

30th Annual European AIChE Seminar

Sponsors



SCORES₄ CHEM Knowledge Platform

**Safety, Control & Optimization:
Research, Education & Services for
the chemical industry & life sciences**

Jan F.M. Van Impe & Geert J.M.F. Gins

A brief history...

A brief history...

2004: SCORES

*Systems, Control & Optimization:
Research, Education & Services*

2005: OPTEC (Center of Excellence)

*Optimization in Engineering Center
Funding: KU Leuven Research Fund*

2009: SCORES4CHEM (Knowledge Platform)

SCORES CHEM

Knowledge Platform

Expertise

Safety

Control

Optimization

Activities

Research

Education

Services



SCORES CHEM

Knowledge Platform

Funding: unique partnership

KU Leuven Industrial Research Fund

essenscia



SCORES4CHEM

KU Leuven Research Fund
Center of Excellence OPTEC

KU Leuven Industrial Research Fund
essencia

Knowledge platform SCORES4CHEM



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FWO

Fundamental Research

Technology Push



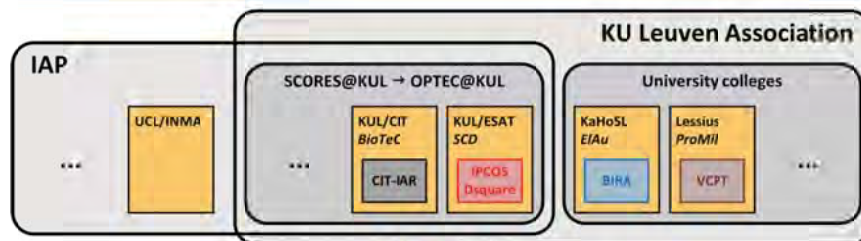
Market Pull

IWT

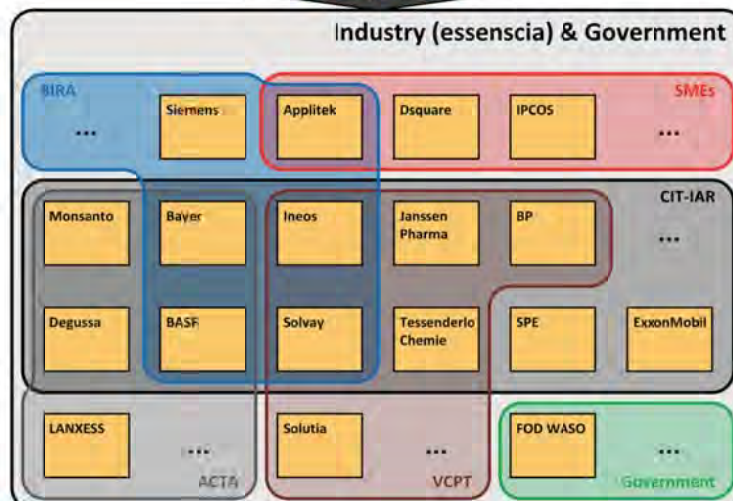
Contract Research

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SCORES4CHEM



SCORES4CHEM
Knowledge Platform



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SCORES4CHEM



SCORES4CHEM in FISCH

FISCH comes up with 8 different, society-relevant projects
status August 20th, 2010



Project 1 - Program 'Micro Algae' Micro algae are the fastest growing vegetal organisms on earth. They grow in polluted water with sunlight and CO₂ and produce oxygen. We use algae as replacement of fossil raw materials for the manufacture of chemical products, food and feed and fuels. This can also be realized in our region. Project by: Proviron	Project 2 - Program 'Microprocess Technology' Microprocessing is miniaturization of (bio) chemical processes, just like in the Human body. This allows you to produce in a safer, smaller scaled and more energy-saving way with less raw materials. Moreover this brings products and their manufacturing closer to the local consumer and reduces therefore the number of kilometers of transport. This technology can be applied in Flanders but will also be marketable internationally. Project by: P&G
Project 3 - Program 'Separation Technology' Waste water contains water and (waste)materials which are not usable anymore (classified as waste). Separation technology allows to separate water again and to recycle the waste materials. Consequently less water is used and waste material becomes useful raw material again. Flanders can become top of the world by building the know how on the subject present at our Flemish industrial clusters (chemistry, pharma, biotechnology, food, textiles, ...) and our knowledge centers, e.g. for purification of treated waste water. Project by: JANSSEN	Project 4 - Program 'Renewable Chemicals' Plants (wheat, grass, agricultural crops, ...) but also CO₂ can be converted into the so-called 'renewable chemical building blocks'. These are alternatives for raw materials originating from petroleum. This makes Flanders less dependent on import of raw materials. Project by: TERMEER
Project 5 - Program 'Valorization of Waste and Side streams' Flanders has built up already a lot of expertise, experience and structures about valorization of domestic and industrial waste (collecting, sorting, incineration, composting or fermentation). However, before doing this with all of the waste, useful chemical compounds can be recycled out of this waste. Furthermore also manufacturing of chemicals out of (waste) streams of plants, animals and industry is an opportunity for Flanders. Project by: AGFA	Project 6 - Open Innovation Infrastructure Cluster (OIC) The cluster will put accelerated infrastructure of the domain of enterprises and knowledge centers for innovation projects about sustainable chemistry. Doing this all forces are banded in order to realize a common use of very expensive top innovation infrastructures. In that way SMEs obtain easier access to optimized infrastructures (social innovation). Foreign enterprises and researchers are attracted by this, products and processes are marketed faster, start-ups and spin-offs are created faster. Project by: AGFA
Project 7 - Sustainable Chemistry Knowledge Center This Consortium for 'Sustainable Chemistry' offers the director (partner of sustainability) and the possible routes to (one of) sustainability which sustainable chemical innovation must comply to. In consultation with all score actors a 'Blue Label' for chemical products, processes and equipment is awarded based on reliable, objective and measurable criteria of sustainability. An SME cluster exists at all innovations. Project by: AGFA	Project 8 - 'Hexagon' Meeting and expression space 'All of Chemistry' (Chemistry Tomorrow or 'Chemofutur') for creative chemistry with innovation and incubation facilities for start-ups and existing SMEs. The Hexagon visitor center for the public should give and observe image of the direction Flemish chemistry will go in order to sustainable society based on an open dialogue. Project by: AGFA

CONTACT

info@scores4chem.be

Carl Van der Auwerda (essenscia Belgium) t (+32) (0)8461 90 33
Lies Van Gerven (VITO) t (+32) (0)47707 98 47



SCORES4CHEM in FISCH

FISCH came up with 8 different, society-relevant projects



SusChem
FLANDERS

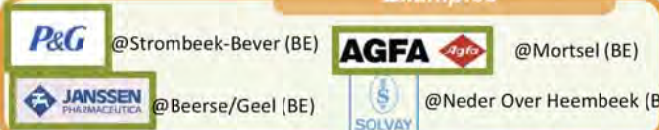
Project 6 = Open Innovation-infrastructure Cluster (OIC)

This cluster will put decentralized infrastructure at the disposal of enterprises and knowledge centers for innovation projects about sustainable chemistry. Doing this all forces are bundled in order to realize a common use of very expensive top innovation-infrastructures. In that way SMEs obtain easier access to optimized infrastructure (= social innovation), foreign enterprises and researchers are attracted by this, products and processes are marketed faster, start-ups and spin-offs are created faster.

Open Innovation-infrastructure Platforms

- Simulation en optimization
- Characterization
- Renewable synthesis
- Separation
- Microprocessing
- Pilot
- Application and demonstration

Open Innovation Sites Examples



Examples



SCORES4CHEM in FISCH

FISCH came up with 8 different, society-relevant projects



SusChem
FLANDERS

Project 7 = Sustainable Chemistry Knowledge Center

This Center/Institute for "Sustainable Chemistry" offers the direction (compass of sustainability) and the possible routes to follow (gps of sustainability) which sustainable chemical innovation must comply to. In concertation with all social actors a "Blue Label" for chemical products, processes and organisations is awarded, based on reliable, objective and measurable criteria of sustainability. An SME counter assists at all innovations.



VLARIP@



Chemical Leasing



Patent Office



Teams

Teams



BioTeC, Prof. Jan Van Impe
KU Leuven
*Chemical & Biochemical
Process Technology & Control*

SCD/SISTA, Prof. Bart De Moor
KU Leuven
*Signals, Identification,
System Theory & Automation*



Teams

ProMil, Prof. Raf Dewil
Lessius – Campus De Nayer
Process & Environmental Technology



E&A, Prof. Jos De Brabanter
University College Ghent
Electricity & Automatization

Research & Services

Research & Services



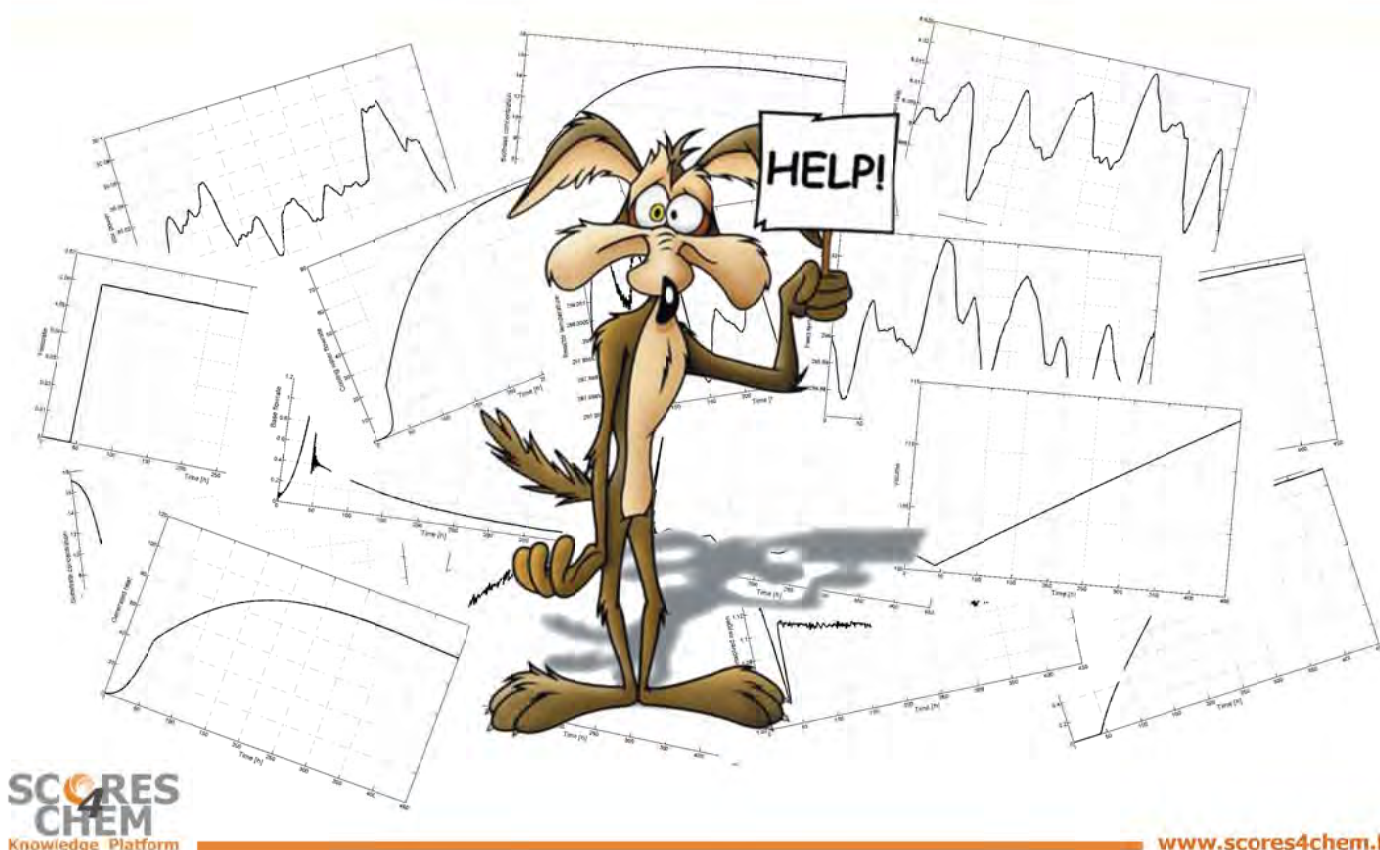
Improve efficiency

- Higher capacity
- Higher yield
- Energetic efficiency
- Zero waste
- Zero emission
- Process safety

Research & Services



Research & Services



SCORES4CHEM

Monitoring, optimization, control & safety

State-of-the-art techniques & tools

Advanced analysis equipment

Large pool of researchers

Large pool of ongoing research

Wide range of problems

Shorter payback period

Examples

- Tighter quality control
- Prediction of final batch quality
- Detection of process disturbances
- Optimized process operation
- Process intensification
- Model-based process design

Tighter quality control

Pulper for recycled paper production

Manual control

Operator dedicated to
consistency control

Capacity

7,000-12,000 L pulp/min

Production

24/7

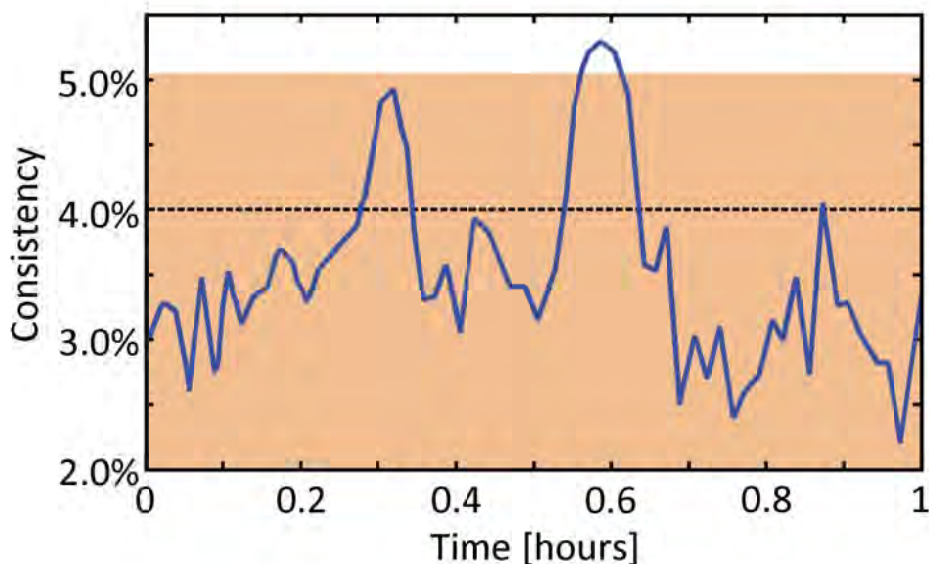


Tighter quality control

€50,000/year

-67% quality variation

Tighter quality control



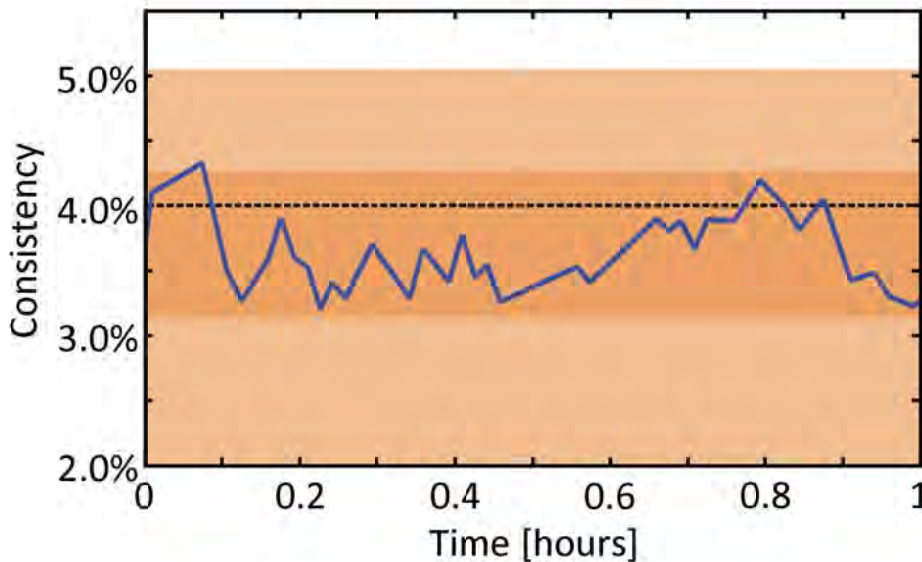
Target quality

4%

Manual

$3.5\% \pm 0.7\%$

Tighter quality control



Target quality

4%

Manual

$3.5\% \pm 0.7\%$

Automatic

$3.7\% \pm 0.3\%$

Examples

- Tighter quality control
- Prediction of final batch quality
- Detection of process disturbances
- Optimized process operation
- Process intensification
- Model-based process design

Final quality prediction

Industrial polymerization

Cost per batch

€9,000

Capacity

8 hours/batch

30 batches/month

2 faulty batches/month



Final quality prediction

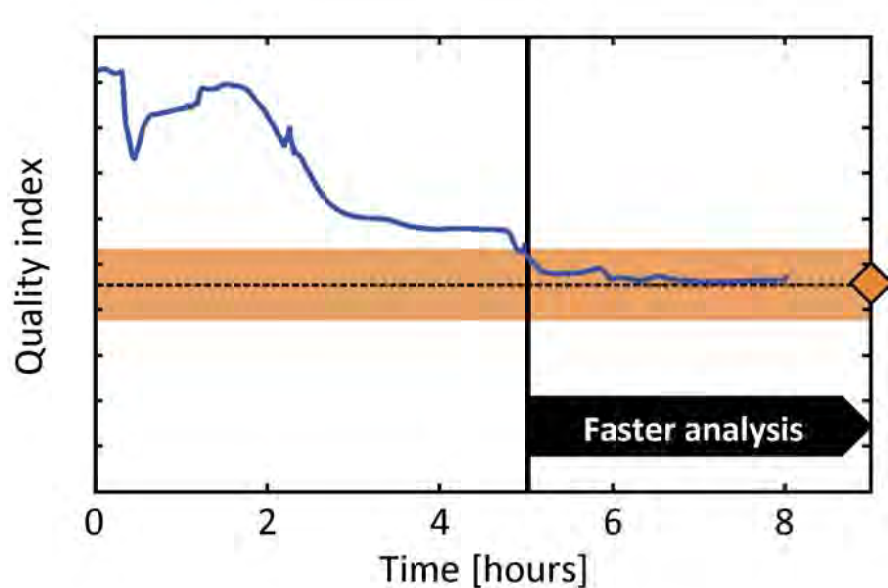
>5 before lab

Accurate prediction at less than 50% completion

€65,000/year

30% cost reduction per off-spec batch

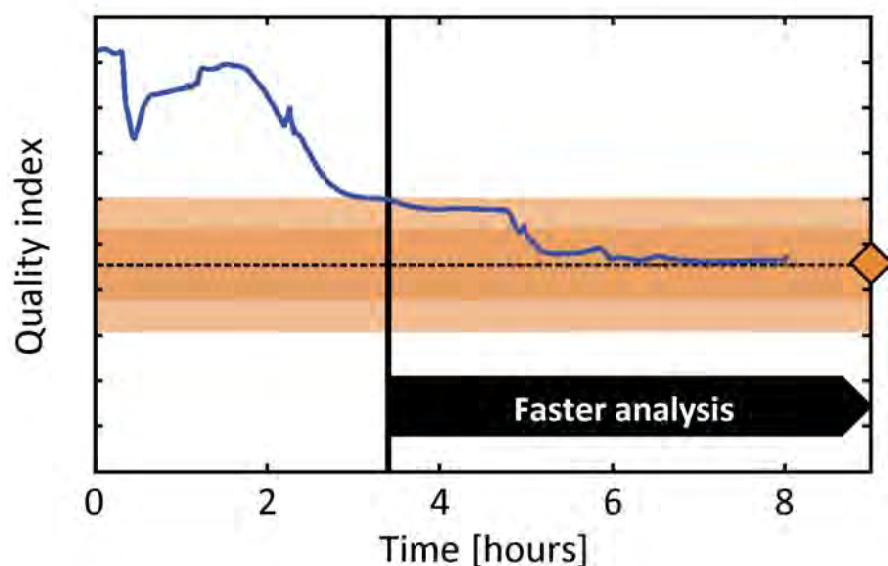
Final quality prediction



Lab analysis
9 hours

Final value $\pm 5\%$
5 hours

Final quality prediction



Lab analysis
9 hours

Final value $\pm 5\%$
5 hours

Final value $\pm 10\%$
3½ hours

Examples

- Tighter quality control
- Prediction of final batch quality
- Detection of process disturbances
- Optimized process operation
- Process intensification
- Model-based process design

Disturbance detection

Penicillin production

Cost per batch

€45,000

Capacity

160 hours/batch

3 batches/month



Disturbance detection

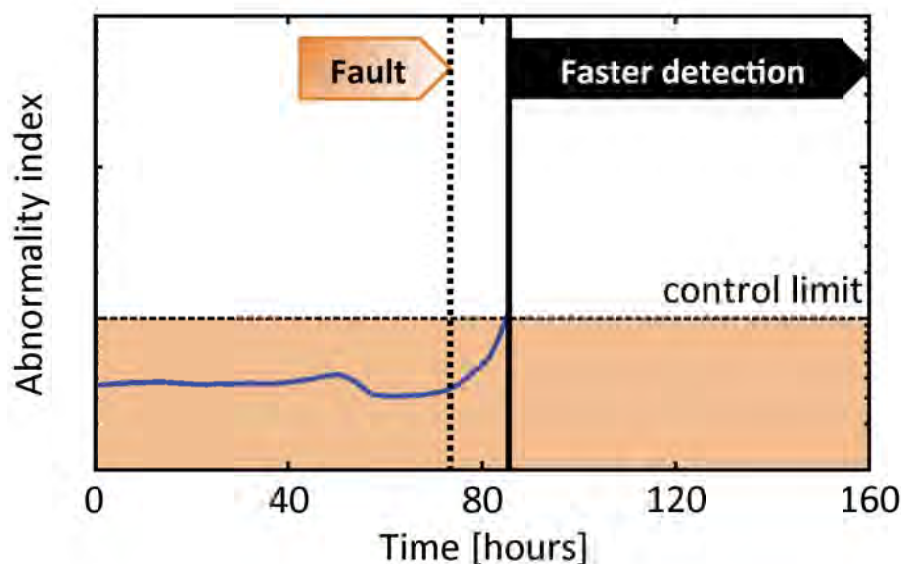
Detection in 2 hours

60% faster than operator

3 months for false alarm

False alarm rate $< 1/20$ batches

Disturbance detection



Normal detection

End of batch or
by operator

Sudden fault

Immediately

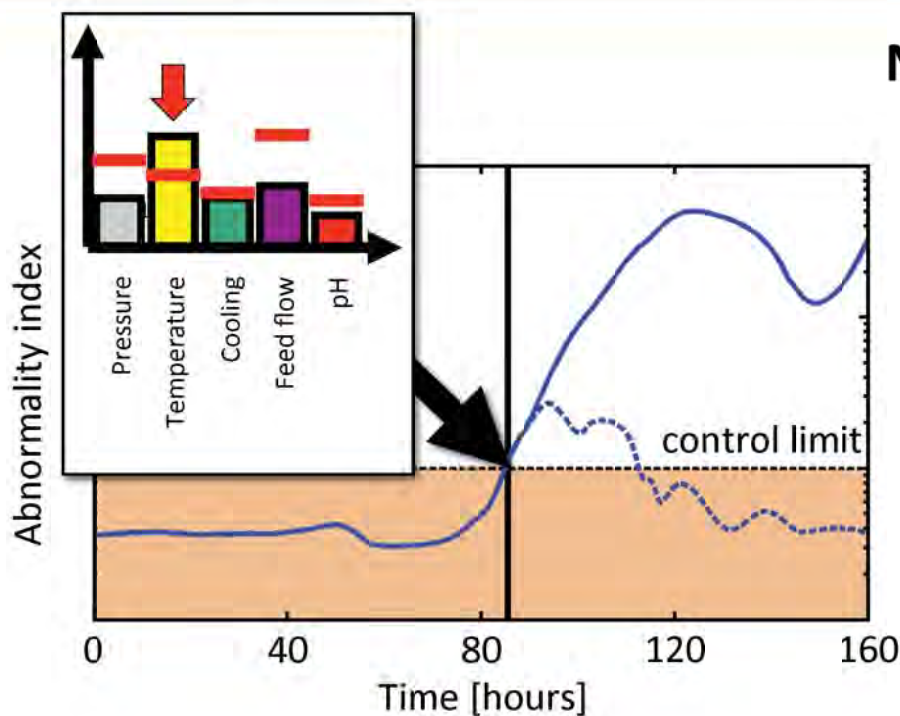
0.30%/h drift

± 2 hours

0.15%/h drift

$\pm 2\frac{1}{2}$ hours

Disturbance detection



Normal detection

End of batch or
by operator

Sudden fault

Immediately

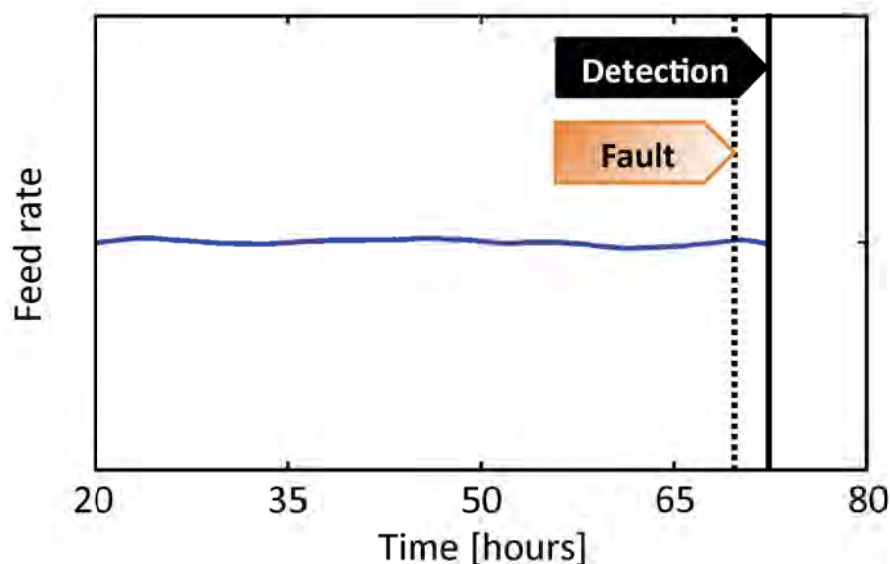
0.30%/h drift

±2 hours

0.15%/h drift

±2½ hours

Disturbance detection



Normal detection

End of batch or
by operator

Sudden fault

Immediately

0.30%/h drift

±2 hours

0.15%/h drift

±2½ hours

Examples

- Tighter quality control
- Prediction of final batch quality
- Detection of process disturbances
- **Optimized process operation**
- Process intensification
- Model-based process design

Optimized process operation

Lysine production

Cost

€2.25 – 2.45/kg lysine

Price

€2.40 – 2.60/kg lysine

Capacity

3,000 ton lysine/year



Optimized process operation

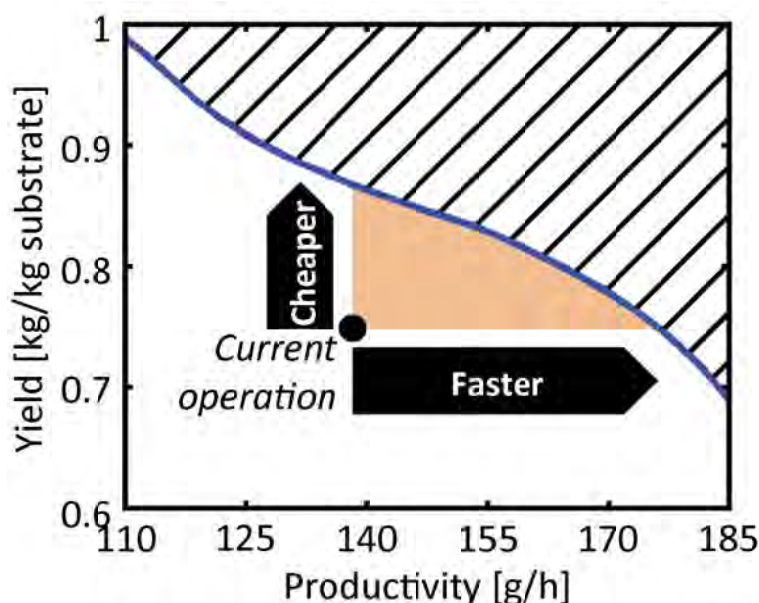
€200,000/year

-15% raw materials for same capacity

€125,000/year

+29% capacity with same raws materials

Optimized process operation



Normal operation

0.75 kg/kg substrate

140 g/h production

Maximal yield

0.88 kg/kg substrate

(+15%)

Maximal productivity

180 g/h production

(+29%)

Examples

- Tighter quality control
- Prediction of final batch quality
- Detection of process disturbances
- Optimized process operation
- **Process intensification**
- Model-based process design

Process intensification

Anaerobic sludge digestion

Capacity

1500 ton sludge/year

Biogas production

585000 m³/year

Energy production

1250 MWh electricity

1710 MWh heat



Process intensification

€300,000/year

+50% production by sludge pretreatment

Examples

- Tighter quality control
- Prediction of final batch quality
- Detection of process disturbances
- Optimized process operation
- Process intensification
- Model-based process design

Model-based constraint pushing

**Low-density
polyethylene (LDPE)
production**

Price

€1.3 – 1.9/kg LDPE

Capacity

400,000 ton LDPE/year

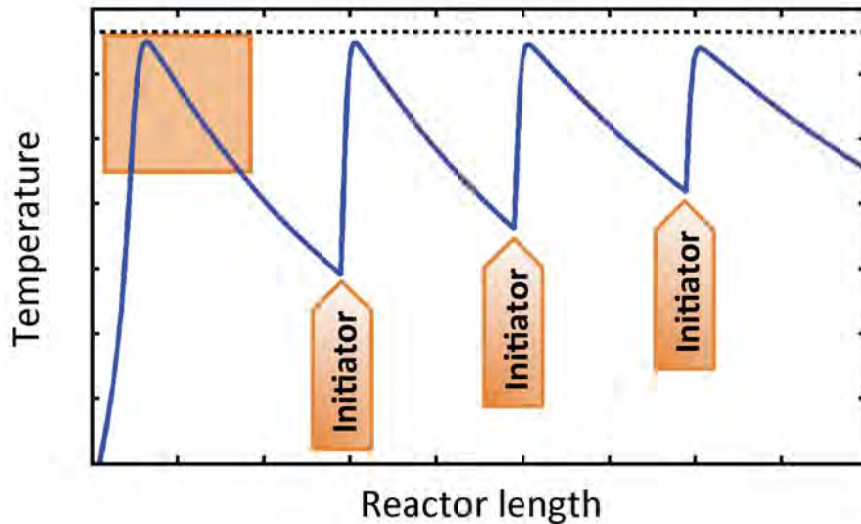


Model-based constraint pushing

€300,000/year

+0.75% product conversion

Model-based constraint pushing

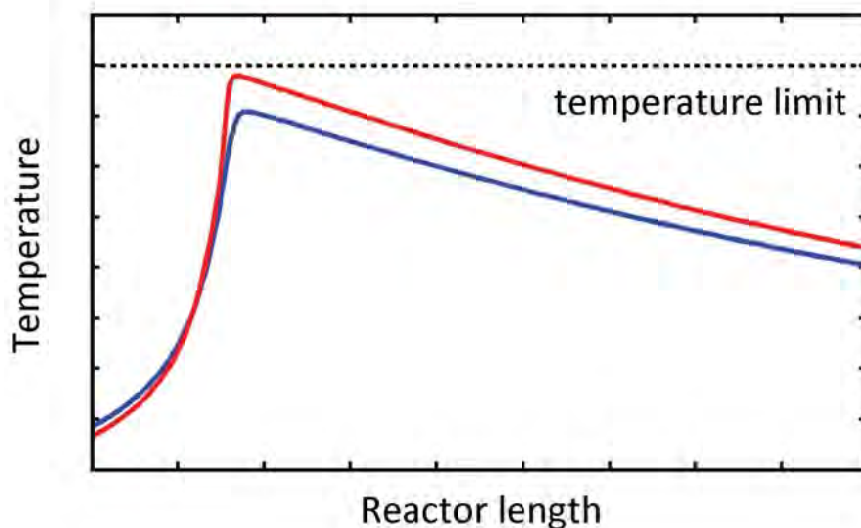


Design challenge

Shot location

Shot size

Model-based constraint pushing



Rules of thumb

Large margin

Model-based

Limits of
performance:

+0.25%

conversion

Industrial collaborations



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Education

Master in Safety Engineering

Content

Safety: technical safety, safe life cycle, risk evaluation

Prevention: occupational safety, health issues

Requirements

Master's degree / suitable professional experience

Duration

1 or 2 years

€5,600 for professionals

Master in Safety Engineering

Common Compulsory Courses: 23 credit points (English)

- (*) 3 pt Introduction to Safety Engineering: General Introduction to Safety Engineering
- (*) 3 pt Prevention Policy and Safety Management Systems
- (*) 4 pt Safety of Chemical and Biological Products and of Chemical Processes
- (*) 4 pt Safety Aspects of Industrial (Thermal – Mechanical – Electrical) Installations
- (*) 3 pt Qualitative Risk Analysis Techniques
- (*) 3 pt Fire Protection and Building Safety
- (*) 3 pt Explosion Safety

Option Process Safety: 16 credit points (English)

Compulsory:

- (*) 3 pt Quantitative Risk Analysis Techniques
- (*) 3 pt Statistics for Safety Engineers
- (*) 3 pt Process Control and Safety of Digital Systems
- (*) 4 pt Selected Topics: Safety in Unit Operations
- (*) 3 pt Selected Topics: Competence in Operations

Option Process Safety: 6 credit points (English)

Electives, choose from:

- (*) 3 pt Materials Selection
- (*) 3 pt Degradation and Corrosion
- (*) 3 pt Reliability and Safety (of Nuclear Power Plants)
- (*) 3 pt Advanced Process Control in the (Bio)Chemical Industry

Option Prevention: 16 credit points (Dutch)

Compulsory:

- (*) 2 pt Inleiding tot de Veiligheidstechniek:
Belgische Context en Groepsoverleg
- (*) 3 pt Juridische Aspecten van de Arbeidsveiligheid
- (*) 6 pt Ergonomie en Psychologische Aspecten van Arbeid en Gezondheid
- (*) 5 pt Medische Implicaties van de Veiligheid

Option Prevention: 6 credit points (English/Dutch)

Electives, choose from:

- (*) 3 pt Quantitative Risk Analysis Techniques
- (*) 3 pt Statistics for Safety Engineers
- (*) 3 pt Process Control and Safety of Digital Systems
- (*) 3 pt Milieubeveiliging (required for "Milieucoördinator")

Master Thesis: 15 credit points

Training

Training

Topics on modelling & monitoring

- Data mining and multivariate analysis
- Design and modelling of fluidized bed reactors
- Experimental design
- Industrial data communication
- Nonparametric statistics
- Parameter estimation
- Quality control & reliability engineering

...

Course: Data mining

Course content

- Basics of data mining
- Data analysis
- Univariate statistics
- Multivariate statistics
- Disturbance detection
- Quality prediction
- ...

Training

Topics on optimization & control

- Control theory
- Handling and storage of powders
- Model-based control theory
- Multi-objective optimization
- PID control
- Pneumatic conveying of powders
- ...

Course: Control theory

Course content

- Basics of control theory
- Basics of model-based control theory
- P, PI & PID control
- Optimal tuning of PID controllers
- Multiple objective optimization
- Model Predictive Control (MPC)
- ...

SCORES4CHEM

Monitoring, optimization, control & safety

- State-of-the-art techniques & tools
- Advanced analysis equipment
- Large pool of researchers
- Large pool of ongoing research
- Wide range of problems
- Shorter payback period

Contact information

Jan Van Impe, SCORES4CHEM chairman

jan.vanimpe@cit.kuleuven.be

Geert Gins, SCORES4CHEM coordinator

geert.gins@cit.kuleuven.be

Jan Degrevè, Director Master Safety Engineering

jan.degrevè@cit.kuleuven.be



www.scores4chem.be

A large, stylized logo for SCORES4CHEM Knowledge Platform. The word "SCORES" is in large, white, outlined letters. The "4" is a large, grey, stylized number. The word "CHEM" is in large, white, outlined letters. Below "CHEM" is the text "Knowledge Platform" in a bold, orange, sans-serif font. The entire logo is set against a background of orange and white geometric shapes.

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the chemical industry & life sciences**