Process Systems Engineering for the sugar industry: concept and applications

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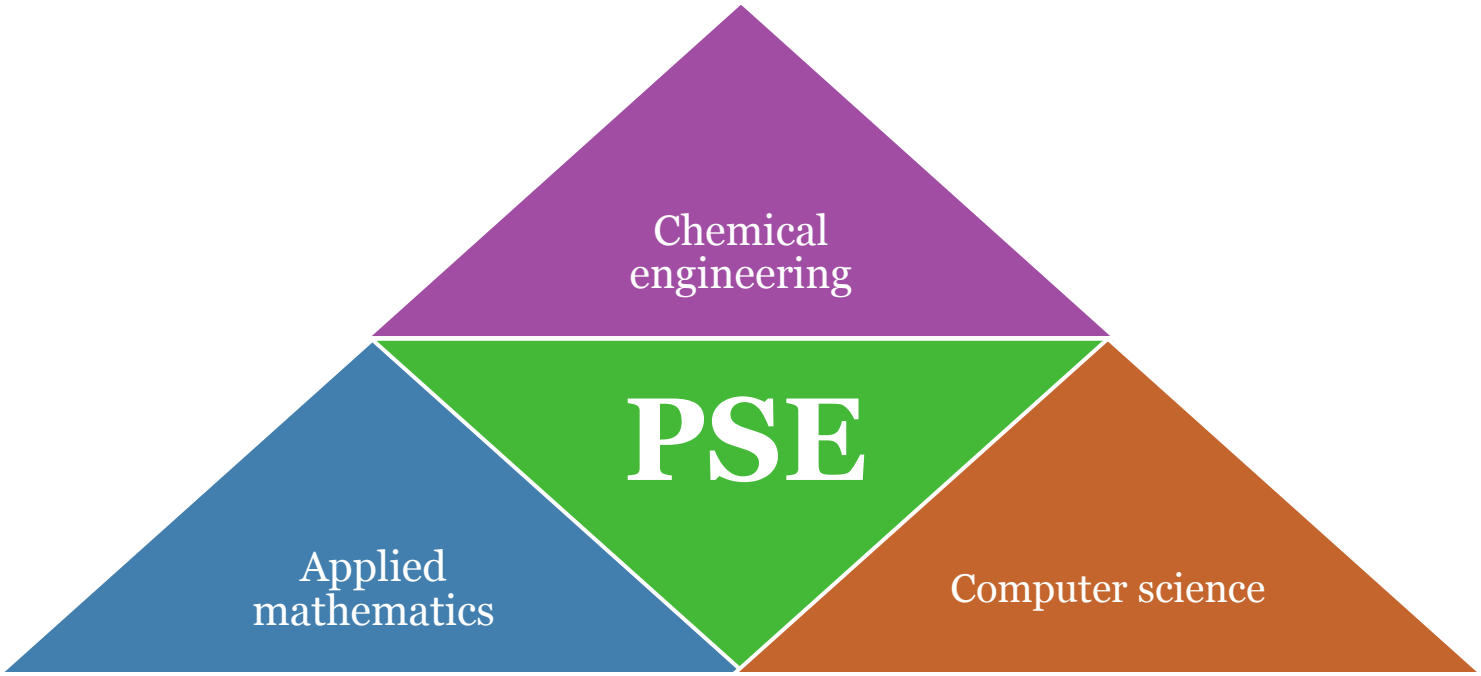
LSU AgCenter Research & Extension

Overview

- What is Process Systems Engineering (PSE)
  - Generalities
  - Process models
- PSE's Activities
  - Simulation
  - Process control
  - Process optimization
  - Planning and scheduling
- Conclusion

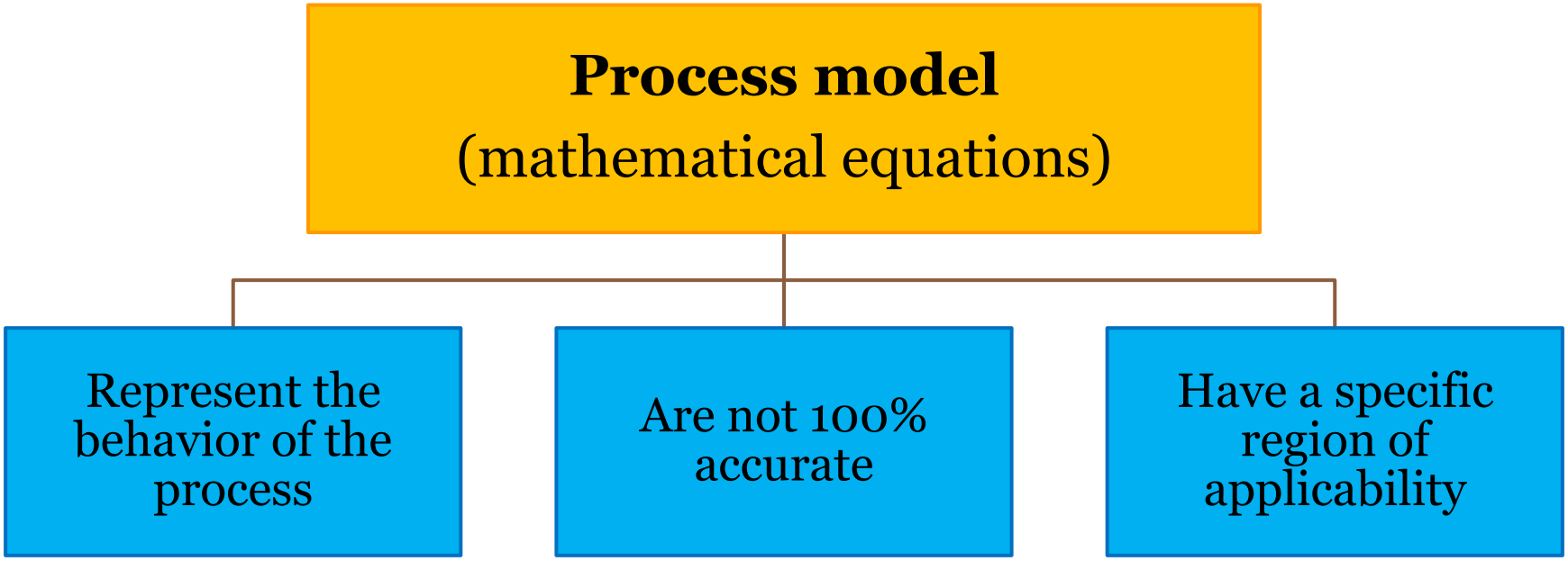
Process Systems Engineering (PSE)

Planning, design, operation and control of physical, chemical and biological processing operations



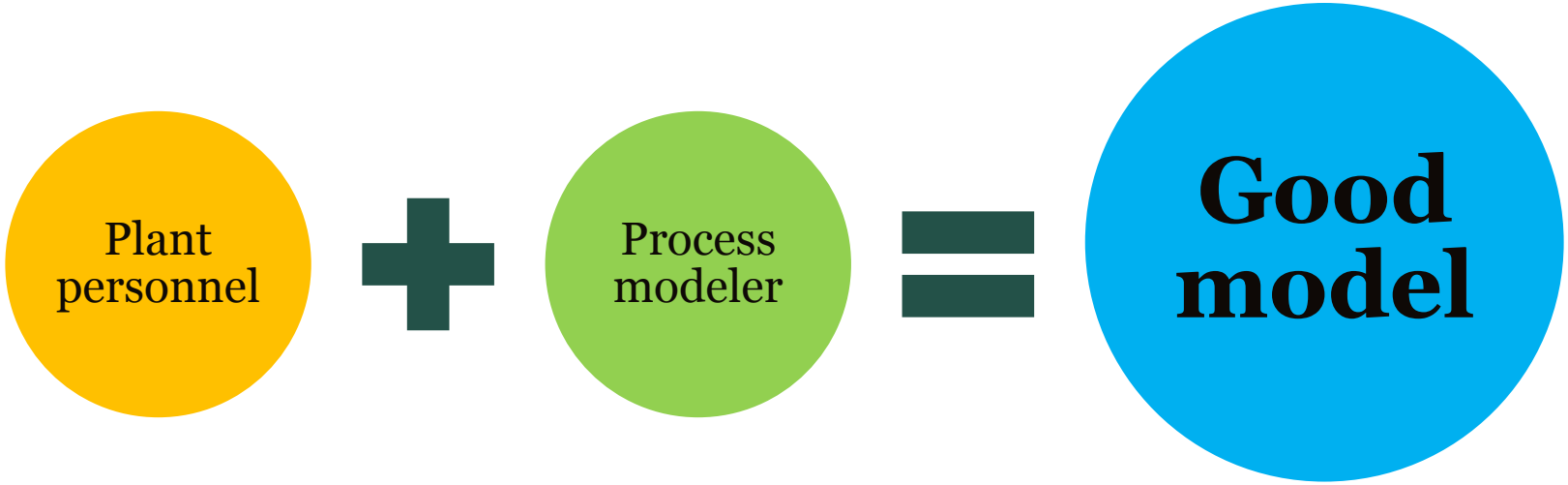
Process Systems Engineering

Mathematical modeling of the individual components in a system and **their interactions**, is the essential element of all modern PSE activities

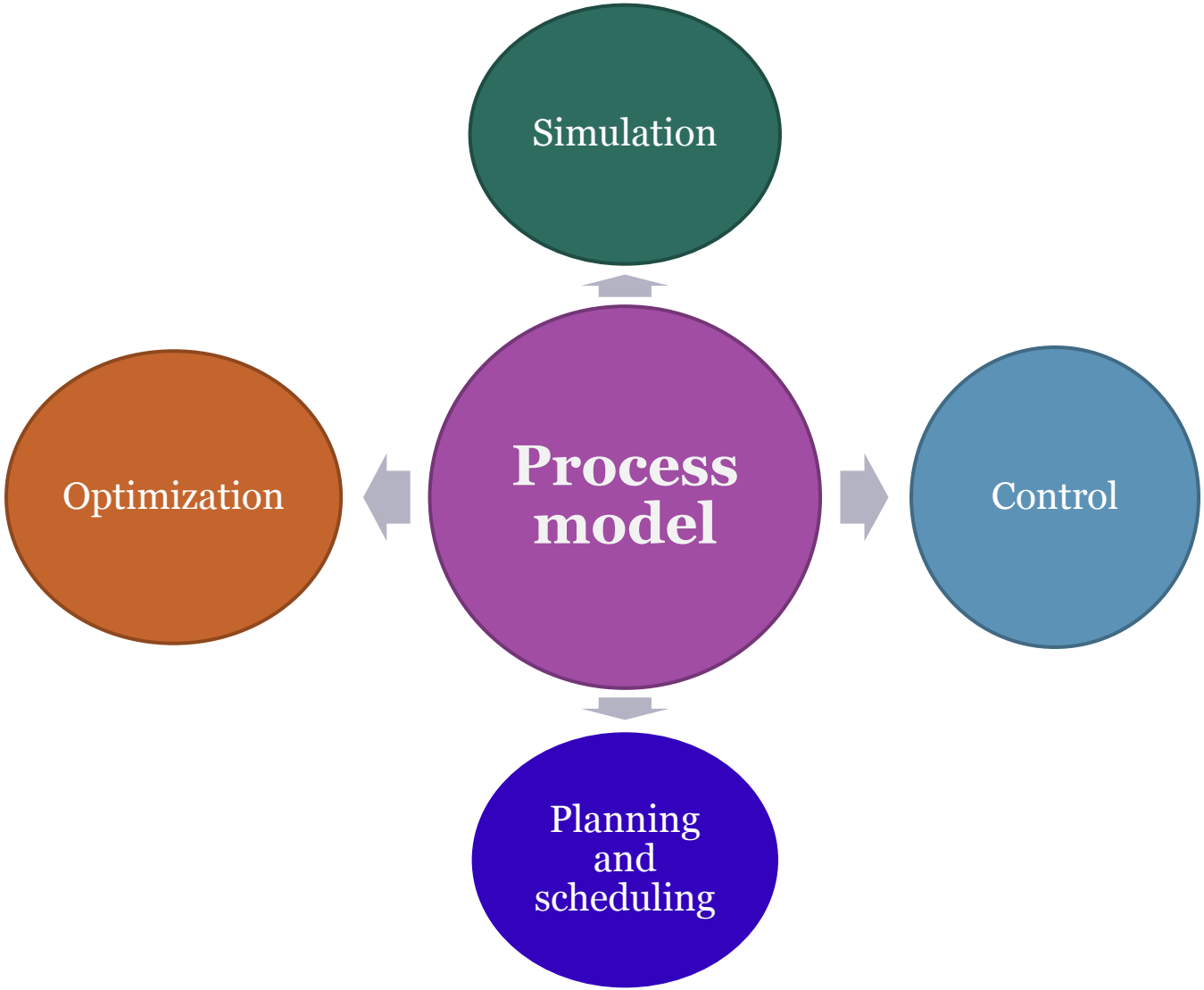


Process Systems Engineering

A good model has the **required accuracy** and **gives answer** to the problem stated by the purpose of modeling



PSE's Activities



Simulation

Use of a process model to obtain a response given certain input values

Cane
Ton/day
Pol
Fiber
…

Solution to model equations

Filter cake
Ton/day
Pol
…

Applications: operator training, factory balances, new equipment installation, evaluating changes in operative conditions, …

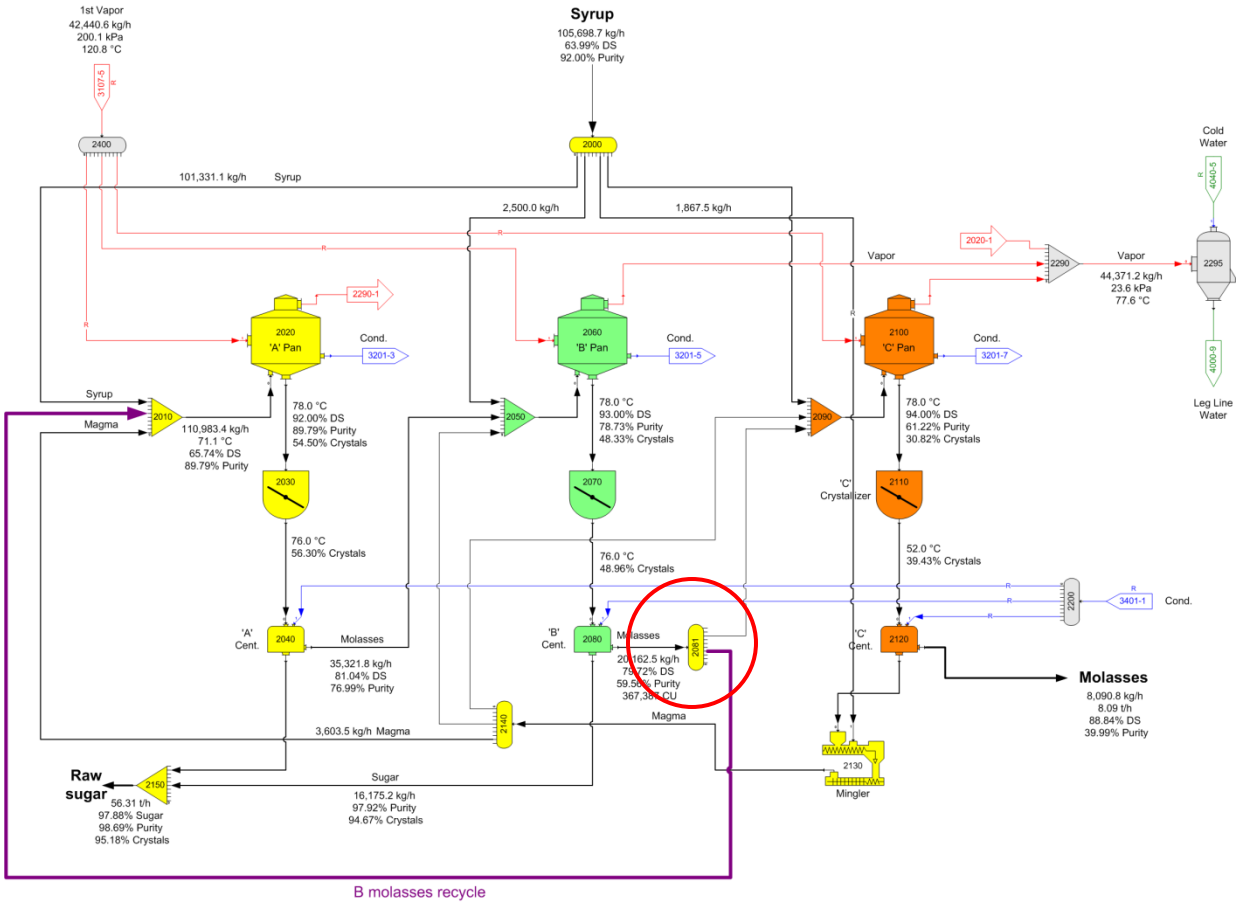
Simulation can reduce costs and risks from experimentation

Simulation Example

- Changes in process conditions in sugar boiling operation
  - Three boiling scheme
  - Syrup purity changes from 85% to 92%
  - What is the change in final molasses purity?
  - How does final molasses purity changes when recycling B molasses into A pans to reduce syrup purity?
  - Model created in Sugars™

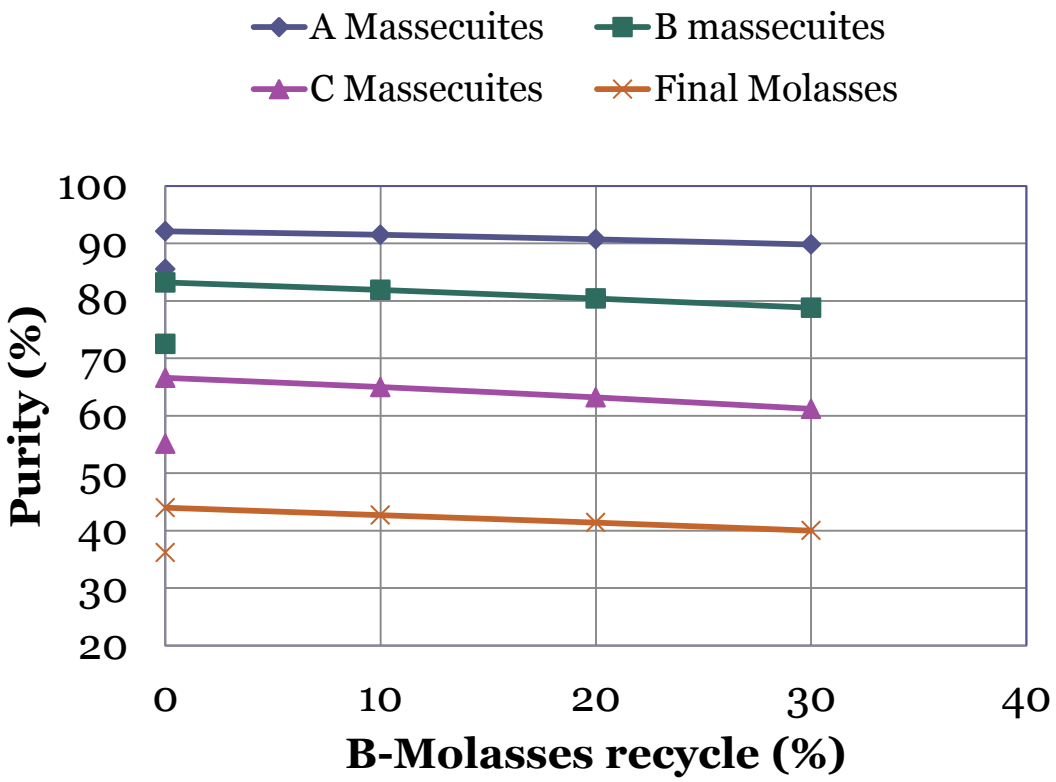
Simulation Example

Three boiling scheme with B molasses recycle into A pans in Sugars™



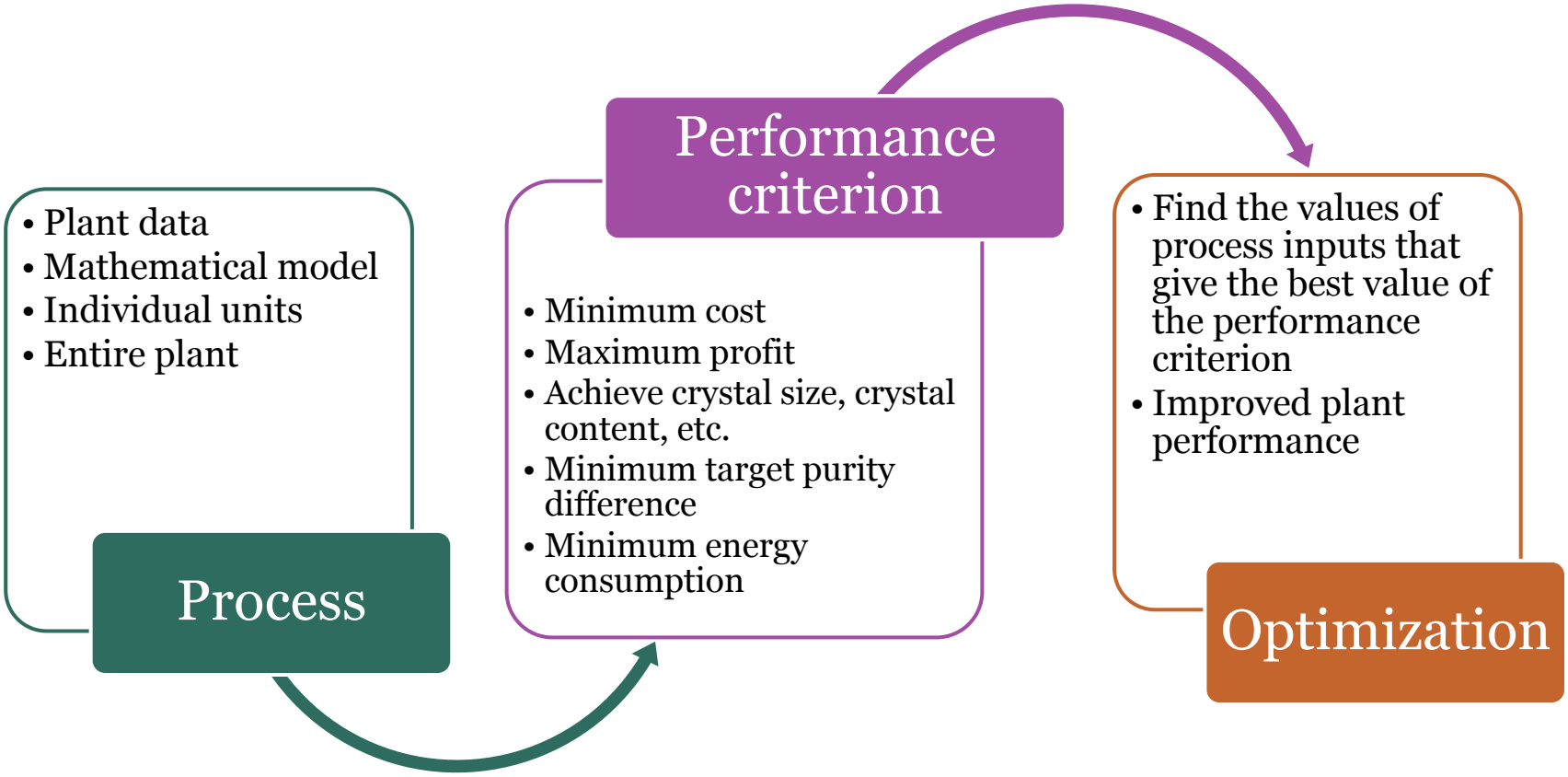
Simulation Example

- Effect of B-molasses recycle on purity of massecuites and final molasses



Final molasses purity decreases 1.3% per each 10% of B molasses recycled

Process Optimization



Optimization Example for a vacuum pan[1]

- Performance measures in crystallization are conflicting objectives
  - Coefficient of variation (CV)
  - Average crystal size (MA)
  - Crystal content (Wc)
- Objective of optimization
  - Define the optimal profiles of feeding rate of liquor/syrup and steam supply rate, to meet performance measures
  - Desired values
    - MA between 0.55 and 0.6 mm
    - CV less than 30%
    - Wc greater than 50%at the end of the strike
- Results
  - Final values of MA, CV and Wc fall within the desired values (CV=28.2 %, Wc=57%, MA =0.6 mm)
  - Smooth behavior of MA and CV

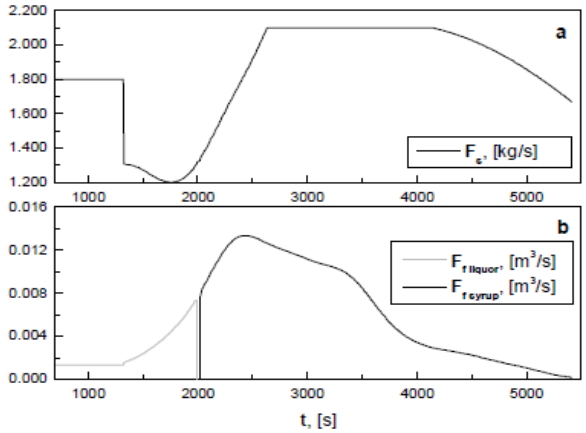


Fig.4. Optimised steam supply (a) and feeding rate (b) profiles, and the optimal switching time.

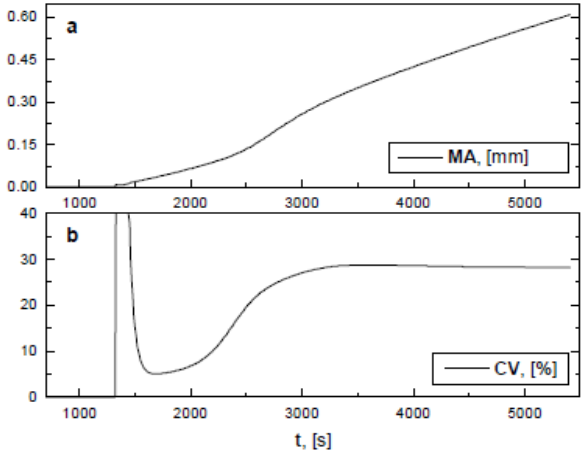


Fig. 6. Average (in mass) crystal size *MA* (a) and coefficient of variation *CV* (b) resulting from the optimised control strategy.

1. Galvanauskas, V. et al. Dynamic Optimisation of Industrial Sugar Crystallization Process based on a Hybrid (mechanistic+ANN) Model. 2006 International Joint Conference on Neural Networks. Canada July 16-21, 2006

Process Control

The objective of the control system is to keep the process conditions at the desired value in the presence of disturbances or changes in set point

pH control in clarification

Disturbances

Process variables

Cane variety and quality

Variable pH

Raw juice

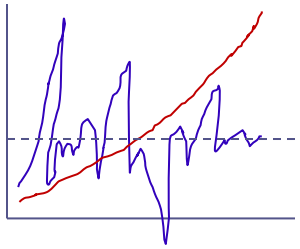
Process

Lime

Inputs

Poor control

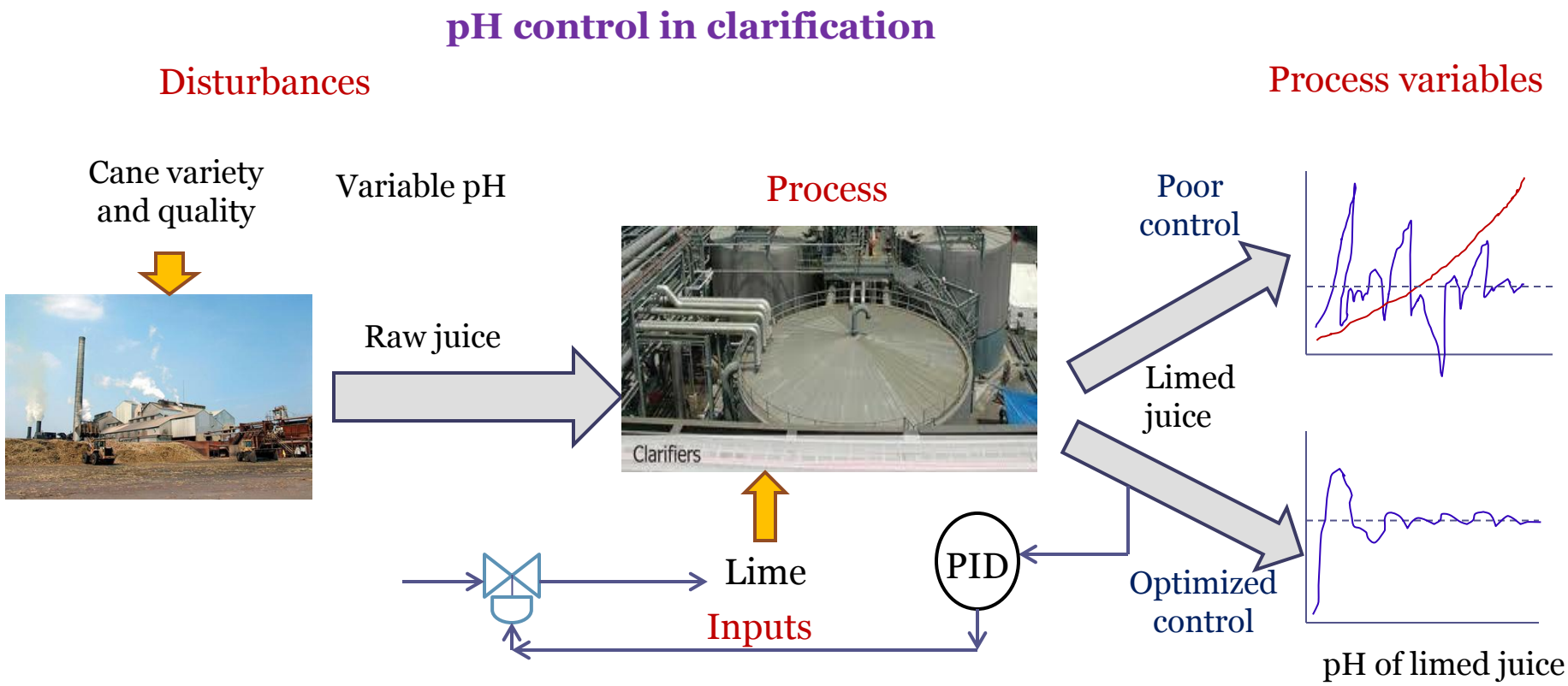
Limed juice



pH of limed juice

Process Control

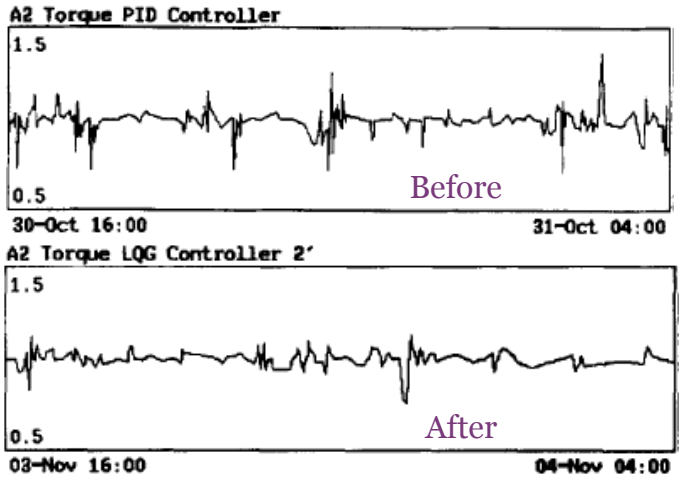
The objective of the control system is to keep the process conditions at the desired value in the presence of disturbances or changes in set point



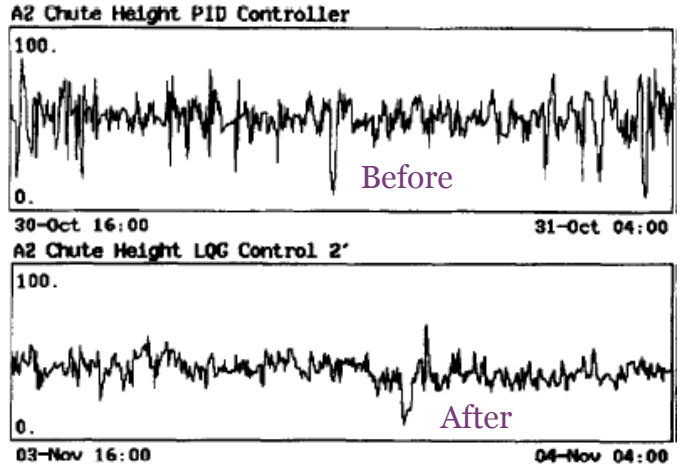
Control Example for a crusher mill[2]

- High feedstock variation (growers, regions, varieties, etc.) in short periods of time
- Conventional PID is enough to cope with feedstock variations but it could be improved.
- Objective of control
  - Improve torque control maintaining chute height at acceptable levels using advanced process control
- Plant data
  - Cane feed rate, drive torques, chute levels, roll speeds
- Results
  - Advanced control improved results over the conventional PID
  - Torque standard deviation reduced by 40 %
  - Chute height standard deviation reduced by 38 %

Torque log



Chute Height Log



2. Partanen, A.G. and R.R. Bitmead. The Application of an Iterative Identification and Controller Design to a Sugar Cane Crushing Mill Automatica, vol. 31 No. 11, pp. 1547-1563, 1995

Planning and Scheduling

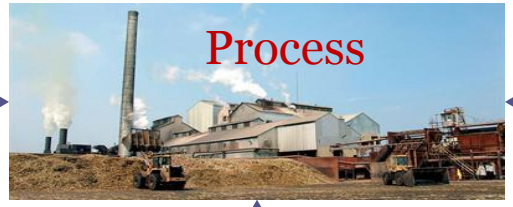
Corporate Operations Planning

- Optimize materials and product movements (supply chain)
  - Cane harvesting and delivery schedule

Plant Operations Scheduling

- Determine length of runs
  - Batch pans
- Determine sequence of operations
  - Evaporator maintenance schedule

Conclusion



Simulation | Control | Optimization | Scheduling

Calculate capacity and evaluate performance of new equipment

Reduce variance in process conditions

Reduce installation and operating costs

Maintenance schedule

Maximize sugar yield

Obtain desired sugar quality

Determine time for graining/A, B or C

Processing schedule yard vs. fresh cane

Operator training

Evaluate process behavior when conditions change

IMPROVED PERFORMANCE = MORE SUGAR = MORE MONEY

Thanks!

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