Process simulation of pulp mills and biorefineries
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Our approach – full-mill process models

- Allows complexity and detail without losing overview
- Can be developed gradually to focus on current issues
- Based on > 10 years experience and incorporation of sub-models from our research work
Typical questions that can be answered with full-mill process models

- Where do Na, S and non-process elements go?
- Where is energy used and wasted?
- How will closure options affect chemical balances, organics to effluent?
- Where are the risks for precipitating salts?
- How can we optimize purge streams?
- How would the installation of a new process affect mass and energy balances of the mill?
- How can we improve our use of secondary heat and minimize cooling needs?
- What flow meters can we trust?
- …?
Theoretical mills are defined with major unit operations, mass and energy flows
But don’t forget that Non-Process Elements (NPEs) are important too!

- Scaling problems (Al, Si, Ca, Ba, Mn)
- Plugging in the recovery boiler (K, Cl)
- Corrosion (K, Cl)
- Inerts in lime cycle (P, Mg, Al, Si)
- Peroxide bleaching (Mn, Fe, Cu)
- Environment (N, P, Cd, Pb, etc.)
Much detail hidden in the full-mill models

**Mass balances**
- Flow and fibre
- Na, S, K and Cl
- COD
- NPE (Ca, Mg, Mn, Ba, etc.)
- Organic compounds
  (Lignin, Hemi, Xylan, etc.)

**Energy balances**
- Steam
- Secondary heat
- Power
Mill configuration described in WinGEMS
Biorefinery options modeled in UniSim

- AIR SEPARATION
- GASIFICATION/ GAS AND GREEN LIQUOR COOLING
- GAS CLEAN-UP AND CONDITIONING
- COMBINED CYCLE
- MeOH/DME
- FISCHER-TROPSCH
- MILL STEAM SYSTEM
Applications for the full-mill models

Optimization of the process

Simulation model

Bench-marking

Trouble shooting

Evaluations of new equipment or new process strategies

Evaluation of implementation of new sub-processes
Example: Benchmarking

Electricity consumption

kWh/ADt

Woodyard | Digester | Bleachplant | Evaporation | Water distribution

Reference mill
Type mill
Mill A

Electricity consumption

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Berglin - Process simulation
Example: Benchmarking

Key parameters

- Water consumption
- COD load
- Electricity production
- Electricity consumption

- Reference mill
- Type mill
- Mill A
Example: New process
Example: Integration of new process

- Methanol and DME are simple molecules that can be synthesized with high selectivity

- Fischer-Tropsch gives mixture of products

\[ \text{CH}_3\text{OH} \]
\[ \text{CH}_3-\text{O-CH}_3 \]
Example: Integration of new process

Calculated Distillation Curve for Hydrocracker Product

- ASTM D86 °C

Boiling Point (°C)

- Naphthta
- Diesel

Mass Percent

- 180°C
- 285°C
- 295°C
- 320°C
- 360°C
Bio-DME plant starting up fall of 2010
Thank you!