CYBERNETICA

Model based control systems for the process industry

Cybernetica AS:
Cybernetics for Profitable Process Performace





Peter Singstad,

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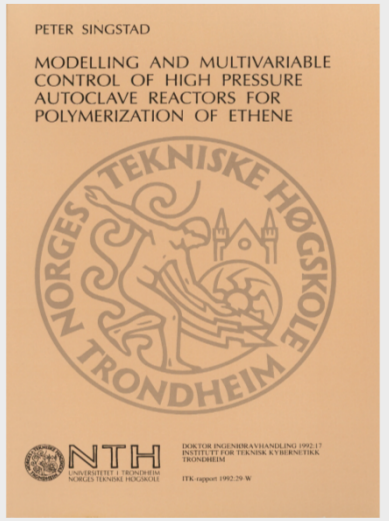
Contents

- About me
- About Cybernetica
- Cybernetica's technology
- Application areas – some examples

About me

Peter Singstad

- Siv. ing. Teknisk kybernetikk, 1982
- Dr. ing. Teknisk kybernetikk, 1992
- Vit. ass., NTH, 1982-83
- Forsker, SINTEF, 83-88
- Stipendiat 89-91
- Gruppeleder, SINTEF, 92-95
- Forskningssjef, SINTEF, 95-00
- Cybernetica AS fra 2000



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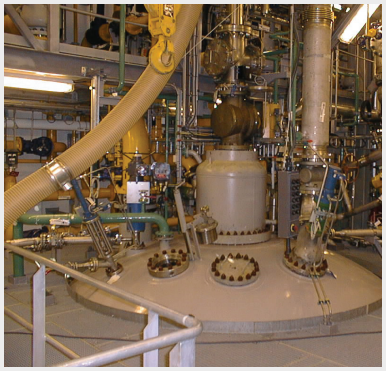
Cybernetica at a glance

- Tailor made *model based control systems* and *soft measurements*
- Unique Nonlinear Model Predictive Control technology
  - industrially proven
  - increases profitability for our customers

Our employees are experts in advanced control and process modelling with strong engineering backgrounds



- Key technologies
  - Model Predictive Control (MPC)
  - ”in-line” dynamic simulators
  - online model-based soft sensing
- Services
  - Plant controller tuning and problem solving
  - Research and modeling for hire
- Key figures:
  - 11 employees + 5 part time
  - revenue 12,3 MNOK (2013)
  - profitable since 2000
- Customers are large international companies in
  - petroleum
  - polymer
  - metallurgical industries

Competence profile

- Control engineering
  - Model predictive control
  - Nonlinear model based control
  - On-line optimization
  - Controller configuration and tuning
  - Model identification and validation
  - Instrumentation
- Systems engineering
  - Real-time software systems
  - Man-machine interfaces
- Process engineering
  - Process modelling
  - Simulator development
  - Dynamic process simulation

Located in Trondheim …

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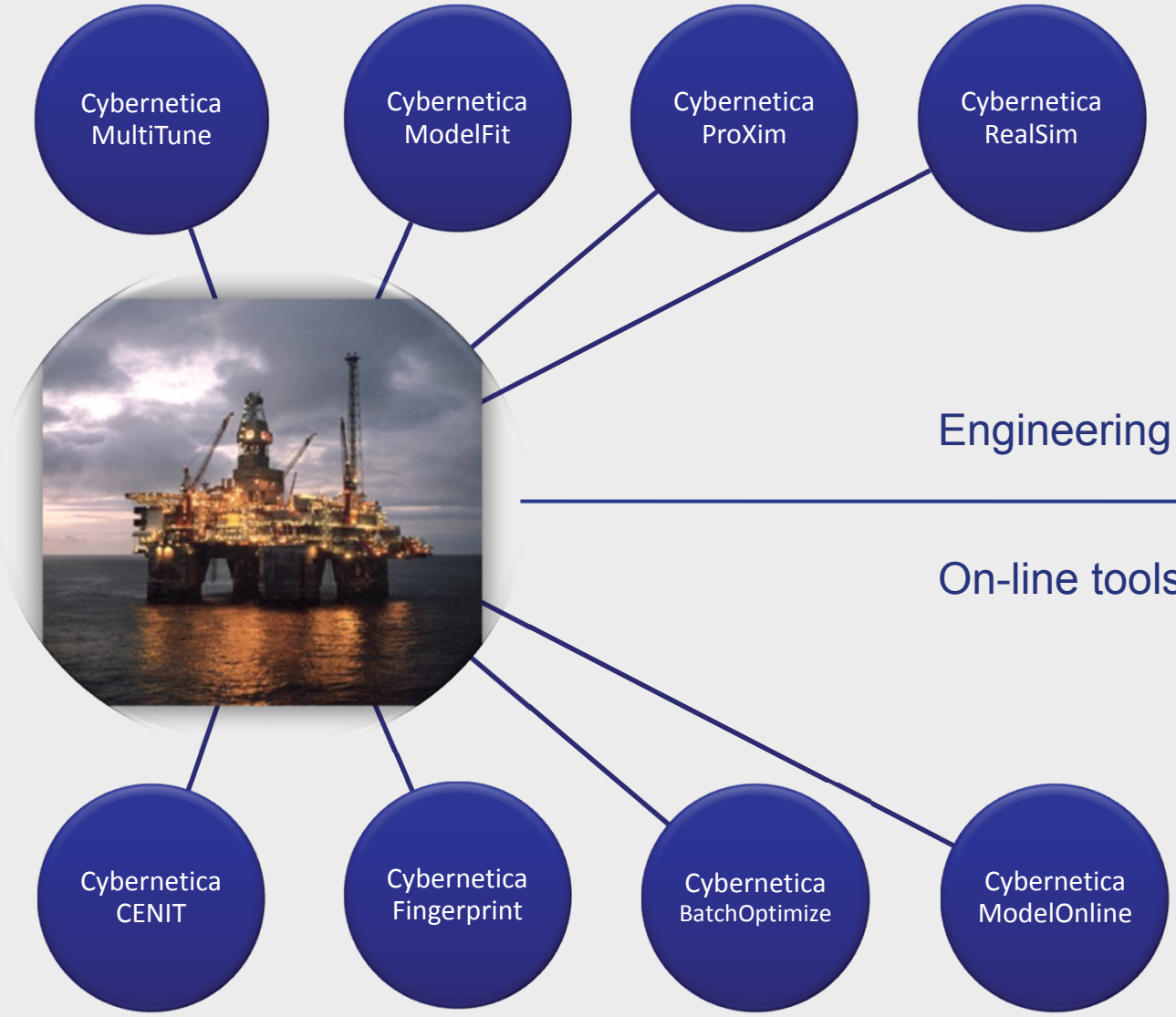
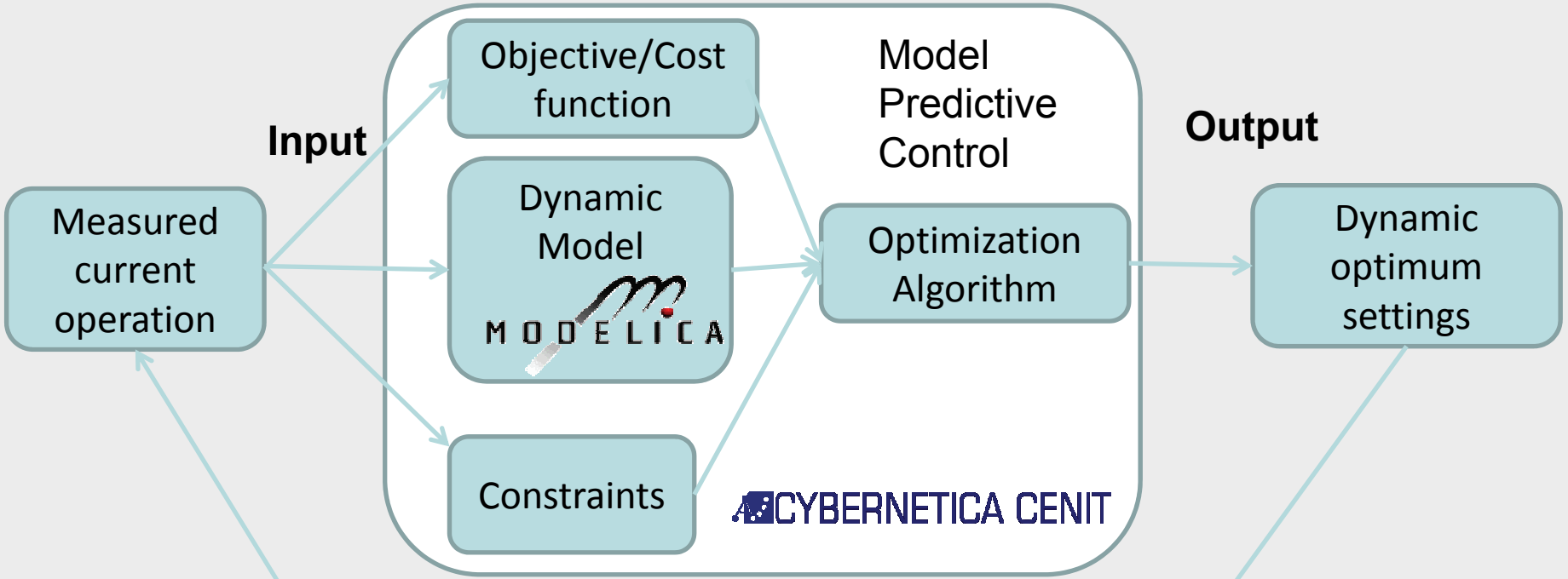
Profitable Process Performance for Customer



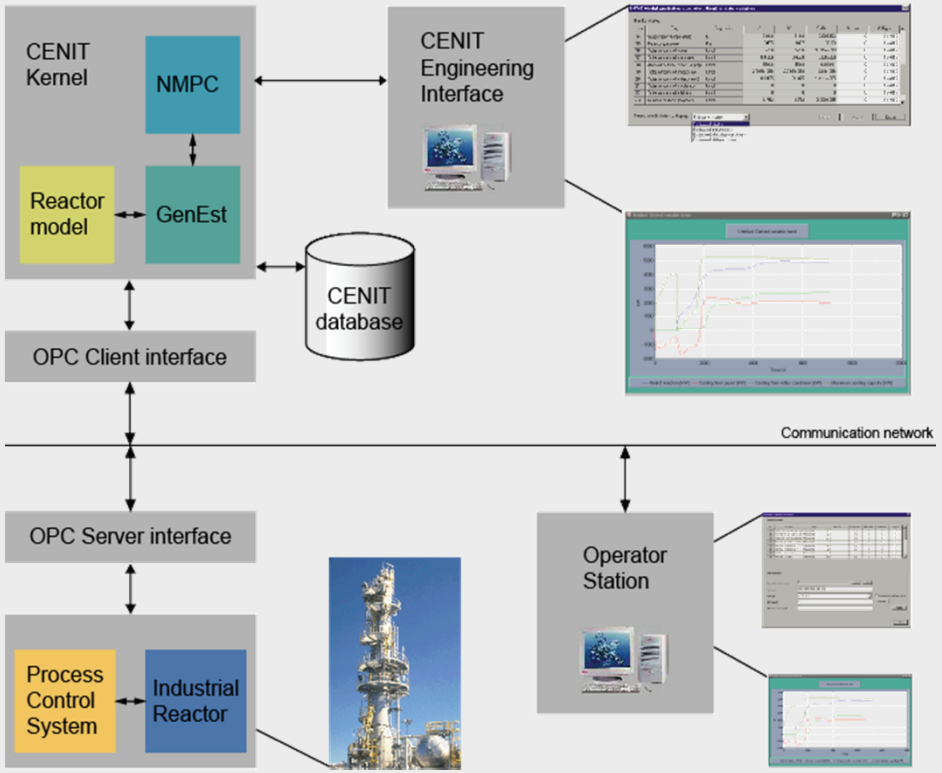
Model Predictive Control



Model Predictive Control

Cybernetica CENIT

- A system for model based predictive control (MPC) and on-line optimization
- Based on models with a physical structure (mechanistic models)
- Contains:
  - software for nonlinear model predictive control
  - software for *on-line* state and parameter estimation
  - software for *off-line* parameter estimation



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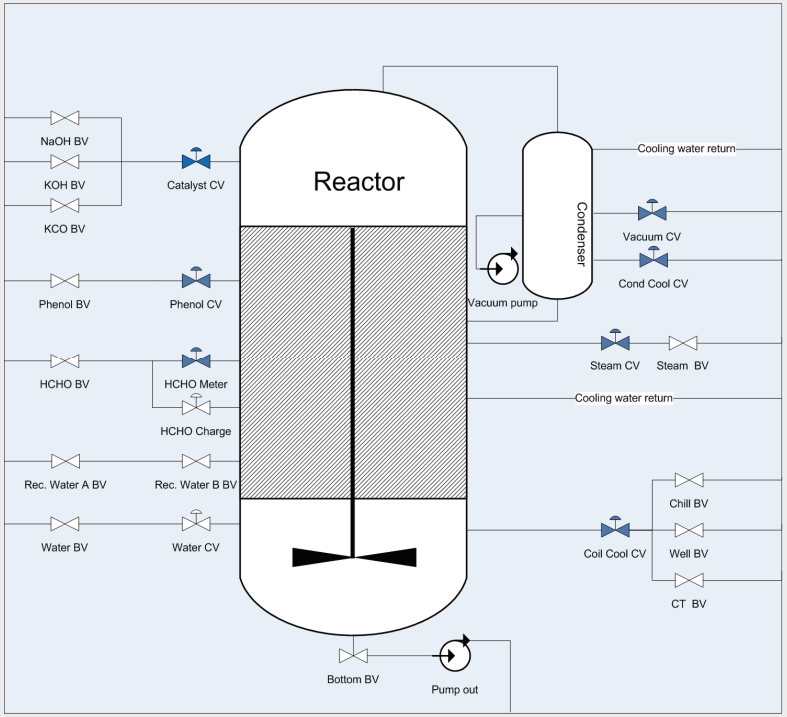
Phenol-formaldehyde Semi-batch Polymerization

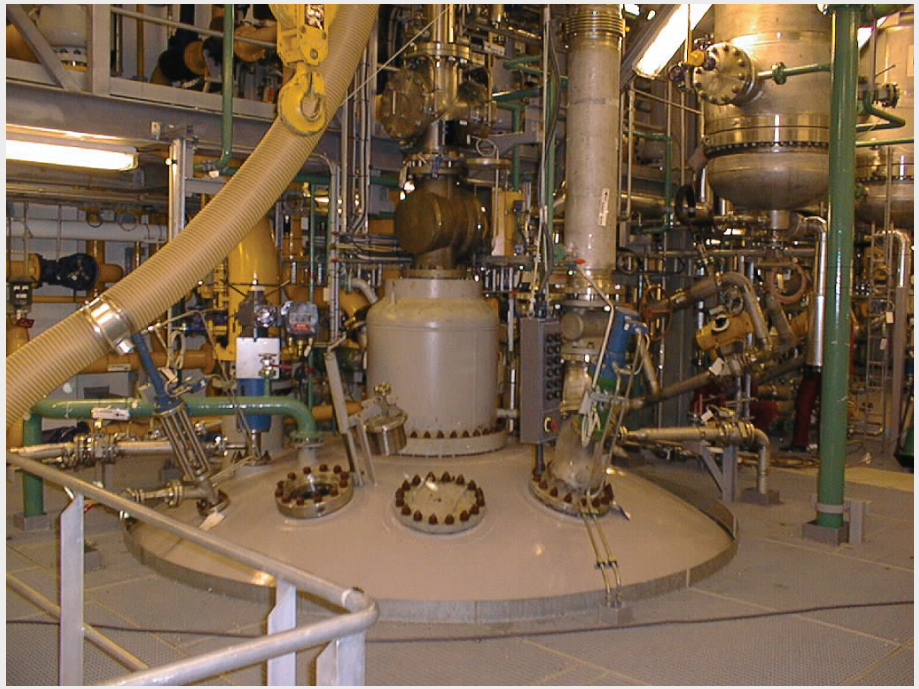
- Base-catalyzed step polymerization with semi-batch operation
  - Raw materials (e.g. formaldehyde and base) are metered at several stages during a batch.
- Nonlinear model predictive control
  - Accurate temperature control
  - Control of reaction rates
  - Minimize batch-time, subject to constraints related to safety and quality
  - Mechanistic model with adaptivity
- Fingerprint monitoring system
- Model based end-point prediction



Implemented on sites in USA, Canada, Finland and New Zealand

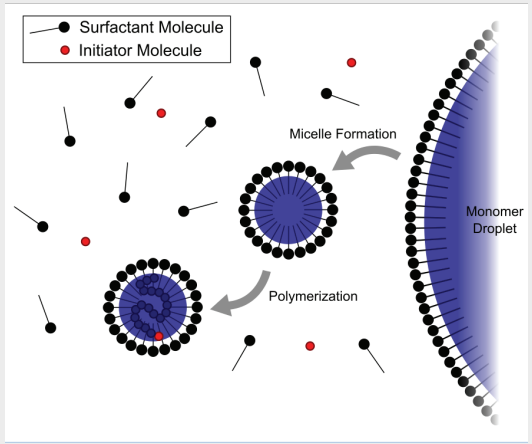
Batch polymerization of S-PVC

- **Run-to-run parameter estimation:**
  - Estimates model parameters after each batch.
- **Run-to-run optimization:**
  - *Optimization* of *initiator* quantities and *temperature* profile.
    - *Economic criterion* weighting *cost of batch time* and *cost of initiator*.
    - Product *quality* and *safety constraints*.
- **Model predictive control:**
  - *Temperature control* by jacket and condenser cooling.
  - Predicts if the *heat of reaction* will *exceed* the available *cooling capacity*.
  - Determines the necessary amount of *inhibitor to regain control* of the polymerization temperature.
  - Controls *venting* of the *reflux condenser*.

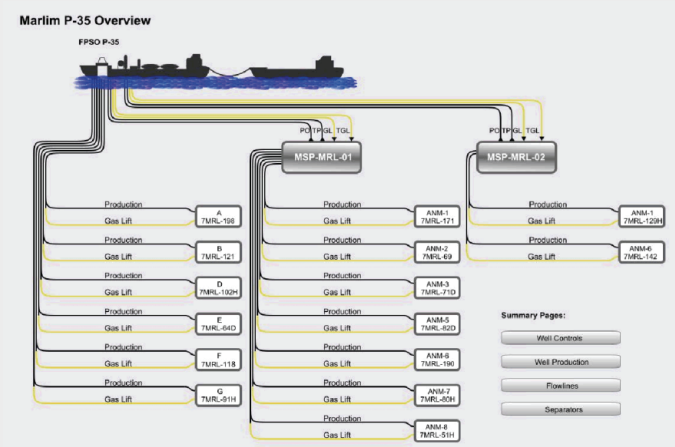


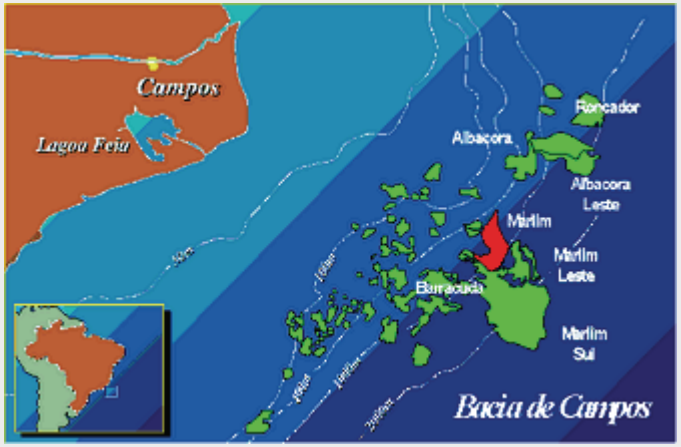
Semi-batch emulsion co-polymerization

- Vision
  - Significant «process intensification»
  - Move from «cook book» to quality based control
- Model predictive control
  1. Temperature control by steam heating and jacket cooling.
  2. Metering of monomers (2 oil-soluble and 2 water-soluble) and initiator in a predetermined ratio.
     - Metering rate is maximized under cooling capacity constraints.
  3. Terminal polymer quality
     - Number average molecular weight is predicted by the model
     - MPC will optimize temperature profile such that
       - The specified number average molecular weight is reached
       - Polymerization time is minimized



Offshore Oil & Gas





- NMPC for increased capacity
  - Operate towards constraints in
    - Gas capacity (max compressor speed or efficiency)
    - Liquid capacity (liquid valves, separator volumes)
    - Water treatment systems (centrifuges, hydrocyclones, oil in water)
    - Product quality (gas dew point, oil RVP)
  - Avoid production decrease due to
    - Slugging
    - Time-consuming start-up procedures
    - Time-consuming well tests
- Gas lift optimization

Aluminium electrolysis

- *Process models for*
  - *Training simulator*
  - *Scenario simulations*
- *Estimators for*
  - *Offline data analysis*
  - *Online applications*
- *Enabling advanced solutions*
  - *Operator support tools*
  - *Model based monitoring*
  - *Soft sensor control*
  - *Model predictive control*
- *Challenges:*
  - *Many units*
  - *Few and seldom measurements*

Metal production and refining

- *Solutions for improved process understanding and control of batch and continuous processes for production of ferroalloys and steel.*
- *Applications:*
  - *Process simulators.*
  - *Process control using end-point predictions.*
  - *Operator support tools.*
  - *Batch optimizing.*
  - *Model predictive operation support.*
- *Challenges:*
  - *Poorly observable processes.*
  - *Raw materials with large variations in material properties.*

Keep your plant stable!