Contract No: STRP 505467-1 HIPCON

HIPCON
Holistic Integrated Process CONtrol

STREP
FP6 NMP priority

Publishable final activity report

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Period covered:
from 1 Jan 2004 to 31 Dec 2006

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Project co-ordinator:
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Duration: 3 years

Revision: 1

Project execution

Introduction

The HIPCON project is a 6th framework NMP priority STREP with contract number 505467-1 with 3 years duration from January 2004 to December 2006.

Process industries in today's highly competitive global market must reconsider their production control policies and strategies if they are to achieve sustainable production and increase their competitiveness. In order to attain sustainable and economically efficient production, it is necessary to take a holistic view of process control and management. This can only be accomplished by integrating consideration of product quality, process economy and environmental impact in the next generation process control and optimisation systems.

Objectives

The HIPCON project aims at developing methodology and technology to facilitate transformation of the European industry to adapting holistic process management from a life-cycle perspective. In order to demonstrate the results and measure advantages a prototype software platform for multi-objective optimisation and control will be developed. In the end of the project the system will be implemented and demonstrated at the two case study industries.

The HIPCON project aims at developing methodology and technology for holistic process management from a life-cycle perspective. The project results will support long-term transformation of European industry and promote increased competitiveness and eco-efficiency of the industries. The specific aims of HIPCON are to:

- Develop new parameters for economic and environmental impact of the processes on company and societal level.
- Develop process control and modelling methods for industrial production processes covering product quality, economic and environmental impact of the processes.
- Integrate performance indicators from different disciplines for holistic process management.
- Identify conceptual models and control objectives for the industrial cases. Successful modelling for all industrial cases, linking process status together with economical, environmental and quality performance.
- Produce prototype computer code integrating mathematical models from different disciplines and control strategies for development of a holistic process management system
- Estimate performance improvements from a holistic viewpoint in all industrial cases.
- Disseminate the scientific results through scientific publications and conference presentations.
- Disseminate the results to relevant European industrial sectors through industrial take-up activities such as an industrial reference group, company visits and industrial seminars.

Results

The HIPCON project was created with the idea of developing methodology and a prototype software-package that enables production management accounting for:

- **Product quality**
- **Economical performance**
- **Environmental values**

This is achieved in an integrated approach. It is expected that the future production need to go in this direction, partly due to the increased attention to environmental impact of industrial production. An integrated approach is to avoid sub-optimisation. The software package is a real-time software with an extensive functionality covering:

- **Monitoring**
- **Advanced control**
- **Simulation**
- **Multi-objective optimisation**

The combination of the wide range of functions accounting for product quality, economical and environmental values makes the HIPCON software package unique.

One of the main objectives for the project was to demonstrate the added value of implementing the software at real production processes in full scale. The case study plants in the project were SSAB Swedish Steel in Oxelösund and Henriksdal wastewater treatment plant situated in Stockholm. These companies have also contributed in an important way with real production issues for the project to work on and by generating real process data for modelling.

At SSAB the HIPCON project was focused on the production chain from coke production and blast furnace to the steel making process including casting. A process model that describes the optimal desulphurisation reagent dose was developed and implemented in the HIPCON software in full scale production. The implementation has resulted in cost savings in the range of 5-8 million SEK/year due to reduced calcium carbide usage. The improved control has also resulted in a more uniform iron sulphur content.

Another example from SSAB is a simulation model for the whole production plant that was developed. The model is based on a combination of mass- and energy balances and empirical correlations and estimates. It includes commodities, energy, products, by-products, pricing and environmental performance. Currently this model is used at SSAB to simulate different scenarios and to find out the best operation conditions given certain process states.

A model-based slopping detection system for the steel converter process was developed and successfully tested on process data at SSAB, correctly and timely recognizing 80% of slag overflow occasions. The system uses slag level estimation based on a signal from a microphone located in the off-gas funnel and a recursively updated model describing the relationship between off-gas flow rate, pressure and slag level estimate.

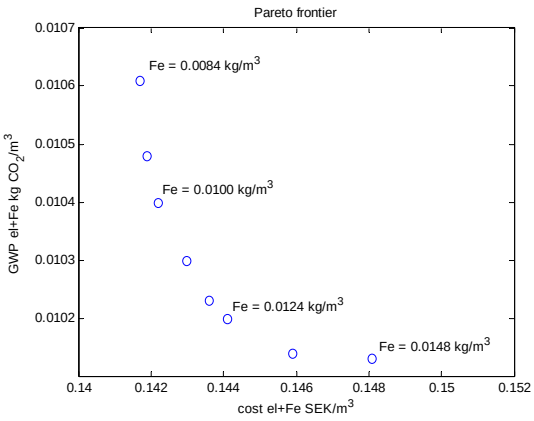

Slopping

At the wastewater treatment plant Henriksdal several different objectives were identified. One of the most important aspects was to reduce the usage of precipitation

chemicals. The precipitation chemical is mainly added to remove phosphorus from the water but it is difficult to measure the phosphorus. Soft sensors were developed that estimates the concentration of phosphorus, nitrogen and COD in the incoming water as a function of parameters that are relatively easy to measure. Using the soft sensors for control of the dosing of precipitation chemical can potentially reduce the use of precipitation chemical about 30%, which corresponds to direct cost savings of 630 000 SEK/year. Less usage of chemicals will also improve the sludge quality since the ferric sulphate being used contains some heavy metals.

The largest single unit energy consumer in the activated sludge plant is the aeration of the biological process. An advanced control strategy for the aeration using a variable aeration volume was developed, implemented and validated in a pilot plant with the same configuration as the full scale plant. The data from the pilot plant experiment indicates that great savings (in the order of 30%) in energy consumption is possible without decreasing the effluent quality. Energy saving in the same order of magnitude at the Henriksdal wastewater treatment plant would imply a yearly saving of about 2 million SEK.

Organic material in wastewater can be removed in either pre-precipitation or in the biological treatment. The precipitation chemical dose controls removal in the pre-precipitation, while the energy needed for aeration (by electric blowers) is dependent (among other things) on the organic matter removed in the biological step. Where is it optimal to remove the organic material with respect to global warming from a life-cycle perspective and cost? And what are the trade-offs? In order to investigate this, multi-objective optimisation methods can be used to produce a so-called pareto frontier that shows how to operate the process optimally from environmental and economic perspective and visualises the trade-offs.



Pareto frontier for the multi-objective optimisation example: the upper point is for all weight to cost objective function while lower/right is for all weight to environmental objective function.

An Industrial Reference Group (IRG) was established by recruiting members from relevant industries. The group consists of representatives from 12 large companies from various industrial fields with a geographical spread over Europe. During the last year, the contacts with the IRG and other relevant industries were intensified in order to disseminate project results and prepare a commercialisation. Various partners of the IRG members have shown a great interest in the HIPCON results and parallel projects have started to transfer parts of the HIPCON approach into their production. In order to meet future demands on software upgrades, support etc the consortium has started the work on setting up a legal entity, with the main task to use the research results on the commercial market.

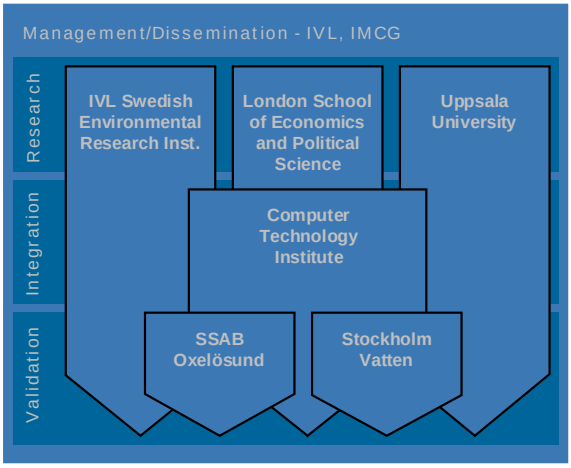
Contact information

Visit the project web site **www.hipcon.org** for information about the project. For further information, contact the project manager at IVL, Jonas Röttorp (jonas.rottorp@ivl.se , +46-8-59856300)

The HIPCON consortium

The development of the holistic process management system requires close co-operation among experts in a variety of fields, e.g. economic, environmental and process modelling, multi-objective optimisation and model based control theory. Integration of the research is of paramount importance.

The consortium consists of 5 partners with expertise in these areas and two case study industries. Contact details and expertise of the partners are given below and the main roles of the partners in the figure.



IVL Swedish Environmental Research Institute, co-ordinator

IVL is Sweden's leading organisation for environmental research. In HIPCON, IVL works primarily with project management, environmental modelling and process modelling.

London School of Economics and Political Science

The activities of London School of Economics and Political Science in HIPCON are in the fields of econometrics and statistics.

Uppsala University, Division of Systems and Control

The division does research in such areas as system identification, signal processing, fault detection and automatic control. UU is responsible for model based control.

Computer Technology Institute (CTI)

CTI specialises in applied research related to computer science. In HIPCON, CTI works with decision support systems and is responsible for integration and implementation.

IMCG Ltd

IMCG is an international management consulting company based in London. IMCG works with dissemination and commercialisation of the project results.

SSAB Oxelösund AB

SSAB is one of the medium-sized steel companies in Western Europe. The steel production facility in Oxelösund is one of the case studies in the project.

Stockholm Vatten AB

Stockholm Vatten produces drinking water and manages and treats wastewater from Stockholm and neighbouring municipalities. One of the company's wastewater treatment plants is a case study in HIPCON.

Dissemination and use

The project aims to develop process control and modelling methods for industrial production processes covering product quality, economic and environmental impact of the processes and to integrate performance indicators from different disciplines for holistic process management. The results have been implemented in prototype computer code of a holistic process management system. The methodology and prototype have been verified at the industrial case studies during the last year of the project. It is expected that the methodology and prototype will have a significant commercial value. The system is open so that new algorithms and methodologies can be incorporated, which means that adaptation to industry specific needs is possible. Productification efforts will be needed after the project before the results can be exploited fully.

Apart from the software prototype itself, the following methods/models for the case study industries implemented in the model are considered to have commercial value:

- Model based soft sensors for WWTP applications
- Method for control of aeration volume in WWTP
- Method for using video camera for detection and quantification of slopping
- Model of process and acoustic data for early warning of slopping
- Process model for accurate predictions of carbide for desulphurisation of pig iron

Industries from the HIPCON Industrial Reference Group (IRG) and other associated industries have started projects that implement the HIPCON concept as a tool for their production management. These new projects will play a major role in kicking off the development of future business and applications. As the projects develop and references are being created, members of the HIPCON consortium are working on setting up a new company to commercialise the results and to meet the future demands on software development, service and support needed for fully functional installations. The new company with associated partners will be the platform for reaching new projects and applications.

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