On application of Multi-scale modelling for Facility Simulation and Process Control Strategy

Moving from Reactive to Proactive Decision Making

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A note to the Reader

- The presentation and it’s contents are summarized using the standard project model: DMAIC, **Define**, **Measure**, **Analyze**, **Improve**, **Control**
- DMAIC is a lean framework that allows the clear dissemination of information
- We the authors are looking forward to a fruitful discussion at the presentation

Presentation Overview

Facility Simulation

DEFINE

Problem Statement & Scope

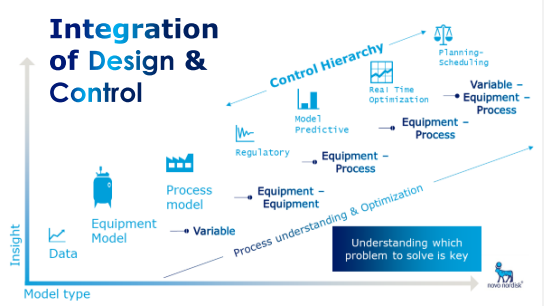
Generate, **A**nalyze, **S**elect ideas for **continuous** improvement/development

Objective:
Maximise productivity, F_{obj}

[=]

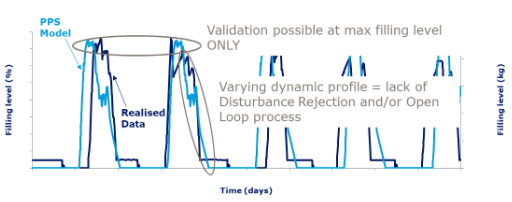
kg/hr

Approach: Multi-scale Modelling



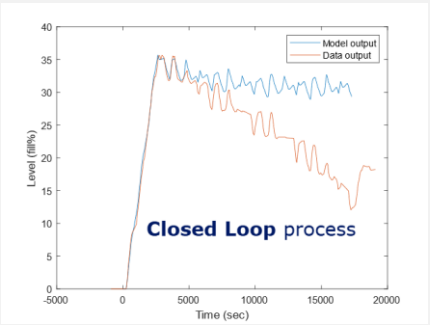
MEASURE

How can PPS be used to drive In-Process (IPC) & Process Control (PC)? IPC – PAT etc. PC – Closed loop



Mismatch between:
logged data (Realized) vs model data (Expected)

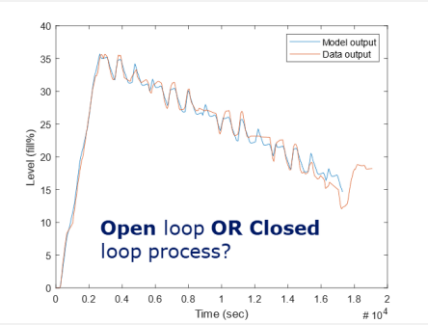
IMPROVE



Closed loop process improves Auto-mation

Improved automation = better disturbance rejection and operability

ANALYZE

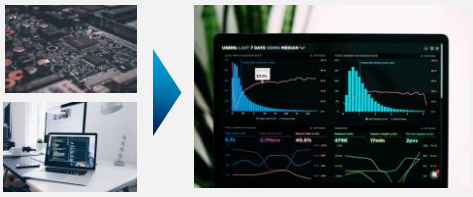


PPS drives analysis at the lower scales of the control hierarchy

Hypothesis: a Closed Loop process would aid disturbance rejection and improve Operability

CONTROL

Improved operability = complex accounting for Equipment-to-Process interactions



Consider: How can In-Process control (PAT) be combined to use Soft Sensors for Real time monitoring?

The presentation will cover

- The application of PPS
- The application of Process control
- The symbiosis between In-process control, process control and soft sensors

Key highlights

- On application of **Digital Twins**
- Methodology
- Application to an existing product
- Results from upscale manufacturing

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Multiscale modelling can be defined as the symbiosis and rotation between different modelling complexities and disciplines to represent elements of a system and thereby, the full system using a mathematical framework to achieve a desired objective. Examples of problems to be solved are, for example, the in-process controls. In-process controls are of importance in order to satisfy CQAs (a.k.a process specifications, for example, product purity, unit operation yield etc.). In-process control can be accomplished by application of process control strategies within the control hierarchy. The control hierarchy consists of, at the lower end, reactive control (PID) and proactive control (model predictive control) that has a time scale of typically seconds and, at the upper end, production planning – scheduling that has a time scale of typically weeks to months.
In the pharmaceutical industry (new) products from, that is, R&D to manufacturing, are ultimately anchored in a facility. A facility is defined as a system where multiple processes are operating in parallel to support one or more core processes making a value-added product. In contrast to a factory (or plant) where a single core process exists to make a value-added product. Pharmaceutical processes are typically batch and therefore, inherently dynamic.
The question to consider is how can information across the control hierarchy be used to achieve in-process control and maintain a stable, psudedo steady-state process while satisfying CQAs and providing the framework to identify and evaluate ideas for process improvement-optimization? For the quantification of the impact of changes on the facility to feasibly analyze, evaluate and generate the best investment portfolio for the multiscale, that is, from facility (scale 1), to individual process (scale 2) to equipment (scale 3) the required control strategy (reactive or proactive) coupled to production planning-scheduling (PPS) can be used.
The objective of this presentation is to present the approach used in Novo Nordisk for enterprise wide decision-making use of multiscale modelling for facility simulation to be both reactive and proactive. The method will be presented, and its application expounded through an example of an existing facility. First, PPS is used for providing information for decision making and portfolio investment through the evaluation of current capacity, and the identification of opportunities for automating in-process control using a reactive control strategy. Second, a reactive control problem is defined and solved based on the PPS output in order to automate a sub-process within the flowsheet to show the connection on how expectations explored at scale 3 are transformed into realizations at scale 2 and scale 3 using the appropriate process control strategy.

References

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