



# HIPCON

Holistic Integrated Process CONTROL



- A project funded by the 6<sup>th</sup> framework programme of the European Union 2004-2006

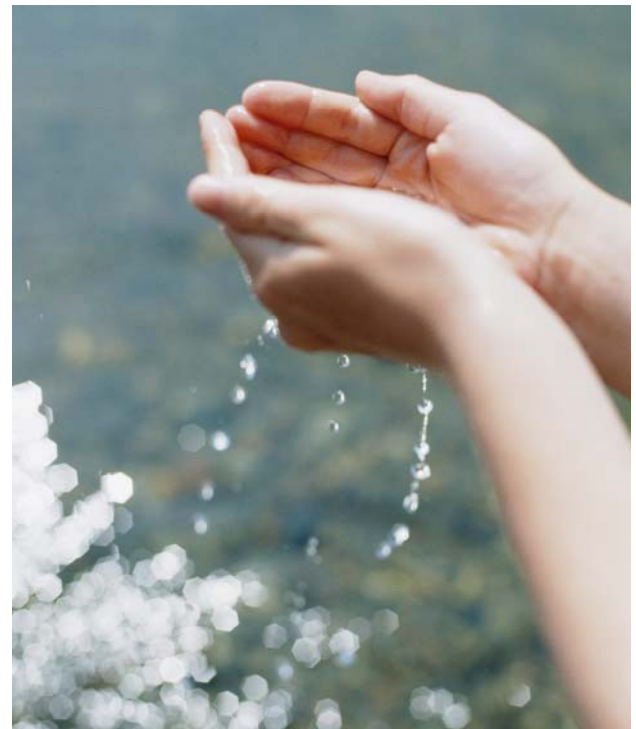
The HIPCON project was based on the idea of developing methodology and a prototype software-package that enables production management with an integrated approach including:

- **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.

An Industrial Reference Group (IRG) has followed the project and has given very useful feed back throughout the project. For some of the industrial partners new projects have been initiated. 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.

# SSAB Oxelösund

At SSAB the HIPCON project was focused on the production chain from coke production and blast furnace to the steel making process including casting.



Desulphurisation of iron is an important process in steel making. Historical data showed that the dosage of the desulphurisation reagent could be optimised, since most of the steel batches used more chemical than needed to reach specification. A process model that describes the optimal 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.

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.



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.



*The consumption of different alloys can be studied in the simulation model.*



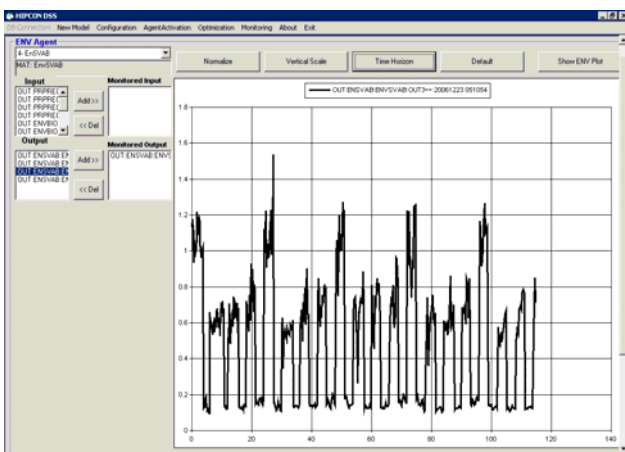
*The HIPCON desulphurisation dose optimisation operator interface*

# Henriksdal wastewater treatment plant

At Henriksdal, precipitation chemical is added to remove phosphorus from the water. However, it is difficult and quite expensive to measure the phosphorus content in the incoming wastewater. In HIPCON, soft sensors were developed that estimates the concentration of phosphorus, nitrogen and organic material in the incoming water as a function of parameters that are easy to measure, e.g. suspended solids, conductivity and pH. 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.



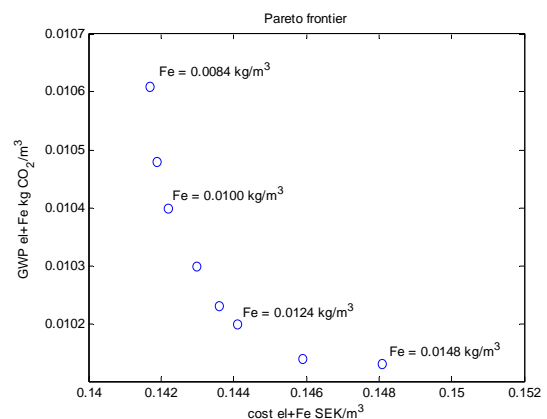
An important objective for the treatment plant was to minimise the usage of energy. The largest single unit energy consumer in the treatment plant is the aeration of the biological process. In HIPCON, an advanced control strategy for the aeration using a variable aeration volume was developed, implemented 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.



Prototype view: Global Warming Potential (kg CO<sub>2</sub>-eq./m<sup>3</sup>) over five days.



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.

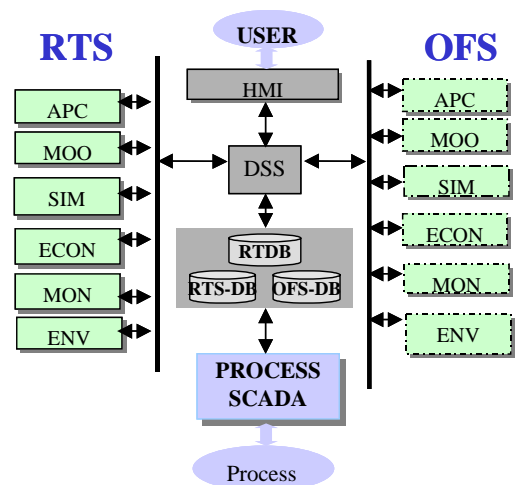


Pareto frontier for the multi-objective optimisation example: the upper point is for all weight to cost objective function while lower/right is for all weight to environmental objective function.

On-line monitoring of process environmental impact with a life-cycle perspective has been established at Henriksdal. The process direct emissions, emissions from production of commodities and treatment of wastes, are all included in the calculation of the environmental indicators. Total impact as well as individual contribution from e.g. electricity use and sludge deposit can be viewed in the prototype.

## The HIPCON software prototype

The HIPCON system is a network comprising distributed agents that are available to support run-time process control as well as off-line simulations. A real-time subsystem (RTS) consists of agents linked to the data base (DB) performing all the on-line functions. The off-line subsystem (OFS) refers to the cluster of off-line models that are useful for simulation purposes and scenario-based reasoning. The different agents have different responsibilities such as advanced process control (APC), multi-objective optimisation (MOO) simulation (SIM) and environmental impact estimation (ENV). The architecture is easily extensible and adaptable to new environments and requirements.



## The HIPCON consortium



### 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.

## More information

More information can be obtained from the HIPCON web site [www.hipcon.org](http://www.hipcon.org) and from the project co-ordinator Jonas Röttorp by e-mail [jonas.rottorp@ivl.se](mailto:jonas.rottorp@ivl.se) or by telephone +46-8-598 563 00.

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