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On-line simulation with Modelica

in a Simulink environment

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- Why *Modelica*?
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Introduction

Modeling and simulation are valuable tools that contribute throughout the lifecycle of any industrial process

- Process Design
  - It can be used during feasibility studies to quantify process parameters
  - It can be used to test concepts and designs

- Existing processes
  - It can be used to determine the impact of modifications
- Process Control
  - Useful tool for testing and commissioning of base level control
  - Modeling provide useful basis for development of advanced control systems
    - reduce time of development, reduce time of commissioning and reduce risk by using offline

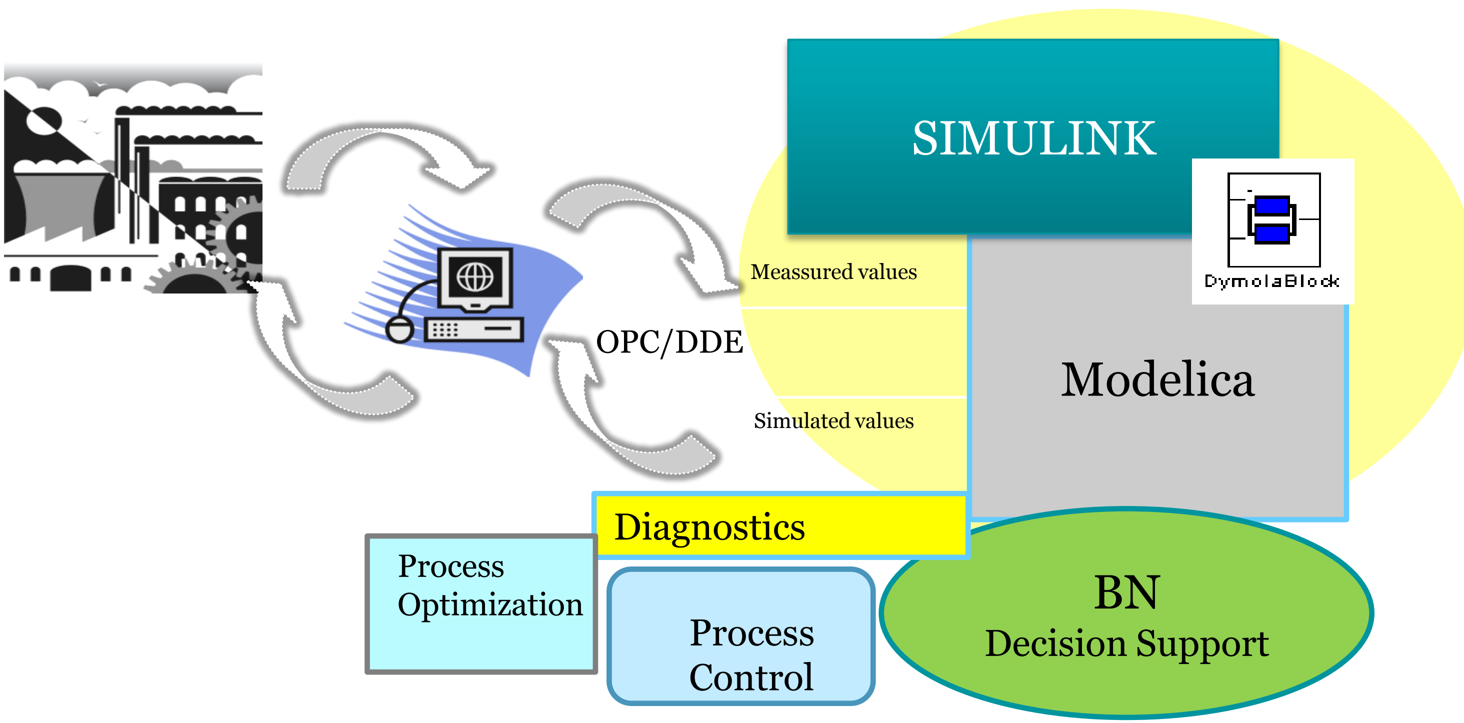
- Process Optimization

- Training
- Diagnostic

Introduction
Application development

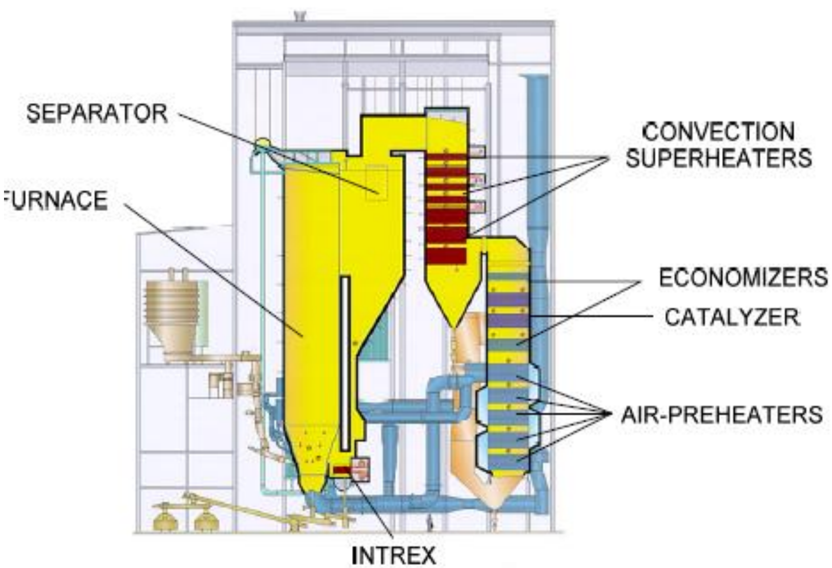
- Dynamic model using Modelica language
- Model validation
- Connection to process database, on-line

Introduction
Application Overview

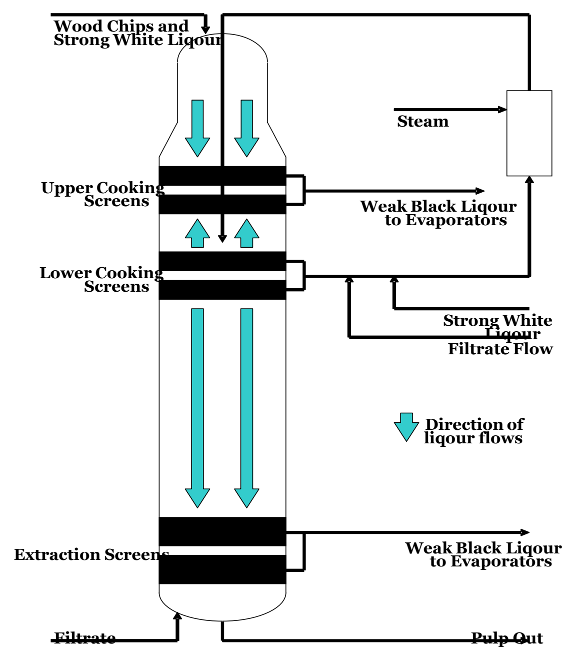


Introduction
Running on-line at…

Power Boiler



Pulp Digester



Why Modelica?

- Acausal modeling
  - Reuse of classes
- Modeling dynamic physical systems feels easy
- Dynamicity by differential equations, avoid complicated loops

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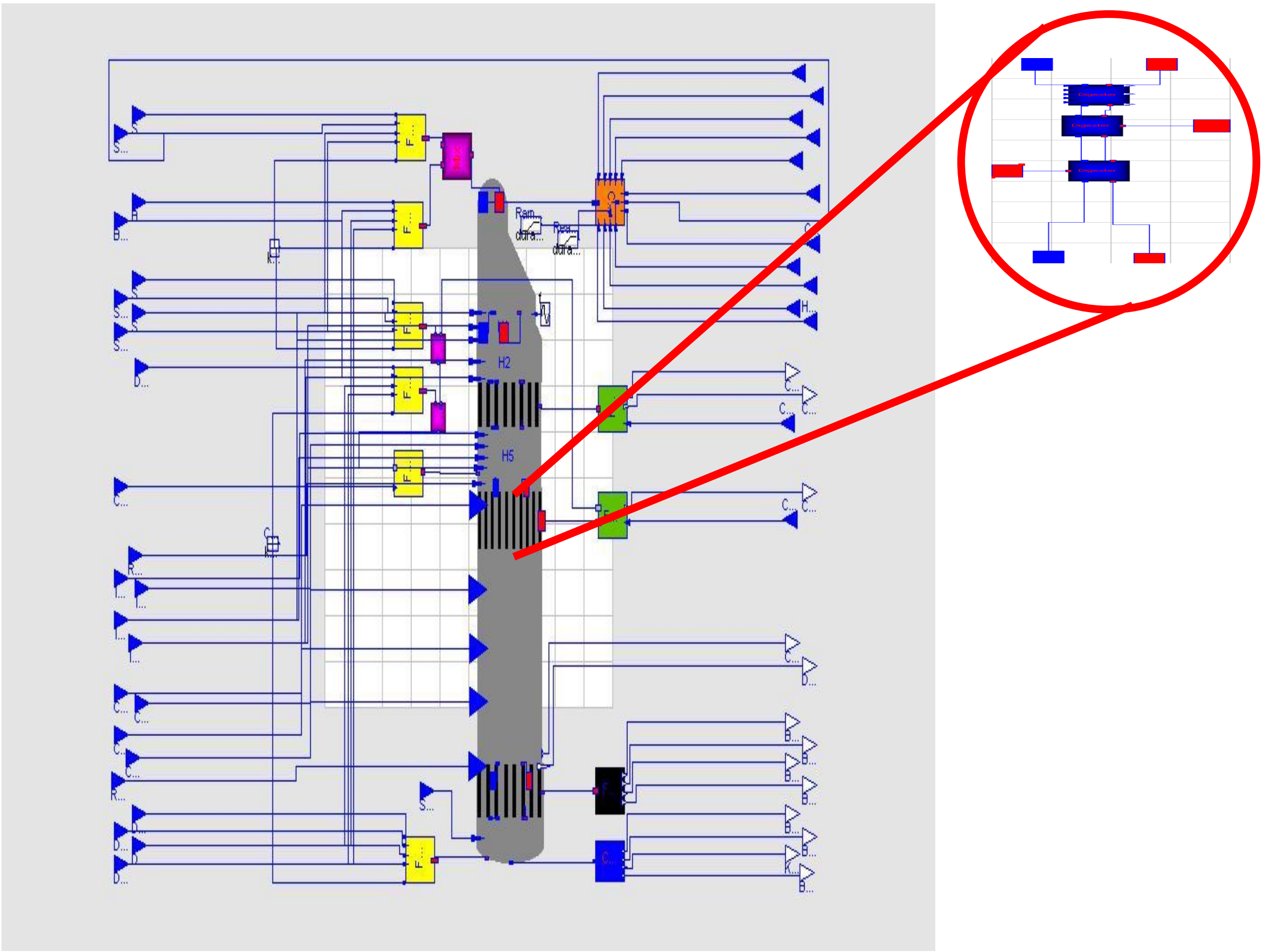
Why Modelica?

*der(outlet_chip_concentration[Dissolved_organics_reference]) = (inlet_chip_volumetric_flowrate*inlet_chip_concentration[Dissolved_organics_reference] - outlet_chip_volumetric_flowrate* outlet_chip_concentration[Dissolved_organics_reference] + reaction_rate[Dissolved_organics_reference])/chip_inventory;*

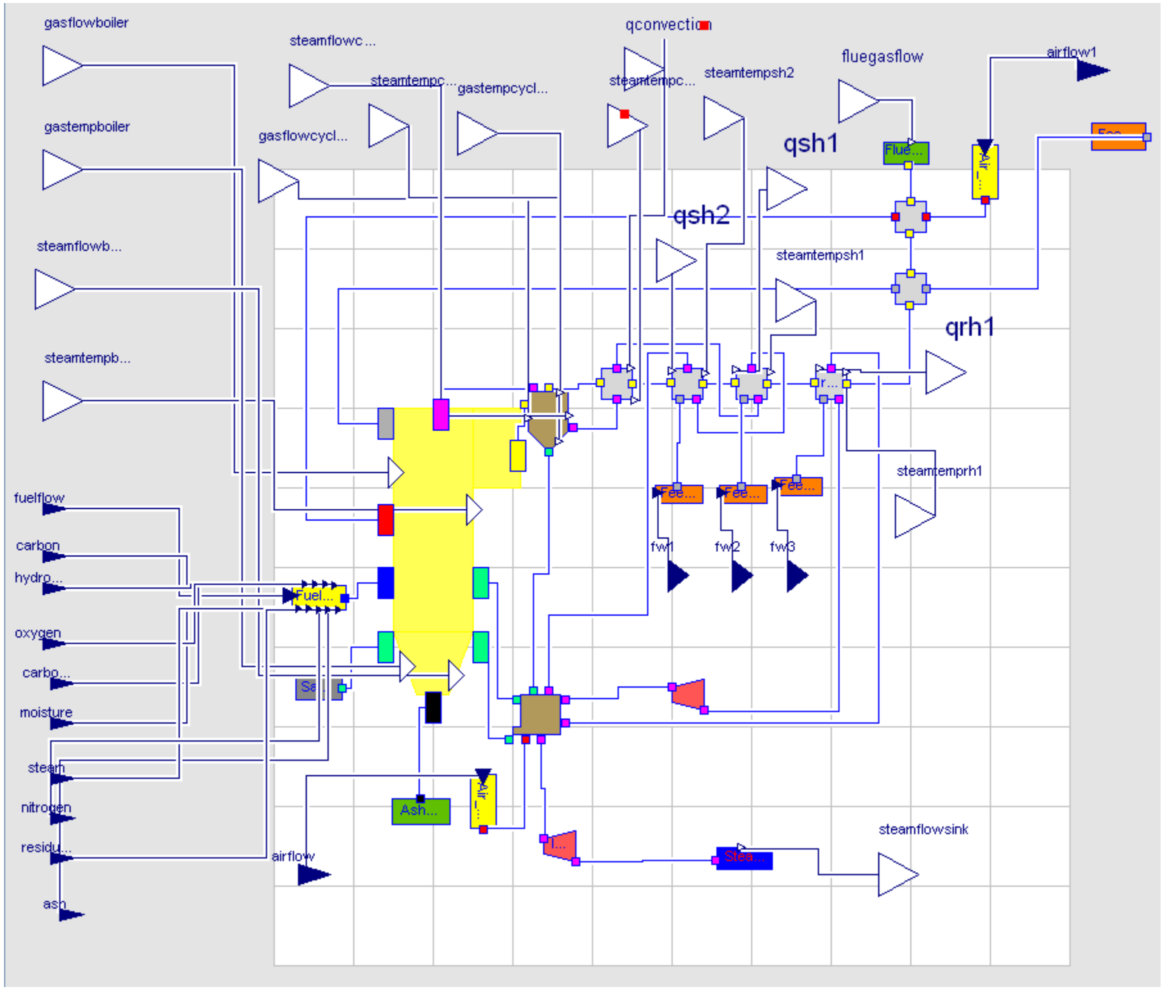
Why Dymola?

- Graphical interface
- Open Modelica in mind but still more difficult to work with for process engineers (more for computer scientist today)

Why Dymola?
Continuous digester



Why Dymola?
CFB Boiler



Why Simulink?

- Control the signal processing between simulator and process database
- Easy to embed compiled Modelica model
- Graphical interface
  - Drag and Drop

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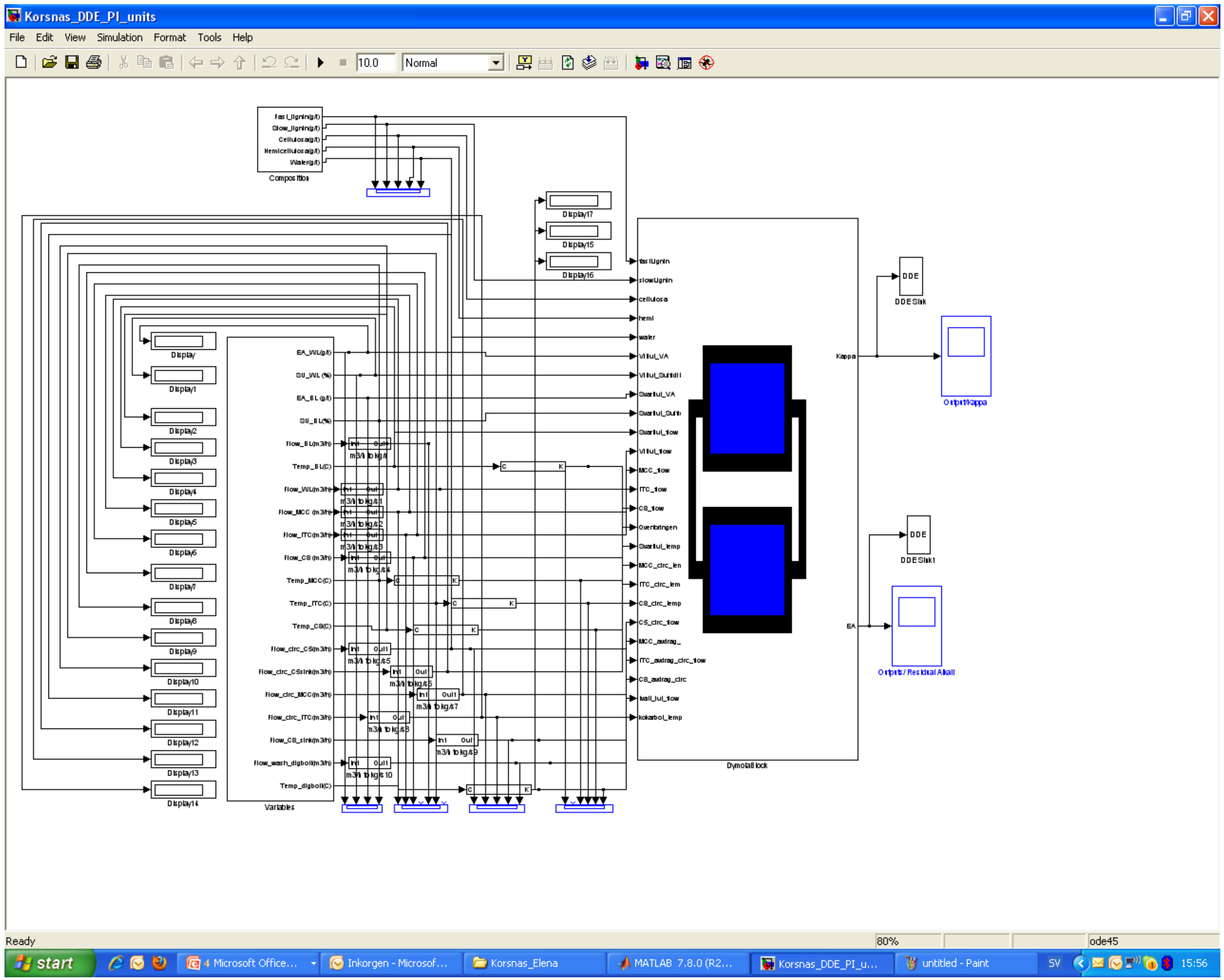
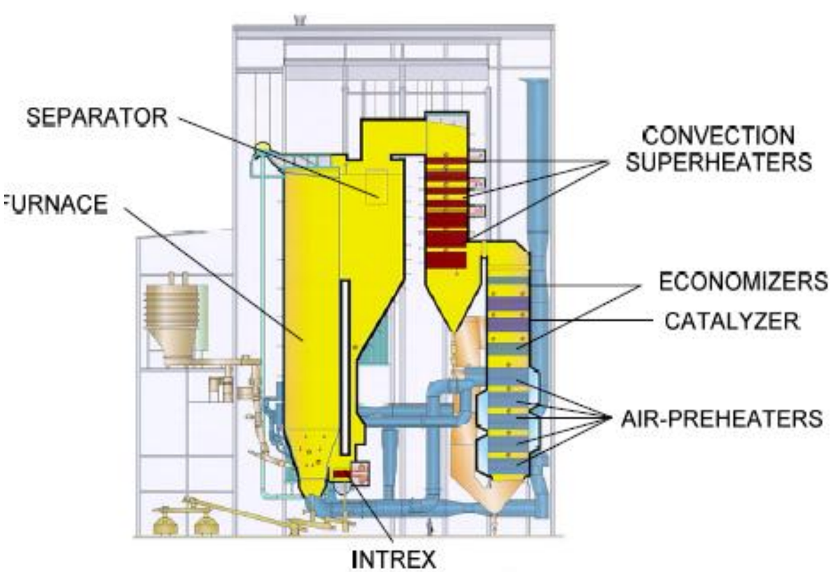
Why Simulink?

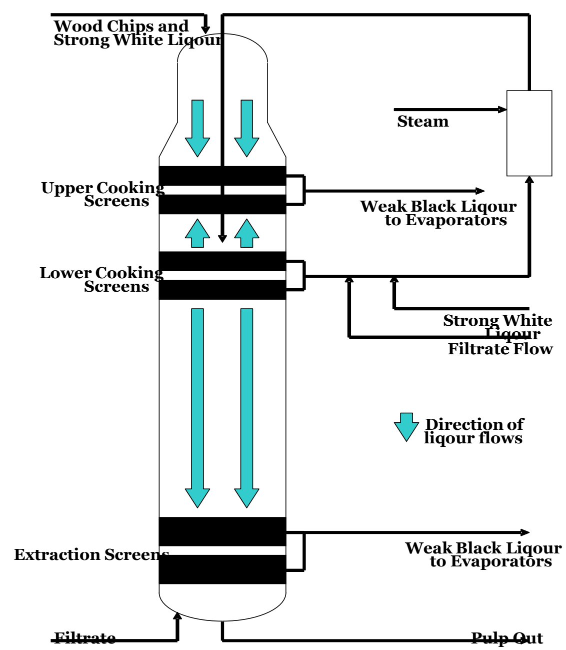


Applications Running on-line at…

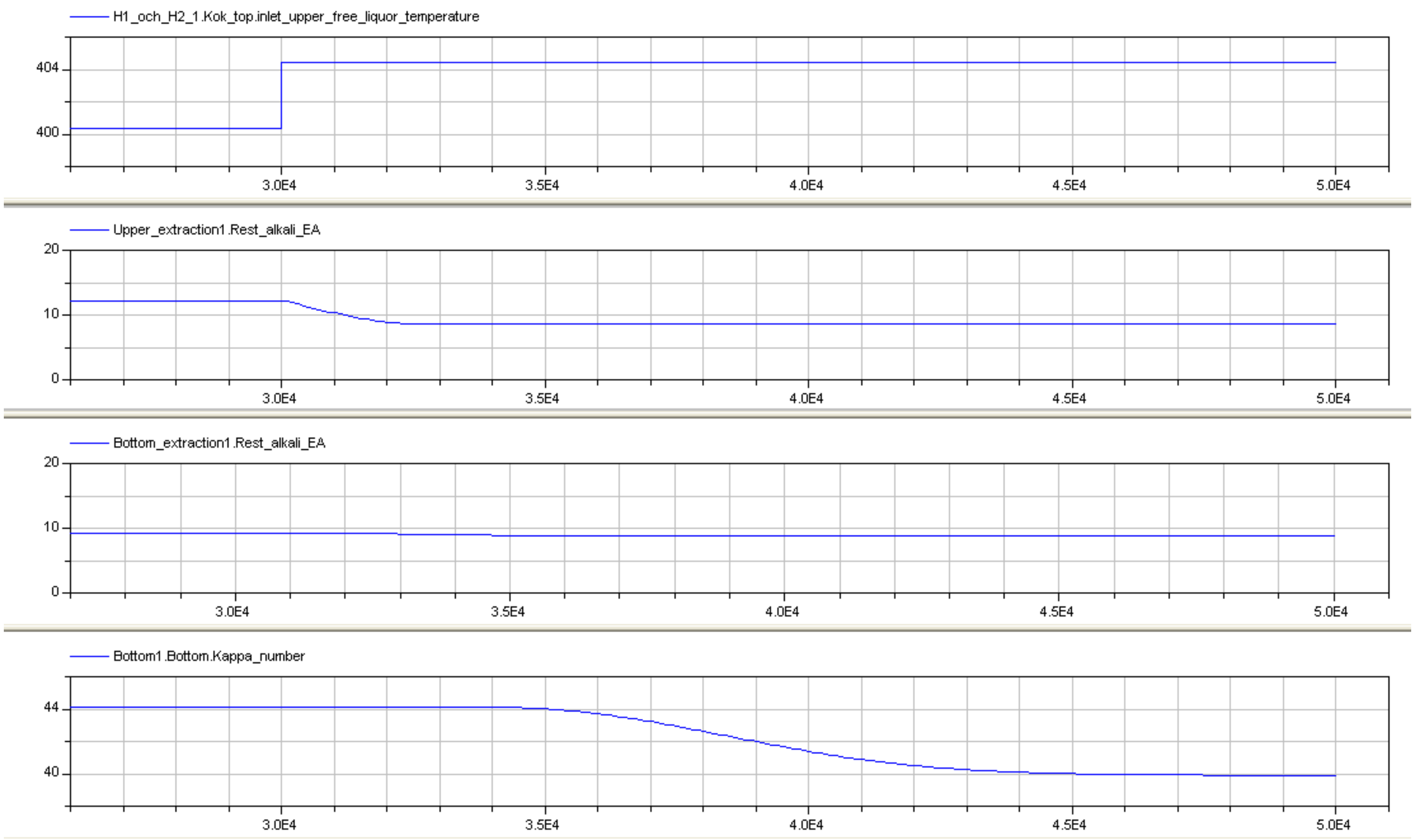
Power Boiler



Pulp Digester



Validated towards process data-
step change in feed temperature



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Validated towards process data

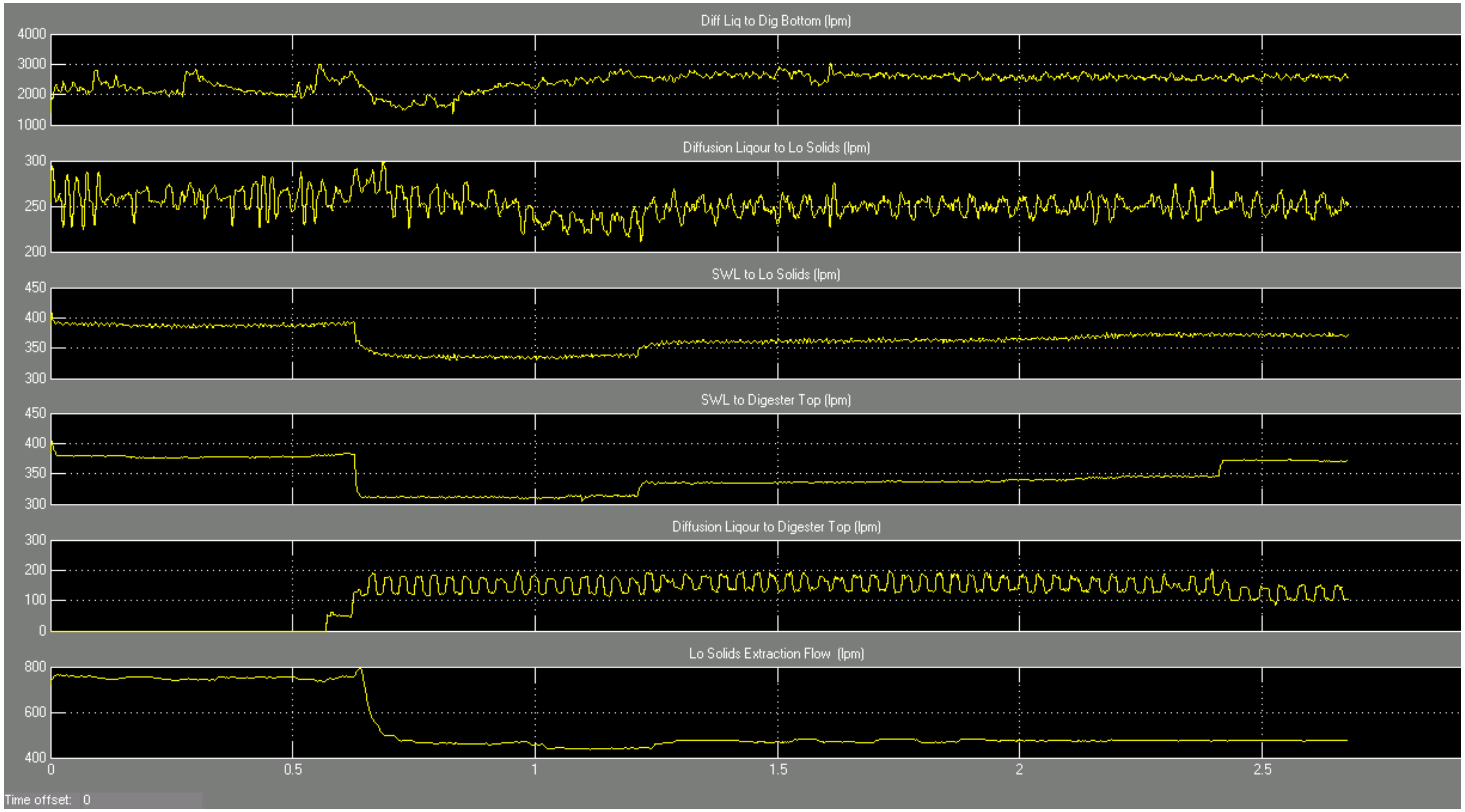
C5 EA (g/L)	EA average (g/L)	Kappa	Kappa average
12.4	13	42.9	47.7
11.4	12	46	48.1
11.7	12	47.5	49.4
11.2	12	49.8	49

Control Purposes

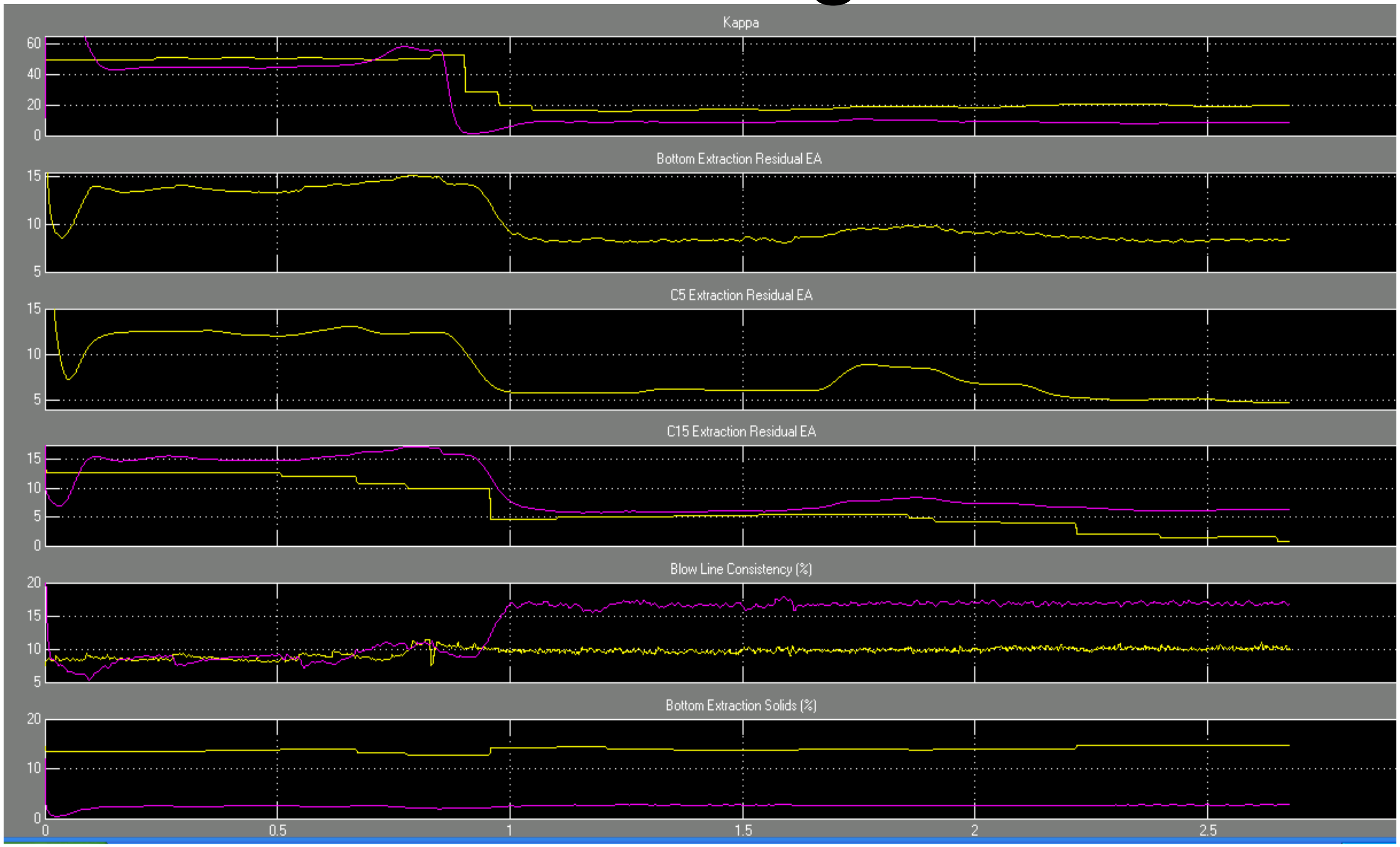
- Simulation results of the quality and chemical consumption during a wood species swing show that reducing the chemical addition at an earlier will improve quality as well as save chemicals.

- The simulations also show that it is necessary to ramp the temperature decrease faster to avoid the dip in the kappa that is caused by the difference in velocity and reaction rate between species (due to difference in density).

Process behavior during a swing



Process behavior during a swing



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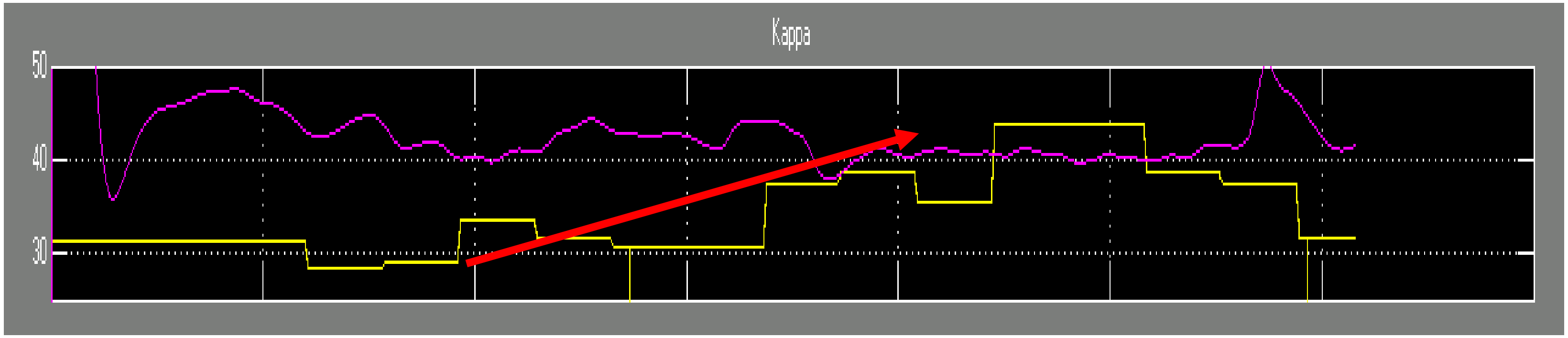
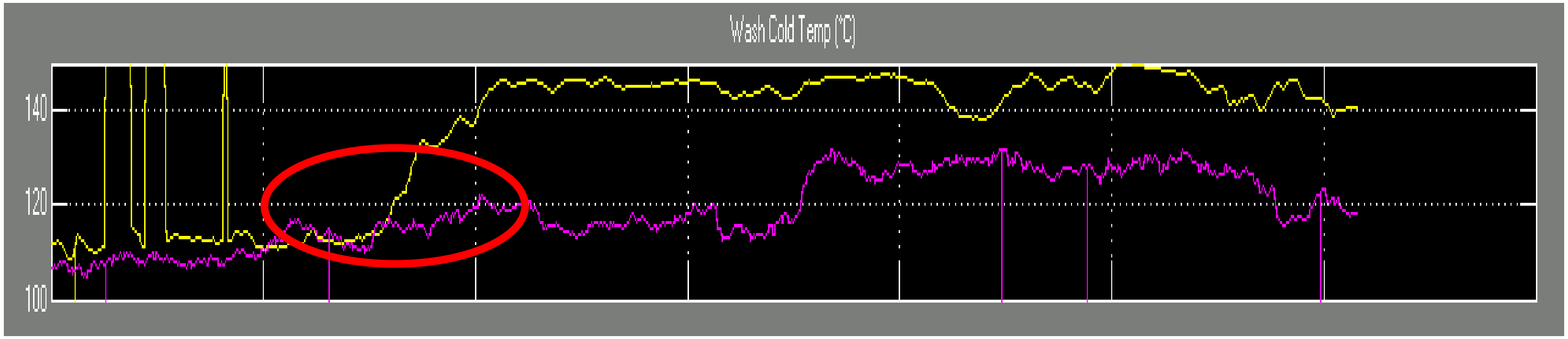
Diagnostics purposes

- To predict upsets early to take necessary actions to avoid them will make the quality variations smaller saving chemicals and energy usage.

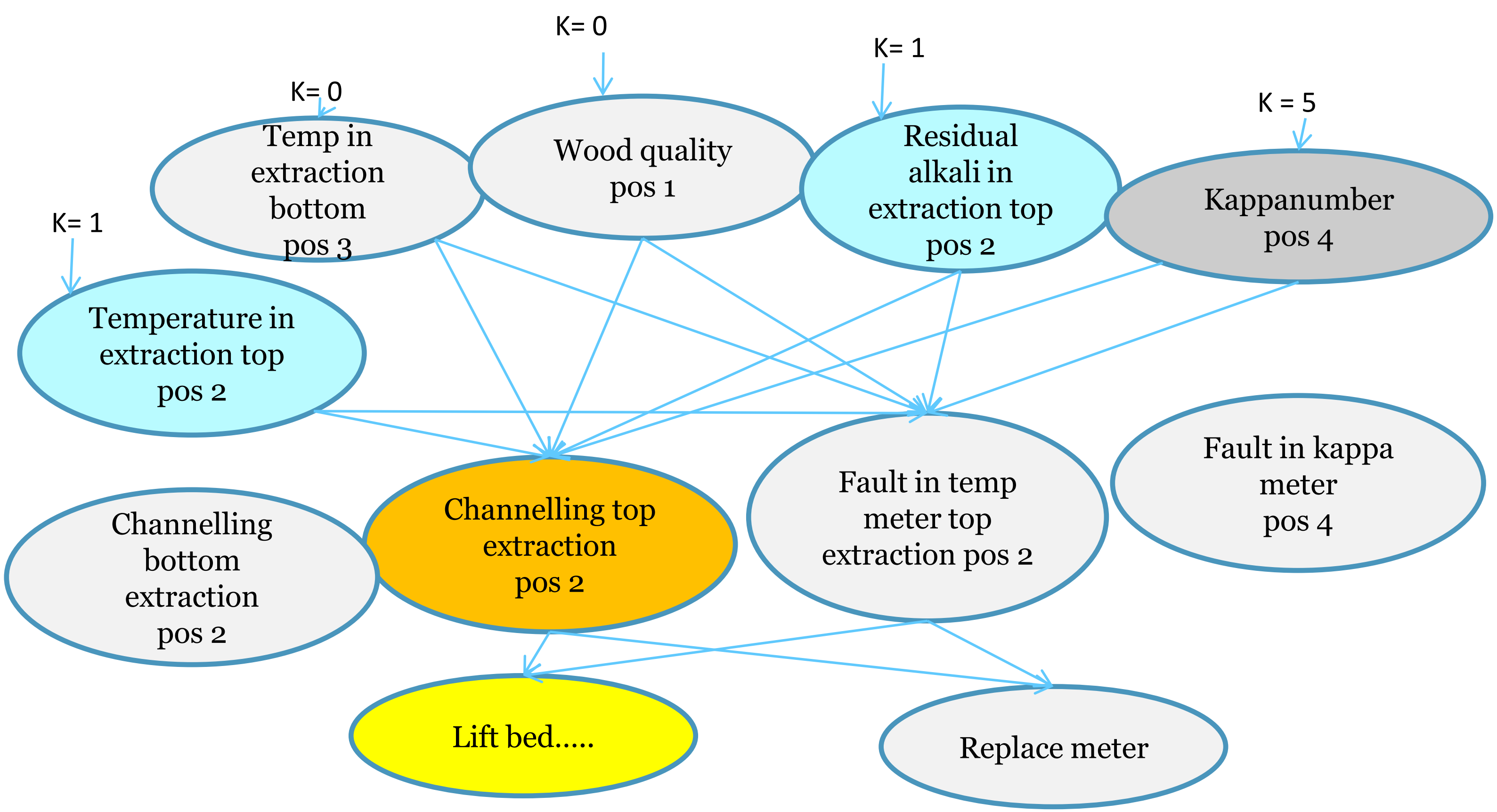
- A good on-line simulation tool will indicate if it is instrumentation or process problem. The output will be used as decision support for the operators.

Detection of problems





BN for decision support



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Ongoing work

- Model improvement
- Work towards model validation
- Addition of features like NIR-meter
- Bayesian Network model

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Thank you!

Questions?

Fiberline optimization

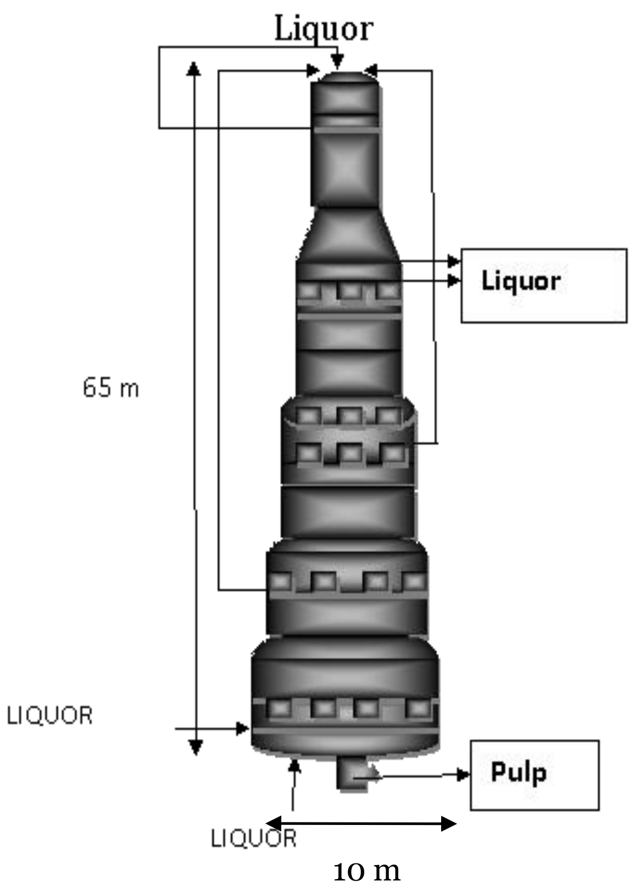
$$\frac{\partial m}{\partial t} = \sum_{i=1}^{i=n} \dot{m}_{in}(i) - \sum_{i=1}^{i=n} \dot{m}_{ut}(i)$$

$$\frac{\partial c,i}{\partial t} = \frac{\left(\sum ci \cdot \dot{m}_{j,in} \cdot \sum ci \cdot \dot{m}_{k,ut}\right)}{m_{inventory}}$$

$$\frac{\partial T}{\partial t} = \frac{\left(\sum T_j \cdot \dot{m}_{j,in} - \sum T_k \cdot c_i \cdot \dot{m}_{k,ut}\right) + \Delta H - U \cdot A \cdot \left(T_{block} - T_{utsida}\right)}{m_{block} \cdot \left(\sum c_i \cdot cp_i\right)}$$

dL(i)/dt = reactivity_const*$[OH^-]^{0.5}[HS^-]^{0.5}$*exp(A-B/T)

Applications
Continuous digester



<u>Steps:</u>
Impregnation
Cooking
Washing

<u>Reaction rate depends on:</u>
Temperature
Chemical concentration
Geometry (of chips)
Chemical composition of the wood