Industrial Experience at Lenzing AG and Petronor

SPIRE Workshop
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Outline

• Introduction Lenzing AG
• Overview Lenzing Case
• MORE Experiences at Lenzing
• Overview Petronor Case
• MORE Experiences at Petronor
• Summary
The Lenzing Group 2014

- Sales: EUR 1,864.2 mn (2013: 1,908.9 mn)
- Export share: 92.3% (2013: 90.8%)
- Fiber sales volumes: 960,000 tons (2013: 890,000 tons)
- Staff: 6,356 (2013: 6,675)
- Listed at Vienna Stock Exchange, Prime Market (ATX)
- Major shareholders:
  - B&C Privatstiftung >50%
  - Oberbank AG >5%
Our core market: Man-made cellulose fibers

- Produced from the raw material wood
  - Halfway position between natural and chemical fibers
  - Natural wearing properties of natural fibers combined with the advantages of synthetical fibers such as purity and consistent quality
Lenzing/Austria 2015
297.000 t Dissolving Pulp
337.000 t Cellulose Fibers
TENCEL®, Modal®, Lenzing Viscose®
Overview Lenzing Case

Case 1.1.: Continuous optimization of actual energy consumption

- Optimize operation by the right settings of the available manipulated variables!
- Define REIs to be optimised
- DCS based solution preferred
- Fully automated
- Realized savings
  
  \[ 300\,\text{€/a} = 1.000.000\,\text{m}^3\,\text{nat gas/}\text{a} = 2700\,\text{t CO}_2/\text{a} \]
Overview Lenzing Case

Case 1.1.: Continuous optimization of actual energy consumption
- Definition of REIs
- Cleaning efficiency
- Modelling incl. fouling
- Optimizer Design
- Feasibility Study
- Savings: to be evaluated

Case 1.2.: Optimization of cycle time

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**Overview Lenzing Case**

**Case 1.1.: Continuous optimization of actual energy consumption**

- Optimize specific steam consumption in total evaporator network (30 Evaporators in 8 loops)
- Modelling, process control strategy, Optimizer, Visualisation, PIMS Implementation
- Savings: to be evaluated

**Case 1.2.: Optimization of cycle time**

**Case 2.1.: Continuous optimization of actual energy consumption (network)**

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<th>Cycle 2</th>
<th>Cycle 3</th>
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**Total Evaporation capacity**

- 5 t/h
- 8 t/h
- 9 t/h
Overview Lenzing Case

Case 1.1.: Continuous optimization of actual energy consumption

Case 1.2.: Optimization of cycle time

Case 2.1.: Continuous optimization of actual energy consumption (network)

Case 2.2.: Optimization of overall cycle cost of evaporator network

Combination of all applied to the entire network:

- Which evaporator shall be operated at which load in which loop best at optimized cycle time?
- Feasibility study
- Savings: to be evaluated
What shall be optimized?

- Think about influences and impacts, feasibility?
- use REI methodology \[ \rightarrow \text{MORE REI – Guideline!} \]

Examples

\[
REI\ 1.1.1 = \frac{\text{actual steam consumption, } t/h}{\text{actual evaporation capacity, } t/h}
\]

\[
REI\ 1.1.2 = \frac{\text{best specific steam consumption } \times \frac{t}{t}}{\text{current specific steam consumption } \times \frac{t}{t}} \times 100\%
\]

\[
REI\ 1.2.1 = \frac{\sum \text{total cost, } €}{\text{cycle time, } h} \bigg|_{\text{evap.cap.}}
\]

NEW!
Availability of information?

- Suitable design of visualization
- on suitable platform
- to the relevant people!

→ MORE Visualization – Guideline!
→ IntexcSuite, PIMS
Make the right decision!

- decision support system
- Implementation of model based optimization methods ➔ UVA, TUDO

Examples:
- static grey box model Evaporator 38: UVA
- fouling model: UVA
- Optimization of one cycle: UVA
- Feasibility study cycle optimization: UVA
- static black box model Evaporator: TUDO
- Optimization of actual steam consumption in evaporator network: TUDO
Grey Nonlinear Model (UVa)

- First principles based stationary mathematical model

Psychrometric conditions. Energy and mass balances. Spinbath C-P-T equilibriums.

Heat transfer to ambient.

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Results for line EV.40

- **Instantaneous RTO:**
  
  **SOLUTION:**
  - Maximum spinbath temperature
  - Minimum circulating flow

- **Already implemented**

  **SOLUTION:** BIG CLEANING
  
  Cleaning in 24 days, 16 h, Update control each 6h
  **Solver time < 1 min** (Intel® Core™ i7-4510 CPU)

- **Cleaning prediction:**

  ![Cleaning prediction graph]

  **Specific steam consumption**

  ![Specific steam consumption graph]

  **Unitary cost (€/h)**

  ![Unitary cost graph]
Petronor: Oil refinery

- Largest site in Spain: production of 11 Mi T/year
  Bilbao

- 945 fixed employees

- 6200 induced jobs
Motivation

- Hydrogen $H_2$ is an expensive utility, very important in the refinery global economic balance.

- $H_2$ requirements have experienced a steady increase in recent years:
  - heavier fuels are processed;
  - more strict environmental regulations;

- $H_2$ production capacity is a bottleneck for oil processing capacity.

- $H_2$ consumption can experience frequent significant changes (feedstock usually changes every 2-3 days)

Goal: Increase efficiency in $H_2$ use in the refinery
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Definition and computation of REIs

- REI 1. Intensity

\[ \text{REI}_1^{\text{Intensity}} = \frac{\text{pure } H_2 \text{ consumed in reactor (Nm}^3/\text{h})}{\text{hydrocarbon processed (m}^3/\text{h})} \]

- REI 2. Efficiency

\[ \text{REI}_1^{\text{Intensity}} = \frac{\text{sum of pure } H_2 \text{ produced (Nm}^3/\text{h})}{\text{sum of hydrocarbon processed (m}^3/\text{h})} \]

- REI 3. Relative Efficiency (compared to best case)

  - Reference is obtained by solving an optimization problem with a material balance model of the H\(_2\) network.

\[ \text{REI}_3^{\text{REI}_{\text{Efficiency}}} = \frac{\text{sum of minimum required material nonpure } H_2 \text{ produced (Ref.)}}{\text{sum of actual material nonpure } H_2 \text{ produced}} \]

- REI 4. Operational Efficiency (secondary REI with operational purposes)

- REI 5. Controllability Efficiency (secondary REI with operational purposes)

  - Use of REIs for Network on-line Decision Support purposes
Optimal management of H₂ network

Producer units: STEAM-REFORMING FURNACES
H₂ byproduct: CATALYTIC PLATFORMERS
Consumer units: HDS, HDT

Which plants must produce H₂ and their Production rates?
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- **CHALLENGES**: an accurate plant state estimation is difficult.
  - Great variability for H₂ consumption in HDT hydrotreating plants:
  - Lack of on-line measurements for H₂ purity and gas molecular weight MW.
  - Error prone Orifice-Plate Differential Pressure flowmeter. Drift error due to:
    - Great influence of variability in light ends composition over total gas MW
      - Uncertainty unless both H₂ purity and gas MW are measured.

- PRECISE ONLINE COMPUTATION OF REI’s WAS NOT POSSIBLE

- EXPECTED BENEFITS around 2-4% in opportunity for profit in operation due to frequent changes in scenarios
Data reconciliation is used to provide consistent estimates:

- **Simplified solubility model** to determine the item *(MP/LP purges)*
- Disregard flowmeters with **gross errors** persistent in time.
- **Estimate H₂ consumption in reactors** according to FI/AI measurements.

Real-time optimisation tests to compute REI 3 *(outline for the moment)*

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**MORE Experiences**

**REI 1 - Intensity**

- HD3 - pure H₂ cons/Hydrocarbon

**REI3 - Relative Efficiency**

- NET - Min non pure H₂ prod/Actual non pure H₂ prod
- Min non-pure H₂ / Actual non-pure H₂
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- **A What-If analysis** regarding REIs is available in simulation

  - **Process**
    - **Data Acquisition** (SCADA + Excel®)
    - **Data Treatment** (EcosimPro®/Excel®)
    - **Simulation** (EcosimPro®)

  - **Optimization** (SNOPT®/IPOPT®)
    - Decision variables: \( u \)
    - Cost function: \( J \)
    - Constraints: \( g \)

  - **Simulation** (EcosimPro®)

REIs for off-line Decision Support

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• A **DMC controller** has been **commissioned** and is in operation
  – Deals with the **main source of inefficiency** in the H$_2$ network operation
  – **Complementary to the RTO** approach
  – Built upon other MPCs managing the operation in each consumer plant
Summary

• SUITABLE RESOURCE EFFICIENCY INDICATORS have been defined.
• SUITABLE CLOSED-LOOP SOLUTIONS have been developed and are already online and working!
• DECISION SUPPORT SYSTEMS have been designed and are in development.
• SAVINGS ARE ACHIEVED: LENZING: around 1.5 MioNm3/y of natural gas and 300 k€/y, PETRONOR: around 1.5% high-purity H$_2$ consumption)
  ... and more are expected!
• MORE IDEAS and EXCELLENT NETWORK OF PARTNERS responsible for achievements
End