

The Process Industry Centre 2008–2014

SUMMARY OF A PROGRAMME FOR RESEARCH AND COMPETENCE DEVELOPMENT
INITIATED BY THE SWEDISH FOUNDATION FOR STRATEGIC RESEARCH (SSF)
AND FUNDED JOINTLY BY SSF AND COMPANIES IN THE PROCESS INDUSTRY

Min synpunkt

Automation hela vägen upp



Sedan 2008 har vi varit medlemmar i den nya gruppen för automation i processindustrin. Detta är en viktig fråga för oss som arbetar med att förbättra produktiviteten och säkerheten i våra anläggningar. Vi ser fram emot att tillsammans kunna utveckla lösningar som gör det möjligt att automatisera hela vägen upp i värdekedjan.

”Ett av de största utmaningarna är att säkerställa att automationen inte bara är en teknisk lösning, utan också en lösning som tar hänsyn till människorna som arbetar i anläggningarna. Detta kräver en nära samarbetsrelation mellan tekniker och operativ personal.”



”Klart planering och logistik är en fråga om automation”

50



Reglerdoktorn per Forstorp försigtig mot konkurrens

22



”Nu gör vi nyckeltalen entydiga”

25

Min synpunkt

Återkoppling på hög nivå



A återkoppling är en viktig del av kvalitetsarbetet i processindustrin. Det handlar om att identifiera och åtgärda fel i tidigt skede, vilket kan spara stora resurser och förbättra produktkvaliteten. Vi måste se till att återkopplingen sker på hög nivå och inte bara begränsas till operativ nivå.

”Om du inte gör återkoppling på hög nivå, riskerar du att missa de största problemen och förlora möjligheten att förbättra dina processer på ett betydande sätt.”

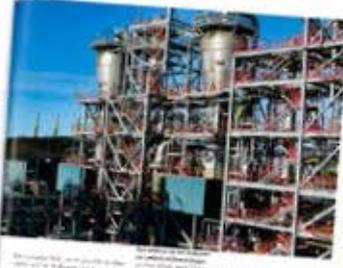


Nu ska nyckeltal bli entydiga

Nu ska nyckeltal bli entydiga. Detta innebär att vi ska se till att våra nyckeltal verkligen mäter det som vi vill ha ut av våra processer. Detta kräver en tydlig definition av målen och en konsekvent mätning av dessa över tiden.

Snabba omställningar vässar Borealis konkurrenskraft

Borealis har lyckats med att snabbt omställa sina processer för att kunna hantera olika typer av råvaror och produkter. Detta har gjort att företaget har blivit mer konkurrenskraftigt på marknaden.



Modviva ett öppet program

Modviva har utvecklat ett öppet program som gör det möjligt för kunderna att integrera sina egna system med Modvivas lösningar. Detta har gjort att företaget har blivit mer flexibelt och anpassningsförmåg.



Kraftfull satsning på processindustrin

Processindustrin är en viktig del av den svenska ekonomin. För att kunna fortsätta utvecklas och konkurrera på internationell nivå måste vi göra en kraftfull satsning på forskning och utveckling inom denna sektor.



De hjälper processindustrin att göra rätt saker i rätt tid

De hjälper processindustrin att göra rätt saker i rätt tid. Detta innebär att vi ska se till att våra processer är optimerade och att vi kan hantera förändringar snabbt och effektivt.



Omprogrammering ökar kapaciteten med 20 procent

Omprogrammering har gjort det möjligt för oss att öka kapaciteten i våra anläggningar med upp till 20 procent. Detta har gjort att vi kan tillgodose våra kunder bättre och mer effektivt.



Processindustrin centrum Linköping

Processindustrin centrum Linköping har blivit en viktig aktör i den svenska processindustrin. Vi erbjuder utbildning, forskning och utveckling för våra medlemmar.



Forskare i satsningsvet Enkel reglerteknisk insats sparar uppemot 200 miljoner

Forskare i satsningsvet har lyckats med att utveckla en enkel reglerteknisk insats som sparar uppemot 200 miljoner. Detta har gjort att företaget har blivit mer konkurrenskraftigt på marknaden.



Processindustrin centrum Lund

Processindustrin centrum Lund har blivit en viktig aktör i den svenska processindustrin. Vi erbjuder utbildning, forskning och utveckling för våra medlemmar.



Executive Summary

The Process Industry Centre, PIC, is a programme for research and competence development initiated in 2008 by the Swedish Foundation for Strategic Research (SSF) and funded jointly by SSF and companies in the process industry.

After a pilot study made by SSF, a national call for proposals, and a thorough selection process, it became evident that no single proposal would be able to address the entire production system in its complexity. Two centres were therefore formed in 2008. The objective of the centres is to stimulate competitiveness and renewal through research and knowledge development geared towards increasing flexibility, controllability and availability in the production systems of the process industry. The process industry is a fundamental sector in the Swedish economy, employing more than 300 000 persons and representing about 50% of the country's export revenue.

The PIC programme has thus included the two centres PIC-Linköping and PIC-Lund and lately also PIC-opic with participants from both centres, together engaging researchers and PhD students in Production Economics, Chemical Engineering and Automatic Control at both Linköping University and Lund University. In addition, close to 20 company partners have participated, several of them recruited along the way, i.e. after the start of the programme.

The core activities of the centre are four; research projects, industrial networking, competence development for industrial staff, and graduate education.

Over the years, the PIC programme has generated impressive results. PIC has had about 200 participants from industry and academia in 8 course modules and 1 two-year master programme, 12 research projects have been running in close cooperation with the 20 industrial partners, 16 individuals have achieved a licentiate or PhD degree focused on the process industry, 7 issues of the PIC:Newsletter and 9 issues of the PICLU:Newsletter have been distributed electronically to a membership list including more than 212 individuals from 35 companies, more than 70 conference papers and 40 journal articles have been submitted, accepted and presented, 2 awards have been given to us, and around 30 presentations aimed at a general public such as branch magazines have been generated, etc.

The two PIC centres each have their own centre management and their own board. PIC-Lund has been led by Prof. Bernt Nilsson together with chairman Inge Pettersson, former CEO of Perstorp AB. PIC-Linköping has been led by Prof. Alf Isaksson and Prof. Joakim Wikner together with chairman Tomas Lagerberg, Department Manager Automation at ABB. The joint project PIC-opic has been led by Ass. Prof. Charlotta Johnsson and Prof. Tore Hägglund. In addition the two centres have been supported by an advisory committee appointed by SSF, Måns Collin och Gustaf Olsson, with Lena-Kajsa Sidén as programme secretary.

PIC has actively participated in the formation and set-up of the new national effort "Process industrial IT and Automation (PiiA)", initiated in 2013. This initiative will further strengthen the process industry, and enable a continuation of the PIC programme activities.

Over the years, many PhD candidates have left the centre with a diploma, heading for an industrial career.

Do not hesitate to contact us if you are curious about PIC and would like to get more information: www.processindustrycentre.se, info@processindustrycentre.se

PIC – providing knowledge for the process industry!



Process Industry Centre and SSF **page 4**



The Process Industry **page 5**



PIC's organisation; PIC-Linköping, PIC-Lund and PIC-opic **page 7**



PIC's activities; industrial network, competence development, research and education **page 6**



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PiiA, Process industrial IT and Automation **page 14**



Academic output from PIC members **page 16**

Process Industry Centre – PROVIDING KNOWLEDGE FOR THE PROCESS INDUSTRY

The Process Industry Centre PIC was founded in 2008 by the Swedish process industry and the Foundation for Strategic Research (SSF), and is located at Linköping University and Lund University in Sweden. The academic disciplines of Chemical Engineering, Automatic Control and Production Economics form the centre together with several industrial partners from the Swedish process industry.

The aim of PIC is to provide knowledge for the process industry to ensure future success.

PIC has four core activities: industrial network, competence development, research, and teaching.

PIC is inspired by the three keywords: Flexibility, Controllability and Availability.



MEMBER COMPANIES



SSF – Swedish Foundation for Strategic Research

The Swedish Foundation for Strategic Research, SSF, was founded in 1994 with a capital of SEK 6 billion. Its remit is to support research in natural science, engineering and medicine and to promote the development of strong research settings of the highest international standards for the purpose of strengthening Sweden's future competitiveness. This is done primarily by means of focused efforts, e.g. framework grants totalling SEK 20–35 million for a five-year period.

The PIC programme is one example of an SSF-funded research project in which universities and industry are collaborating. PIC's Programme Committee, appointed by SSF, consists of: Måns Collin, former CEO of AB Nynäs Petroleum, and Gustaf Olsson,

Professor Emeritus of Industrial Automation, Lund University. Lena-Kajsa Sidén has served as SSF liaison.



Måns Collin



Gustaf Olsson



Lena-Kajsa Sidén

The Process Industry



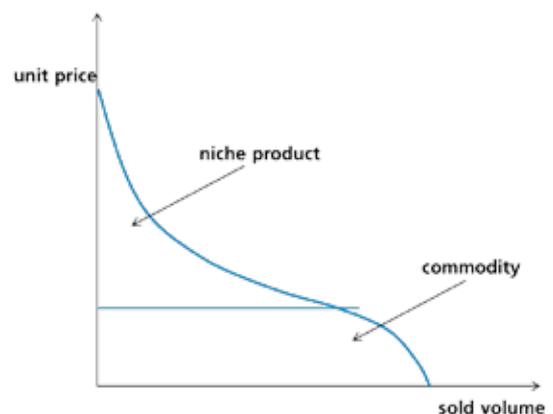
The process industry refines complex raw materials – wood, crude oil, ore and natural gas – into value added products: paper, chemicals, metals, food, etc. The process industry in Sweden employs more than 300 000 persons and represents about 50% of the country's export revenue, making it a fundamental sector in the Swedish economy. The aim of PIC is to ensure the future competitiveness of the Swedish process industry through research and competence development.

The process industry is dominated by raw material and energy costs. Minimising these costs is essential for profitability, making development of process technology and efficient methodologies as important as product development. The same processing equipment being available globally is therefore not the determining factor, instead know-how and process

understanding are key. Product transfers, maintenance, start-up and process control are examples of important issues. A lot of work has been put into process development for the manufacturing industry. Some of this knowledge can be applied to the process industry but there is also a need for new and specific insights for the process industry.

The process industry in Sweden is characterised by the dominance of high-value niche products rather than the standard commodities. Plastics, paper, petroleum products, etc. can all be produced to meet very specific standards. Success in this field requires understanding of the pro-

cess and possible variations in the raw material. Often the manufacturer also has to understand the customer's process in order to manufacture an optimal product and help the customer take advantage of its properties.



Presentation of Programme and Activities

The aim of PIC is to provide knowledge for the process industry to ensure success both now and in the future. This is done through four core activities: industrial network, competence development, research, and teaching.

Industrial network

The membership club PIC:Club and the newsletter PIC:News provide a network for sharing knowledge right now. This is further discussed below.

Competence development

The industrial competence development programme trains those working in the

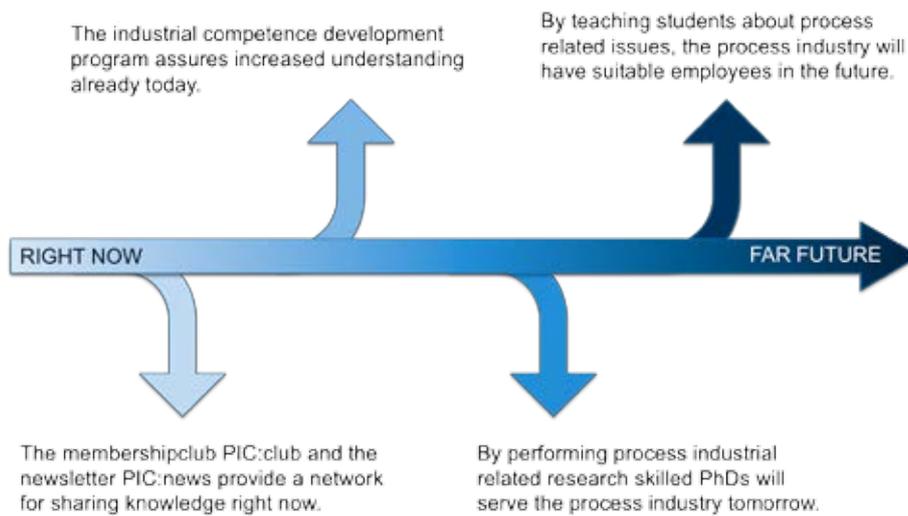
process industry today. This is further discussed on page 8.

Research

By conducting research relevant to industrial partners, skilled PhD graduates with new knowledge will serve the process industry tomorrow. This is further discussed on page 9.

Education

By incorporating issues from the process industry in undergraduate and graduate teaching, the process industry will be able to recruit competent engineers in the future. This is further discussed together with the industry competence development programme on page 8.



INDUSTRIAL NETWORK

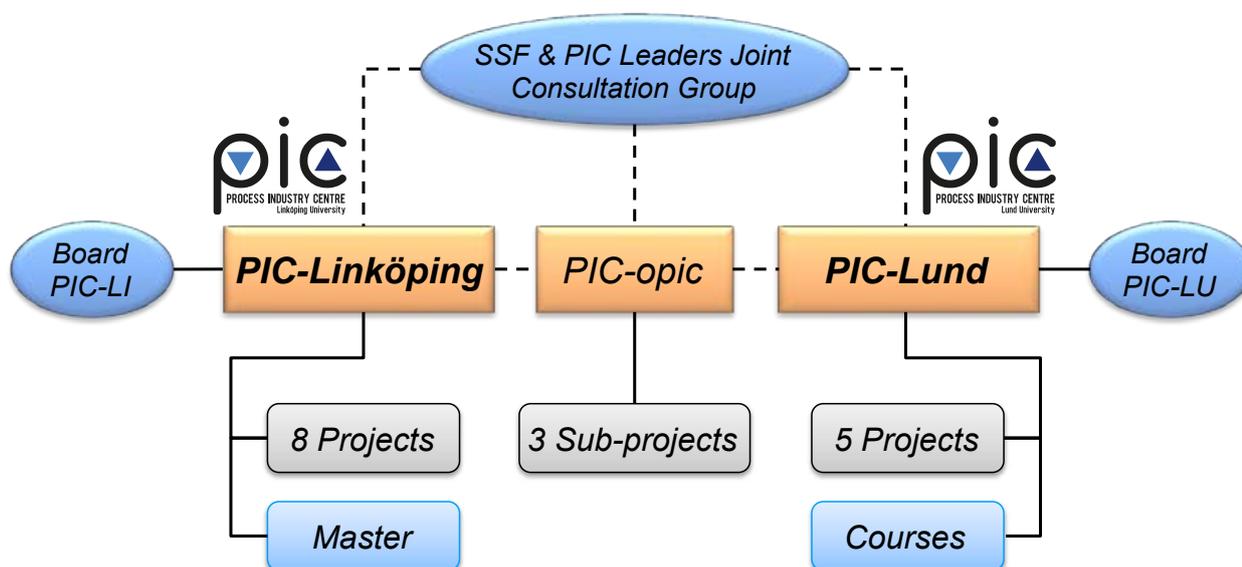
Membership club and Newsletter

Anyone and everyone interested in process industry-related issues is welcome to join PIC:Club and receive the newsletter.

The Newsletter PIC:News is distributed four to six times per year. The Newsletter presents PIC's activities – these could be

project presentations, member company presentations, competence development activities and/or interviews with our members.





PIC'S ORGANISATION

The organisation of PIC is one programme comprising two centre units, i.e. PIC-Linköping and PIC-Lund, and one joint research project, i.e. PIC-opic.

An important goal for PIC is to conduct research in fields of relevance for the process industry. The centres and the joint research project each have sub-projects.

PIC-Linköping

PIC-Linköping consists of researchers from the Departments of Production Economics, Automatic Control, and Optimisation.

Both research and competence development are covered.

PIC-Linköping have research collaborations with several process industry companies: AstraZeneca, ABB, Cloetta, Korsnäs, Nynäs, Perstorp, SSAB, and Södra Cell. The research projects are focused on production and supply chains, bottleneck management, maintenance, and energy efficiency. PIC-Linköping offers a Master's degree in Process Industry Management. The 1-year programme, with yearly acceptance, is open to participants from industry and academia.

PIC-Lund

PIC-Lund consists of researchers from the Department of Chemical Engineering and the Department of Automatic Control. Both research and competence development are covered.

PIC-Lund has research collaborations with several process industry companies and research projects with each of them: Perstorp, Novo Nordisk, Novozymes, KA Rasmussen, Pfizer, Knauer, Siemens, Modelon, and Amgen. The research projects include optimal grade changes, utility disturbance management, quality by design and control, flexible design and fed-batch control.

PIC-Lund traditionally offers competence development courses twice per year; in spring and autumn. One, two, or three different courses are given on each occasion. Participants from both academia and industry are accepted on the courses.

PIC-opic

PIC-opic (Optimisation, Performance, Integration and Control) is a joint research project between the two centres PIC-Lund and PIC-Linköping. The aim of PIC-opic is

integration; both between the decision hierarchies found in the process industry, and the two research centres PIC-Lund and PIC-Linköping. PIC-opic has three sub-projects; buffer management and inventory, performance metrics, and economic optimisation. In all three sub-projects, there has been close collaboration with Perstorp Chemical AB.



COMPETENCE DEVELOPMENT AND TEACHING

PIC offers a set of activities for competence development intended both for industry and for academia. The competence development programme has five parts:

- Master in Process Management (part-time over two years)
- Independent course modules (approx. 1 week)
- PhD courses
- Master's degree project
- Seminars and conferences

Master in Process Management

This Master's programme, managed from PIC-Linköping, is intended for those working in the industry who would like to get an academic education with focus on process industry management. The programme consists of 7 course modules over two years and ends with a master's degree project.

Course modules in the programme:

- Economic analysis and evaluation
- Process Control
- Optimisation in production and supply chain
- Planning, Improving Manufacturing operations
- Process modelling and diagnostics
- Corporate organisation and leadership
- Strategic operations management
- Degree project

Independent Course Modules

The independent course modules are intended for industrial personnel that would like to take a short and focused course in a subject related to the process industry. The independent course modules are managed from PIC-Lund.

Courses given are:

- Control of industrial processes
- Optimisation of industrial processes
- Industrial process simulation
- Advanced process simulation
- Measurement and control techniques
- Process engineering
- Simulation of preparative chromatography
- Process integration in the biopharmaceutical industry

PhD courses

PhD courses are organised for PhD students and industry experts. They are given a few times per year in topics related to the PIC research programme.

Master's degree projects

Master's degree projects are organised together with industry and coordinated and supervised by PIC-Lund and/or PIC-Linköping. All degree projects are publicly available and can be ordered from PIC.

Seminars and conferences

Seminars and related conferences are organised on a regular basis as well as upon request.

Four national PIC conferences have been organised; April 2010, May 2011, May 2013, all in Stockholm (World Trade Center) and May 2014 in Stockholm (Nordic Light Hotel).



Örenäs slott: the venue for an internal PIC conference in 2012.

RESEARCH

One important goal for PIC is to conduct research in fields of relevance for the Process Industry. There are currently three main research nodes, each with several projects; PIC-Linköping, PIC-Lund and PIC-opic.

Optimal Transitions: The project studies grade transitions during continuous manufacturing of polyethylene and start-up of thermal power plants using modelling and optimisation techniques. The project is done in collaboration with Borealis, Modelon and Siemens.

Disturbance Management: The project focuses on minimising the economic effects of plant-wide disturbances in utilities. The project is performed in collaboration with Perstorp AB.

Quality By Design and Control: Development of manufacturing procedures of pharmaceuticals is highly regulated. This project develops methodologies to incorporate model-based engineering tools into the process design of new protein-based pharmaceuticals in collaboration with Novo Nordisk, Amgen, Knauer and Pfizer Health.

Flexible Design: The project focuses on developing a new and alternative separation technology for rare earth elements and precious metals based on chromatography. The project is done in collaboration with K.A. Rasmussen AS in Norway.

Fed-batch Control: The project focuses on developing, improving and optimising fermentation control strategies for the *B. licheniformis* fed-batch processes. The project is done in collaboration with Novozymes A/S in Copenhagen, Denmark.

Buffer Management and Inventories: The project looks at how strategies from inventory management can be used in traditional buffer management within production. A simulation tool has been developed.

Performance Metrics: The project focuses on finding production-related key performance indicators suitable for use in the process industry. Focus is on production, sales and operations planning. The project has included active participation in the international working-group developing the global and industry-related standard ISO 22400.

Economic Optimisation: The project investigates how the economic effect caused by disturbances in utilities (e.g. steam, electricity, cooling water, etc.) can be optimised (i.e. made as small as possible). Algorithms for proactive and reactive disturbance management have been developed.

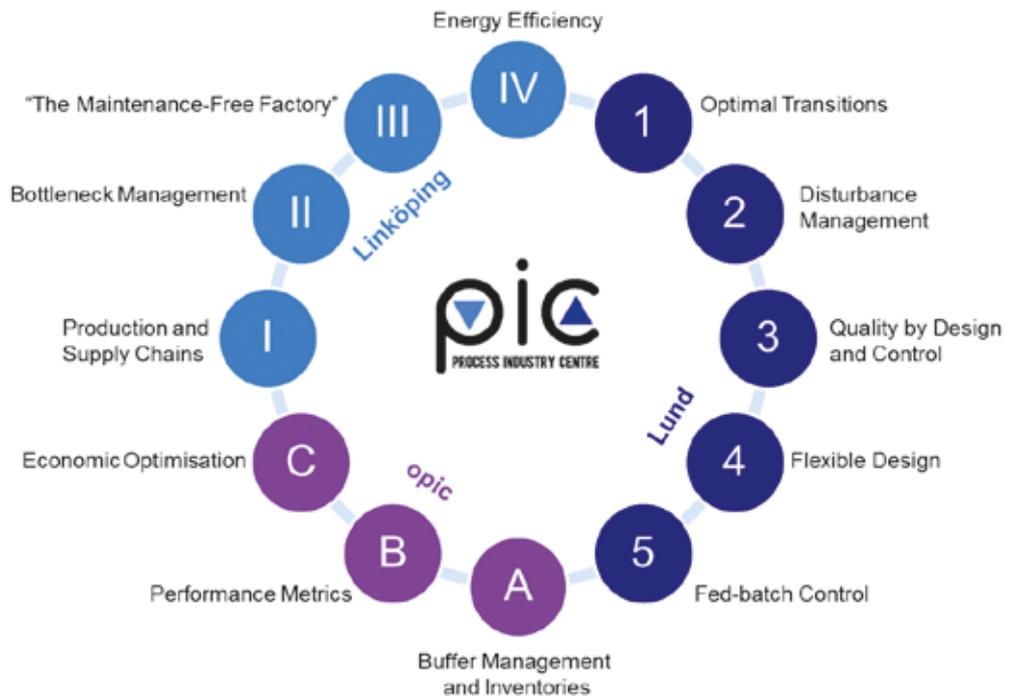
Production and Supply Chains: The material flows in the process industry are challenging to manage since they frequently are of a divergent character, requiring consideration of by-products as well as decisions on optimal product mix. It is however important also to recognise that process industries usually constitute

a hybrid of continuous flows and discrete flows where the latter carry many similarities with challenges in discrete manufacturing industries.

Bottleneck Management: Emphasis on high utilisation is important in asset-intensive process industries. In this context, the bottleneck of the material flow is also constraining the financial result. Managing these finite and constraining resources is supported by applying advanced planning and scheduling systems to use the bottleneck in the best possible way.

The maintenance-free factory: The maintenance-free factory is a vision for many process industries. The concept of availability in the process industry is tightly linked to maintenance and, careful planning of maintenance reduces the impact on availability. The application of holistic frameworks for maintenance is however sparsely used as this research has shown, and production planners have quite a pragmatic approach when considering maintenance in production planning.

Energy Efficiency: Energy plays a key role in many process industries, yet production planning rarely considers the impact of energy either as an input or as an output. By carefully considering energy availability and energy prices in production planning, profitability is improved. Energy aspects are readily included in optimisation of the enterprise as flow in addition to the core material flows.



PIC in Action

One important goal for PIC is to conduct research in close collaboration with companies in the process industry. There have been many companies actively involved in PIC research projects.



Anna Lindholm
at one of Perstorp's
production sites.

PIC RESEARCH AND PERSTORP AB

PIC research on *Disturbance Management* and *Economic Optimisation* has been performed through the project *Hierarchical scheduling and utility disturbance management* where Perstorp has been involved from the beginning as a collaborating partner. The initial idea for the project was established by Charlotta Johnsson at the Department of Automatic Control at Lund University together with Krister Forsman at Perstorp, and the research directions have throughout the PIC years been further discussed and developed in close collaboration between Lund University, Linköping University, and Perstorp.

In the initial phase of the project, Anna Lindholm visited the Perstorp site

in Stenungsund several times to collect data and worked together with Hampus Carlsson at Perstorp. The results from the initial case study at Stenungsund were discussed with personnel at the site.

During the final phase of the project, the research results and future work directions were discussed at meetings with the research members involved both at the universities and at Perstorp. These meetings have taken place both at Perstorp's main office in Perstorp, at the universities in Lund and Linköping, and at PIC conferences.

The collaboration has resulted in several co-authored conference papers, and has given Perstorp valuable insights relat-

ed to production control, scheduling, and plant-wide disturbances in production at their sites.

"Anna's work is almost unique in its ambition to reflect and resolve real world scheduling problems in the process industry, in all their complexity. In my opinion it is an excellent example of how problem-driven research, and cross-discipline research, is much more fruitful and inspirational than technology-driven research", says Krister Forsman, Corporate Specialist at Perstorp AB and responsible for the PIC research collaboration projects at Perstorp.

PIC RESEARCH AND NOVOZYMES A/S

The project *Fed-batch control* has been a collaboration between Novozymes and the Departments of Automatic Control and Chemical Engineering at Lund University. The project was based on an idea by Ola Johnsson at the Department of Automatic Control and Jonas Andersson at Novozymes, with the aim of developing improved control of industrial-scale fed-batch bioprocesses. The purpose of this was to facilitate better productivity and decrease the rate of process failures in this type of process.

The project started with Ola developing and implementing a new control strategy at the Novozymes pilot plant in Bagsværd,

Denmark. After this was shown to be a success, studies in production scale were initiated at the Novozymes site in Kalundborg, Denmark. Modelling and analysis have demonstrated the possibilities for implementation of the strategy in production scale and a decision was recently taken at Novozymes to implement the new control strategy in their production facilities.

Several researchers and MSc students at Lund University, as well as process specialists, technicians and others at Novozymes, have been involved in the project. It has involved meetings at many different levels between university faculty staff and Novozymes employees to jointly contrib-

ute with ideas and ensure that the findings of the project are scientifically and industrially relevant.

“From Novozymes’ perspective this has been a highly rewarding project where the output has been an invention that is easily implementable and brings benefits to our production both in terms of robustness and productivity. Besides the scientific results, the networking opportunities and involvement of different scientific disciplines has also contributed to creating a lot of value in this project”, says Jonas Andersson, product coordinator at Novozymes.

PIC RESEARCH AND SÖDRA CELL



PIC research on *Energy Efficiency* has been performed through the project *Including energy in supply chain planning at a pulp company*. Södra Cell has been involved as industrial partner. In this project Martin Waldemarsson, at the Department of Management and Engineering at Linköping University, focused on mathematical modelling and programming in order to develop a combined supply chain and energy optimisation model. The developed model has taken inspiration from a previous model for integrated production and distribution planning at the pulp company developed by Helene Lidestam (and others). Martin extended and developed the previous model to include decisions on energy mix by choosing the energy input at the pulp

Södra Cell is one of the world’s largest market pulp supplier, with a total annual production of 1.6 million tonnes.

mills. Energy is also introduced as a revenue-generating product on the output side, and the model is extended to use monthly time periods over a 12 month planning horizon.

Martin, supervised by Helene, visited Södra several times and worked mostly together with Albin Andersson, Gustaf Collin, and Jonas Larsson at Södra in order to get sufficient data and material for his research. Results show that when energy-intensive raw materials not only give fibre to the pulp process, but also generate an energy surplus, there is room

for different planning approaches to maximise the total profit. Depending on energy price changes, a prioritisation of pulp products to produce is provided by the model, resulting in managerial implications on when to increase or decrease pulp production.

“Södra Cell AB is a very energy-intensive company in both using and producing energy. It is important for us to find ways to consider the energy aspects when planning our production. The research carried out by Martin has widened our view on the aspects of integrating energy into our planning process. There could be possibilities to develop and refine his proposed model in order to find a model that can be implemented at Södra Cell AB in the future”, says Jonas Larsson, Customer Supply Manager at Södra Cell.

PIC RESEARCH WITH SSAB

The objective of this project, within *Bottleneck Management*, is to develop decision support systems to analyse and optimise the inventory stacking problem in the finished products storage yard, which involves the planning and activities after production and before shipping. As SSAB turns to niche markets, it receives many small orders including various products. Consequently, it lacks space to continue the traditional stacking principle of one slot for products for one customer and one product category. A new stacking policy is proposed by stacking products for different custom-



Daquin Wang (right) together with Johan Wilhelmsson (left) and Ingegård Karlsson (centre) at one of SSAB's production sites.

ers and categories in a mixed way. This is supported by an optimisation model which minimises the potential reshuffles in retrieving products. A simulation tool is developed to analyse different scenarios for handling the dynamics in the storage yard. Since the arrival of products and the retrieval of information are usually uncertain, the benefits of using different kinds of information in stacking decisions are also investigated. We find that reducing the retrieval uncertainty by improving the retrieval plan is more effective in reducing reshuffles than collecting more information on future arriving items.

"We saw the potential of improving the management of our storage yard for finished goods inventory. Thanks to this project, SSAB receives a general picture of how this improvement can be achieved. With the support of the analysis and the proposed model in the project, we will change, step by step, some operations in inbound stacking, outbound retrieving, and inventory control principles of the finished goods," says Johan Wilhelmsson, Manager logistics development Plate, SSAB.

PIC RESEARCH AND NOVO NORDISK



PIC research in the area of *Quality by Design and Control*, has had strong support from Novo Nordisk, a pharmaceutical company in the Copenhagen area.

"Novo Nordisk's participation in this project has enabled us to develop our implementation of mechanistic modelling for process development, opti-

misation and trouble-shooting to a state-of-the-art level within the biopharmaceutical industry," says Arne Staby, Scientific Director at Novo Nordisk, Denmark.

The research has been focused on production issues in protein purification, from fundamental understanding of the process behaviour to methods for formal documentation of control strategies. The research has been conducted in a set of subprojects, with five PhD students and one postdoc. The collaboration can be characterised as mutual long term competence development which has resulted in large industrial co-funding, both in cash and in kind. Characteristics for biopharmaceutical production are high or very high product value, small scale and batch wise production, rigorous and formal production control based on regulatory demands. There is a general need in the industry to increase the level of automation and production efficiency. Novo Nordisk is the leading company in the introduction of model-based design and control, which in many cases is based on the PIC collaboration. To maximise the industrial relevance of the research, the experimental work has, in some cases, been carried out in the industry, using the best facilities and laboratory expertise.



Experimental setup for protein purification.

PIC RESEARCH AND BOREALIS AND SIEMENS

PIC research on *Optimal Transitions* has been conducted together with Borealis, on a polyethylene plant in Stenungsund, and Siemens, Erlangen, on gas fired combined cycles power plants, CCGP.

Production changes in both quality and quantity are interesting problems in larger scale continuous processes. Quality transitions have been studied at Borealis and at Siemens. In the Borealis case, a polyethylene process needs to change between 18 different grades and production changes



Borealis' polyethylene plant in Stenungsund.

are carried out every week. In the project the Jmodelica.org framework is used to implement a model-based transition optimisation.

Gas fired CCGP are being used as a power source for balancing changing power demand. This means that they are started and shut down a number of times every day. Here is a need to do optimal start-ups and to exploit the process behaviour and this current state to be efficient. The subproject focused upon parameter selection and estimation of large models.

JModelica.org is an extensible Modelica-based open source platform for optimisation, simulation and analysis of complex dynamic systems, mainly developed at Modelon AB.

"Modelon's participation in PIC has given us access to two important ingredients to innovate with our computational tools: industrial partners with challenging problems, and world-class researchers to help us solve these problems efficiently. We consider our participation in PIC one of our most successful long-term research engagements," says Hubertus Tummescheit, CEO Modelon Inc.

PIC prototypes

PCS – Preparative Chromatography Simulator: a MATLAB toolbox for analysis and design, developed by the Department of Chemical Engineering, Lund University. Open source software downloadable from the website.

SMBsim – SMB simulation and design tool: a prototype developed by the Department of Chemical Engineering, Lund University.

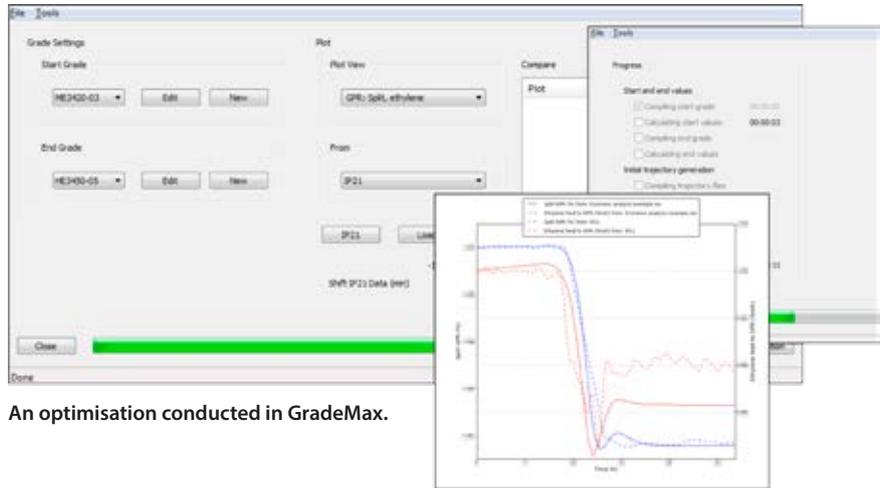
GradeMax – A Graphical User Interface for Polyethylene Production Grade Changes: a prototype developed by the Departments of Chemical Engineering and Automatic Control, Lund University

ParComp – Computer cluster for parallel computing: a demo system using MATLAB, COMSOL and JModelica.org developed by the Department of Chemical Engineering, Lund University.

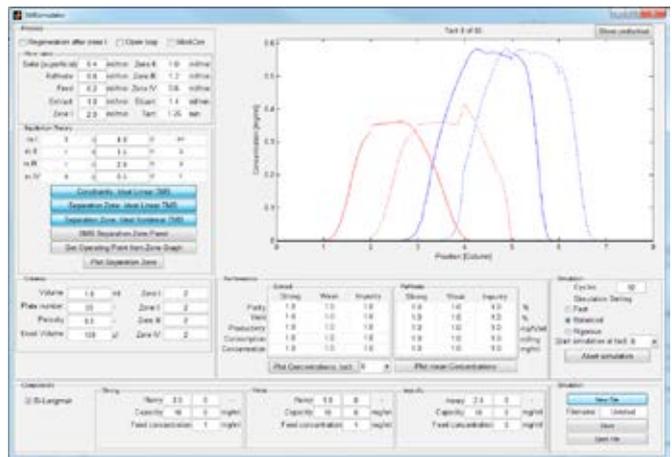
FermControl – Controller for optimal production of a fermentor system: a demo system developed by the Departments of Automatic Control, Lund University.

ACT – advanced chromatography toolbox: a toolbox for parameter estimation, analysis, optimisation and design developed by the Department of Chemical Engineering, Lund University.

UDM – Utility Disturbance Management: a toolbox for proactive utility disturbance management developed by the Department of Automatic Control, Lund University



An optimisation conducted in GradeMax.



Simulation of a continuous protein separation using SMBsim.

PIC Awards



Anna Lindholm and **Pontus Giselsson** received the Best Paper Award for their paper “Formulating an Optimization Problem for Minimization of Losses due to Utilities” at the International Symposium on Advanced Control of Chemical Processes, Singapore 2012.



Helene Lidestam, **Nils-Hassan Quttineh**, **Mårten Ahlstedt** and **Sven Olsson** received the Best Applied Paper Award for their paper “Supply Chain Planning at a Chemical Process Industry” at the annual meeting of the Decision Science Institute, Baltimore, MD, USA 2013.

A Word from the PIC Centre Chairs



**THOMAS LAGERBERG,
CHAIRMAN
PIC IN LINKÖPING**

Today, Sweden is a successful country and our base-industries, with the process industries in front, largely contribute to this success. Our capabilities to extract, utilise and refine our natural reserves have brought us to our current position. Much of our export incomes

result from our process industry. In order to stay competitive and maintain our position as a successful nation, we have to stay at the forefront regarding technology, assure continuous competence development and leverage these competences, and we have to be innovative.

The Swedish process industries continuously have to sharpen their competences and guard their market positions. As a part of this, the development and execution of a master's programme, managed by PIC-Linköping, "Process industry management", is very interesting. The main challenge has been the lack of interest, from the Swedish process industry side, in attending this unique programme. I do not believe that the Swedish process industry already possesses all the competence needed to best face the future challenges. Competence development is important!

I consider collaboration between industry suppliers, academia, and process industrial end-users, vital for the development of new knowledge and creative innovations. The effort made by SSF when launching the process industry centres was definitely an important contribution in this direction. Not least with respect to the coming national long-term investment in Process industrial IT and Automation (PiiA), in which both PIC-Lund and PIC-Linköping played an important role.

Through this joint national effort, we will together be able to bring the Swedish process industry to new innovative heights. I believe we face an interesting future.



**INGE PETERSSON,
CHAIRMAN
PIC IN LUND**

What is needed to be a leading research organisation in advanced industrial processes? The process industry being a multifaceted term, includes production in areas as different as pharmaceuticals, food, paper, chemicals, steel and energy. Despite their differences,

these production processes also have similar needs. When Lund University together with industrial partners, and with financial help from SSF, accepted the challenging task of doing research and providing competence development in this area, a very interesting journey started for me.

After years of experience in the petrochemical industry, I have realised that the need for flexible and controllable processes with high availability, is vital. For the processes to be competitive, these characteristics should co-exist.

Within the framework of PIC-Lund, research has been conducted into various advanced models for how to control the production of pharmaceutical substances, how to perform grade-changes in a plastic production facility, and how to alter the capacity in a thermal powerplant.

Within PIC-Lund, about 10 PhD students have graduated and are now involved in new research projects focused on competence development, or have started a career in industry. PIC-Lund has also collaborated with PIC-Linköping on joint projects. Collaborations are very important. I also believe that other important processes, such as collaboration and gathering of competences, need to be maintained and will ensure new challenges, in new constellations, for PIC.

PIC's future – Process Industrial IT and Automation (PiiA)

Process Industrial IT and Automation (PiiA) represents a national mobilisation in management, innovation, and competence supply. It includes a budget from VINNOVA, the Swedish Energy Agency, Formas, and industry for the period 2014–2016 of about SEK 250 million.

The purpose of PiiA is to foster growth by strengthening the Swedish process industry in the field of IT and automation, while industry suppliers are developing their capacity for innovation. This is achieved through collaboration between three key players:

end users in the process industry, its suppliers, and academia. This collaboration strengthens the competitiveness of Swedish enterprises, where cooperation is developed to attract future talent and lays a foundation for Sweden's continued industrial future. More information about PiiA is available on www.sip-piia.se.





Graduates from the PIC Programme



PhD Thesis:
Design of robust preparative chromatography

Marcus Degerman, PIC-Lund, defended his thesis "Design of robust preparative chromatography" on May 8, 2008. Professor Paulo Mota, Universidade de Lisboa, Portugal, served as the external reviewer.



PhD Thesis:
Optimization of low-level controllers and high-level polymer grade changes

Per-Ola Larsson, PIC-Lund, defended his PhD thesis "Optimization of low-level controllers and high-level polymer grade changes" on Nov 11, 2011. Professor Sigurd Skogestad from NTNU, Trondheim, Norway, served as the external reviewer.



Licentiate Thesis:
Case Studies in Advanced Planning Systems for Tactical Planning in Process Industries

Ola Cederborg, PIC-Linköping, presented his Licentiate thesis on November 1, 2011 entitled "Case Studies in Advanced Planning Systems for Tactical Planning in Process Industries". PhD Roger Lindau, from Chalmers University of Technology, Göteborg, Sweden, served as the external reviewer.



Licentiate Thesis:
On Automation of the PID Tuning Procedure

Kristian Soltesz, PIC-Lund, presented his Licentiate thesis on January 13, 2012 entitled "On Automation of the PID Tuning Procedure". Professor Clara Ionescu from the University of Ghent, Belgium, served as the external reviewer.



Licentiate Thesis:
Energy and Production Planning for Process Industry Supply Chain

Martin Waldemarsson, PIC-Linköping, presented his Licentiate thesis on November 20, 2012 entitled "Energy and Production Planning for Process Industry Supply Chain". Professor Erik Dotzauer from Mälardalen University, Sweden, served as the external reviewer.



Licentiate Thesis:
Averaging level control in the presence of frequent inlet flow upsets

Peter Rosander, PIC-Linköping, presented his Licentiate thesis on June 04, 2012 entitled "Averaging level control in the presence of frequent inlet flow upsets". Professor Morten Hovd, from the Norwegian University of Science and Technology, served as the external reviewer.



PhD Thesis:
Modeling for Quality and Safety in Biopharmaceutical Production Processes

Karin Westerberg, PIC-Lund, defended her PhD thesis on November 16, 2012 entitled "Modeling for Quality and Safety in Biopharmaceutical Production Processes". Professor Nigel Titchener-Hooker from the University College of London, served as the external reviewer.



Licentiate Thesis:
Towards successful integration of maintenance and production

Johan Johansson, PIC-Linköping, presented his Licentiate thesis on December 20, 2012 entitled "Towards successful integration of maintenance and production". Reader Jakob Rehme, Linköping University, Sweden, served as the external reviewer.



PhD Thesis:
Hierarchical Scheduling and Utility Disturbance Management in the Process Industry

Anna Lindholm, PIC-Lund, defended her PhD thesis on October 11, 2013 entitled "Hierarchical Scheduling and Utility Disturbance Management in the Process Industry". Associate Professor Christos Maravelias from University of Wisconsin-Madison, USA, served as the external reviewer.



Licentiate Thesis:
Extremum-seeking Control of Industrial-scale Fermentation Processes

Ola Johansson, PIC-Lund, presented his Licentiate thesis on October 18, 2012 entitled "Extremum-seeking Control of Industrial-scale Fermentation Processes". Dr. Mats Åkesson from NovoNordisk AS, Denmark, served as the external reviewer.



PhD Thesis:
Modeling and Calibration of Preparative Chromatography

Niklas Borg, PIC-Lund defended his PhD thesis on November 22, 2013 entitled "Modeling and Calibration of Preparative Chromatography". Professor Andreas Seidel-Morgenstern, Max Planck Institute for Dynamics of Complex Technical Systems, Magdeburg, Germany, served as the external reviewer.



Licentiate Thesis:
Supply chain coordination using optimal transfer pricing to balance co- and by-product demand within a process industry

Martin Kylinger, PIC-Linköping, presented his Licentiate thesis on April 15 2014, "Supply chain coordination using optimal transfer pricing to balance co- and by-product demand within a process industry". Professor Johan Marklund from Lund University, Sweden, served as the external reviewer.



PhD Thesis:
**Adaptive CPU resource
 management and noise filtering
 for PID control**

Vanessa Romero Segovia, PIC-Lund, presented her PhD thesis on April 23 2014, entitled "Adaptive CPU resource management and Noise filtering for PID control". Dr. Ola Dahl from Enea Software AB. Sweden, served as the external reviewer.



PhD Thesis:
**Parallel computing in model-
 based engineering**

Niklas Andersson, PIC-Lund, defended his PhD thesis on May 9, 2014 entitled "Parallel computing in model-based engineering". Professor Paulo Mota from Universidade de Lisboa, Portugal, served as the external reviewer.



PhD Thesis:
**Modeling and optimization
 of rare earth element
 chromatography**

Mark Max-Hansen, PIC-Lund, defended his PhD thesis on June 13th, 2014, entitled "Modeling and optimization of rare earth element chromatography". Associate professor Jörgen Samuelsson from University in Karlstad, Sweden, served as the external reviewer.



Licentiate Thesis:
**A Framework for Sales and
 Operations Planning in Process
 Industries**

Sayeh Noroozi, PIC-Linköping, defended her Licentiate thesis on June 11 2014 entitled "A Framework for Sales and Operations Planning in Process Industries". Professor Martin Rudberg, served as the external reviewer.

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