spinbath recovery needs to be so.

**Real-time network operation**
- Data-based model of the overall heat-transfer coefficient depending on flows and the current state of fouling.
- Model parameters are fitted by constrained regression to guarantee predictions with physical coherence.
- Hybrid continuous-discrete model to represent the network layout and all the operation possibilities.
- Real-time optimisation to allocate sources to heat exchangers.
- Mixed integer nonlinear formulation solved in ~1.5 min.
- Information on heat exchangers that are operating under reduced efficiencies. Cleaning suggestions.
- A dashboard with Excel interface has been designed to show the operators the relevant information.

**Networks**
- Fouled evaporator
- Clean evaporator

Remainder

**Mixed-integer and nonlinear optimisation in real time is now possible at industrial scale!**

- Process models are the core and their obtaining is the main bottleneck.

- Significant savings can be achieved by developing advanced control and optimisation tools to support plant operators, supervisors and managers.