PRONTO
PROcess NeTwork Optimization for efficient and sustainable operation of Europe's process industries taking machinery condition and process performance into account

PRONTO
PROcess NeTwork Optimization

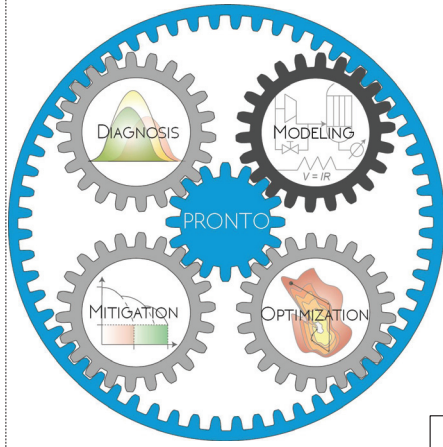# Models for change of condition

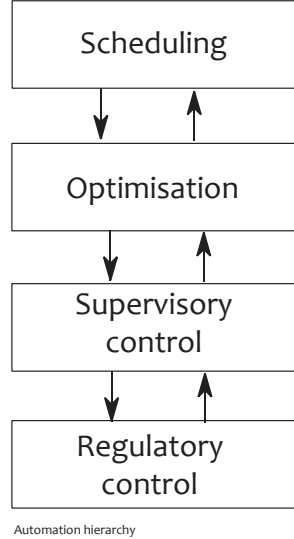Imperial College London, ABB Corporate Research Germany, Acciai Speciali Terni, BASF

Models for change of condition

Motivation and Objective: Tailor-made models to meet requirements for **specific applications in process industry** aiming for **efficient and sustainable operation.**

Francesco Borghesan
Imperial/ABB DE
Assessment and optimization of site utilities

Giancarlo Dalle Ave
ABB DE/TU Dortmund
Investigation of energy and production synergies

Jesus Hernandez
AST/TU Dortmund
Optimization of the material and energy flows in the stainless steel industry

Ouyang Wu
BASF/NTNU
Monitoring and operation of batch reactors under consideration of degradation effects

Marta Zagorowska
Imperial/ABB NO, ABB PL
Condition-based control systems taking account of stress on equipment

Scheduling

Optimisation

Supervisory control

Regulatory control

Automation hierarchy

- **Data-driven models** efficiently capture the complexity of changes of condition on all layers of process automation.
- The relationship between the change of condition and the system is reciprocal: the **system is influenced by the changes** and the **changes are influenced by the system**.
- Models of change of condition take into account **factors influencing** the changes of condition

Models for supervisory control – plantwide disturbances

Disturbances can affect the quality of the product, or they can cause a malfunction of the site machinery and accelerate its wear. Predicting change is important to allow the controller to compensate the disturbance entering in a process unit.

- Change of condition is modelled as a disturbed time series entering a plant
- It is a data driven model that by looking how past time series segments, similar to the current one, evolved, is able to predict the future evolution of a time series

Prediction of disturbances
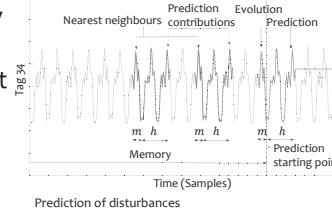
Models for scheduling – Electric Arc Furnace

Major costs in steel production are electricity costs and the replacement of the electrodes in an Electric Arc Furnace (EAF). Change of condition describes the consumption rate of an electrode based on the electrical power that passes through the electrodes

- The model predicts remaining electrode weight
- Electrode weight is a constraint in the optimization problem; cost of replacing the electrodes is in the objective function

EAF degradation model
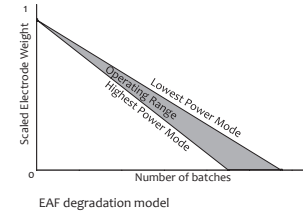
Models for optimisation – compressor station

Decreased performance results in increased control effort, which might increase the cost.

- Change of condition is related to fouling
- The model detects the state of the compressors and predicts future degradation
- The model depends on application:
  - Load sharing taking degradation into account – no influencing factors
  - Trade off to manage the degradation – with influencing factors

Degradation in a compressor map

Real and expected efficiency
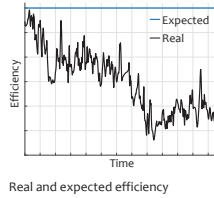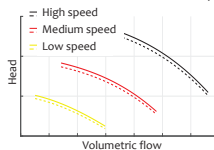
Models for scheduling – heat exchangers

Fouling in heat exchangers leads to longer batch duration in a multipurpose reactor. The reactor needs to be shut down for cleaning once the fouling reaches an unacceptable level.

- Change of condition is modelled as a batch-to-batch recipe-independent KPI that is sequence-dependent
- The production scheduling of a chemical batch plant with fouling is improved by integrating the models into the optimization framework.

Recipe-independent model of fouling