Fulfilled Environmental Specifications by a Comprehensive Coke Plant Operation Management System

Mr. Klaus Damberger, Mr. Gerald Dixon
PSI Metals GmbH

Mr. Klaus Peter Paul Leuchtmann
Uhde GmbH

Contact data

Mr. Klaus Damberger, PSI Metals GmbH
40239 Düsseldorf, Germany
Phone: +49 211 60219-583
Fax: +49 211 60219-240
E-Mail: kdamberger@psi.de

Mr. Gerald Dixon, PSI Metals North America Inc.
Park West One, Suite 200, 1000 Cliff Mine Road
15275 Pittsburgh, PA, USA
+1 412-747-900
+1 412-747-0901
gdixon@psi.de

Mr. Klaus Peter Paul Leuchtmann
Uhde GmbH, Coke Plant Automation
Friedrich Uhde Str. 15
44141 Dortmund, NRW, Germany
+49 231 547-2810
+49 231 547-2440
Klaus-Peter.Leuchtmann@thyssenkrupp.com

Key Words

PSImetals, Coke Plant Operation Management System, Coal Blending Bed, Coal Blending Planning, Technical Data Warehouse, Spare Parts, Operational Log, Cokemaster®, Autotherm™, Manutherm™, RamForce™, BatControl™, PushSched™, GasControl™

Abstract

The Coke Plant Operation Management System is joining data of different coke plant facilities in one system. Operational process data is archived continuously. Material transportations, spare parts, and operation logs and more functions are included. Cokemaster® online process control is integrated. Autotherm™, Manutherm™, RamForce™, BatControl™, PushSched™, GasControl™ are used by operators to control their plant and by the management level for further investigations. Maintenance work is supported by equipment failure reporting and spare part purchase orders. Coal deployment and blending bed planning is used by coal delivery dispatchers and the coke plant management level has access to needed key informations.

Introduction

PSI’s coke plant execution system together with the Uhde online process control system delivers a high level of coke plant automation. Starting with an overview of the software components, the integration with the upper level automation is explained, and the features of the coke plant operation management are discussed. Finally, the operational results of Uhde’s online process control system are presented.

The Schwelgern Coke Plant is located in Duisburg / Germany. It consists of 2 batteries with 70 ovens each. The coke ovens have dimensions of: 8,32 m height / 0,59 m width / 20,8 m length. The coke production is designed for 2,64 million tons per year and covers about 70 % of ThyssenKrupp Steel's coke requirement at Duisburg. Because of its location, directly on the Rhine river, the coke plant is provided with coal by ship from the seaport of Rotterdam / Netherlands. Additional coal transportation by rail is available.

Requirements

There are special characteristics of coke production:
- Coal coking is a continuous process with coking times of 25h and more - during these long production intervals a stable battery operation is a must,
- Coal deployment must be planned ahead to guarantee continuous coke production; coal blending is used to improve the coal quality and to reduce the costs for the coal,
- Regular maintenance intervals to prevent operational delays caused by equipment failures,
- Consistent documentation requirements for statutory regulations.

These factors lead to the following requirements for manufacturing execution systems:
Within the subordinated system. Any change leads to values from Uhde online process control system called treatment, gas refinery, auxiliary plants) and 300 validity values can be switched online or offline within a new version of the respective process value. Process value attributes (low and high limits, engineering units, description) are sent to PSI's coke plant operation management system. Approximately 7500 values from process automation level (coal plant operation management system. Approximately 3000 values are received from subordinate systems and archived in a relational database. Typical measurements are:

- temperatures,
- pressures,
- flows,
- switch positions,
- valve positions.

Archives are available for time resolutions of 1 min, 5 min, 1 hour, 8 hours, 1 day, and 1 month. Actual values are stored together with minimum, maximum, average, sum, standard deviation and the number of valid values. Process value attributes (low and high limits, engineering units, description) are sent to PSI's coke plant operation management system as part of PSIметалs is the overall data acquisition of the different coke plant facilities in one common system. Input data is received automatically from various process automation systems and additionally from Uhde's online process control. Environmental data is part of the data delivered by the process automation level. Automatic reporting of the environmental data documents that the production adheres to statutory regulations. There are standardized and automated procedures within PSIметалs in order to support the documentation of statutory reports as well as documentation of maintenance activities.

Data Acquisition

During continuous coke production the process data are received from subordinate systems and archived in a relational database. Typical measurements are:

- temperatures,
- pressures,
- flows,
- switch positions,
- valve positions.

The focus of PSI's coke plant operation management system is the overall data acquisition of the different coke plant facilities in one common system. Input data is received automatically from various process automation systems and additionally from Uhde’s online process control system. Environmental data is part of the data delivered by the process automation level. Automatic reporting of the environmental data documents that the production adheres to statutory regulations. There are standardized and automated procedures within PSIметалs in order to support the documentation of statutory reports as well as documentation of maintenance activities.

Solution by Schwelgern's Coke Plant Operation Management System

The focus of PSI's coke plant operation management system is the overall data acquisition of the different coke plant facilities in one common system. Input data is received automatically from various process automation systems and additionally from Uhde’s online process control system. Environmental data is part of the data delivered by the process automation level. Automatic reporting of the environmental data documents that the production adheres to statutory regulations. There are standardized and automated procedures within PSIметалs in order to support the documentation of statutory reports as well as documentation of maintenance activities.

Data Acquisition

During continuous coke production the process data are received from subordinate systems and archived in a relational database. Typical measurements are:

- temperatures,
- pressures,
- flows,
- switch positions,
- valve positions.

There is no SCADA or PIMS system needed, i.e. no additional software and maintenance costs.

Besides the continuous acquisition of process data, PSIметалs receives data on events. When a material transport is finished the process automation level transfers the corresponding material transportation data to PSI's coke plant operation management system. This concerns coal, coke and by-product material transports. During the coke plant operation flue gas treatment plants.

The Schwelgern coke plant uses the following components:

- Autotherm™ - automatic measurement of chamber wall temperatures during oven pushing,
- Manutherm™ - manual flue temperature measurement using a hand-held infrared pyrometer,
- Ramforce™ - automatic control of the heating,
- PushSched™ - pushing schedule calculation,
- GasControl™ - model for gas treatment plants.

The Schwelgern coke plant is operated by an automatic pushing and charging schedule. The schedule is generated by Uhde’s process control model PushSched™ and additionally archived in PSIметалs. Coke plant operators use the HMI (human machine interface) provided by PushSched™ whereas the management level and others may get the pushing and charging schedule information using PSIметалs. Production events like “charging”, “pushing” and “levelling” are also archived in PSI’s coke plant operation management system.

Material Balancing

Planning and execution of coal input into Schwelgern coke plant, as well as coke output, are supported by...
PSI’s coke plant operation management system. Normally material tracking starts with the coal input delivered by ship. When a coal ship has been unloaded a corresponding message will be generated within the process automation level and sent to PSImetals. Each coal transport will be reported automatically including coal type, amount and production period.

Schwelgern’s coke plant knows, among other factors, the following material flows:
- coal input by ship to blending bed,
- coal input by rail to blending bed,
- from blending bed to coal tower,
- from coal tower into charging car and charging into ovens,
- coke output, rail loading and transportation,
- by-product output (crude tar, crude benzene, liquid sulphur) transported by truck.

Material tracking is done by process automation and sent to PSImetals for all above mentioned material flows.

Coal Deployment Planning

Coal input is planned by material requirements planners for the coal blending. They schedule coal types and amounts to be delivered by ship and train within the next week. Planning and input is done manually by the planners. Each coal delivery is automatically registered by the automation process and transferred to PSI’s coke plant operation management system where following status information on transport units is displayed:
- planned,
- upstream (on waterway),
- ride at anchor / arrived,
- unloaded.

The delivery dispatcher is thereby informed on coal already delivered and/or unloaded and additional coal delivery planned.

### Coal Blending Planning

Schwelgern’s coke plant operates two blending beds, one in construction (growing with every new coal shipment) and the other taking down (removing coal). PSI’s coke plant operation management system calculates the amount of each coal grade charged on the blending bed. Actual and historical blending bed compositions may be checked by PSImetals users. When information on coal deliveries (grades and quantity) is received from the automation system, the PSI’s coke plant operation management system creates a material flow image of the coal blending. Individual coal transports lead to stockpiling in one blending bed, at the same time loads of coal are reclaimed from the other blending bed or blending bin and delivered to the coal bunker connected to the coke batteries. Thus one blending bed is always in a loading state while the other is being unloaded. The status of both blending beds changes when a blending bed is completely unloaded.

<table>
<thead>
<tr>
<th>blending bed</th>
<th>stockpiling number</th>
<th>status</th>
<th>planned total amount [t]</th>
<th>PSI [t]</th>
<th>imported coal [t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35</td>
<td>planned</td>
<td>80000</td>
<td>20000</td>
<td>60000</td>
</tr>
<tr>
<td>2</td>
<td>34</td>
<td>loading</td>
<td>80000</td>
<td>20000</td>
<td>60000</td>
</tr>
<tr>
<td>3</td>
<td>34</td>
<td>reclaiming</td>
<td>80000</td>
<td>20000</td>
<td>60000</td>
</tr>
<tr>
<td>4</td>
<td>33</td>
<td>finished</td>
<td>80000</td>
<td>20000</td>
<td>60000</td>
</tr>
</tbody>
</table>

A blending bed planning chart displays coal grades specific stockpiles in respective blending beds. Through a graphic display system it is possible to recall information records on past stockpiles, thereby enabling the analysis of coal composition delivered during a given period.
Production Balance

The produced amount of coke is summed up by grade, and this information is eventually transferred to the adjoining steel plant controlling system. The area of carbonisation processing is also integrated in PSI’s coke plant operation management system. Information on material deliveries and shipments to and from carbonisation units is also kept in the system. The coking plant’s total consumption of coke oven gas, natural gas, water etc. as well as the amount of the coke oven gas produced by the coking plant accomplishes the coking plant’s total production balance.

Online Evaluation

The PSI/Uhde systems provide a complete current and historical overview of Schwelgern’s coke plant metrics and operational conditions. Evaluations containing data from different facilities at the same time are available. Additional process values are calculated by a calculation engine. PSI metals system operators define the value together with its calculation formula. Calculated values are archived like measured values and may be used in reports and graphic evaluations. This function may be used also for calculating additional key performance indicators.

The “Technical Data Warehouse” allows:
- process data visualization,
- trendplots custom as needed and pre-configured,
- special Manutherm, Autotherm, Ramforce graphs,
- equipment failure reporting and alarm messages.

Displays containing process data are pre-configured by PSI metals users. Beside current data it is also possible to review past data at a particular point in time that may be of interest.

Trendplot graphics display current and historic process values as a time oriented graph. Pre-configuration and customizing is done by PSI metals users. Access and visibility rights of these evaluation components are maintained by the owner (creator of the evaluation) and PSI metals system operators. This means for example, that operators who are working on coal handling will have access to coal handling evaluations only.

Manutherm™, Autotherm™ and Ramforce™ graphics are based on measurement data gathered by the online process control. The graphic layouts are fixed and will be explained within the online process control chapter (see below). Manutherm™, Autotherm™ and Ramforce™ measurement data are available on the PSI metals to all coke plant personal. Especially the plant managers are interested in a long term archive for process monitoring, optimisation and historical surveys. If there are limit violations this will be reported by sending an SMS or an e-mail to the coke plant operation.

Equipment failure reporting is very important for maintenance. At least once a day the electrical and mechanical maintenance teams get their corresponding failure report as input for their maintenance work. If there is a spare part needed, the maintenance person can get information about the spare parts available on site or if a new spare part has to be ordered externally.

Spare Parts

The functional unit spare parts yard contains typical spare part description data and further information on actual stock level for each spare part. Every usage of a respective spare part is followed by a corresponding availability control of the remaining stock level for that spare part. If the stock level falls below reorder point a refill purchase order for the respective spare part is issued.
Through information on actual stock levels and inventory variations (due to build up and removal of spare parts) the operator is fully informed on stock movement history.

Operation Log

Government reports which have to be completed by the coke plant operation are automated by PSI’s coke plant operation management system operation log. Documentation of the current situation is done as well as the archiving and retrieval of historical operating data.

During the configuration procedure of the report, the name, description, time period, technical operational entity etc. is defined according to the governmental instructions. Pre-configured templates may be stored together with the configuration. PSI’s coke plant operation management system checks these configurations on a periodic basis for open issues. If open issues are found the coke plant operator will be informed by an SMS or e-mail. This is done some days in advance, allowing the operator to do the necessary work until the government report has to be delivered. When the operator has finished the required inspections he saves this document as an attachment in PSI’s coke plant operation management system. These attachments are recalled later for delivery to the regulating authority.

PSI’s coke plant operation management system operation log is not only used for government reports. The Schwelgern coke plant maintenance reports are also included here. There are periodic maintenance tasks to perform as part of preventive maintenance.

PSImetals generates (configurable) system reports either automatically or at operator request. The reports can be displayed on screen shots or printed (in PDF-Format) as lists or attached as PDF files in an e-mail. All reports are highly configurable. It is possible to insert new reports or to create new ones by modifying and extending the existing ones. Reports can also be adapted to new operational circumstances. Updating of reports after modification of report parameter or formulae is performed automatically.

Coal receipts reports

These reports deal with special functions concerning coal requirements and blending bed plans such as:
- Unloading coal grades from ships.
- Discharging coal grades from railroad,
- Reporting on daily coal supply,
- Grades build up in coal blending bed.
Shift, daily and monthly reports

PSI metals maintains Shift, daily and monthly reports as follows:

- Coking plant daily report,
- Daily report on material transports,
- Monthly supplies to by-product plant,
- Monthly discharges from by-product plant,
- Monthly coking plant report,
- Energy balance,
- Energy estimation.

- Actual,
- Aim schedule,
- Morning shift schedule (06:00),
- Afternoon shift schedule (14:00),
- Night shift schedule (22:00).

The long time archiving of the shift schedules are done on PSI metals as well as the distribution to the coke plant operation.

### Table: KBS

<table>
<thead>
<tr>
<th>Week</th>
<th>Actual</th>
<th>Actual</th>
<th>Actual</th>
<th>Actual</th>
<th>Actual</th>
<th>Actual</th>
<th>Actual</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Fig. 9: Monthly report on supplies to carbonisation plant

### Fig. 10: Monthly report on output of carbonisation plant

### Fig. 11: Pushing and charging schedule

### Online Process Control

The online process control is done by Uhde's CokeMaster® components featuring:

**ManuTherm™ - Manual Heating Flue Measuring System**

The optical pyrometer ManuTherm™ is a newly designed instrument to take manual temperature readings on a coke oven battery. The new feature is the combination of an infrared pyrometer device to take the temperature readings with a data store memory in one high quality, heavy duty instrument. ManuTherm™ has been developed to speed up and simplify the extensive work of the temperature measurement on the heating flues, the temporary storage of the data on the oven top and the evaluation of the data in the heating control office. The pyrometer is specially designed for easy handling while taking multiple crosswall and longitudinal temperature readings in one measuring sequence.
The heating flue temperatures are measured through the inspection holes by the ManuTherm™ pyrometer and stored in the integrated data store. Back in the heating control office these data are transmitted to the evaluation PC by an infrared interface to avoid plugs and openings in the pyrometer body. The ManuTherm™ evaluation software makes it possible to evaluate and archive longitudinal, serial, and crosswall measurements apart from data acquisition. Plant-specific data like heating type, number and designation of batteries, walls and heating flues as well as measuring routes for the relevant measurement can be assigned to each measurement. The most recent ManuTherm™ graphics can be displayed on the CokeMaster® HMI to the operators for process control and as a trouble-shooting tool, but are also available on PSI’s coke plant operation management system to the plant managers in a long term archive for process monitoring, optimisation and historical surveys. Either crosswall or longitudinal heating flue temperatures may be displayed. Crosswall measurements consist of 40 measurements, one for each heating flue of one oven. Longitudinal measurements consist of 71 measurements, for all walls of the battery.

A ManuTherm™ evaluation example for two crosswall readings (same wall measured on different days) is shown in the graph below:

Measuring data transmitted to the PC are checked for plausibility by comparison with reference data to detect heating adjustment problems which may lead to bad coke quality and pollution during pushing. Several valuable types of evaluations are possible. Average curves from multiple measurements can be made and compared against each other, heating flue temperatures „out of range“ or outside of limit or reference curves are detected, the temperature „slope“ is analysed and alarmed if the temperature increase from pusher side to coke side is not ok, etc.

**AutoTherm™ - Automatic Coke Temperature Measuring System (on Oven Wall)**

To evaluate the battery temperature as well as the individual temperatures of each oven, various automatic temperature measurement systems have been developed by UHDE. The Schwelgern Coke Plant has decided to use the AutoTherm™ system because it provides the most reliable and exact readings. The system has been ingeniously engineered into the new pusher machines with minimum efforts and investment costs.

The AutoTherm™ System is a coke chamber wall temperature measurement system via air cooled fibre optic cables and attached pyrometers mounted on the “cold” rear end ram beam of the pusher car. The temperatures of the walls are measured when the ram passes through the oven. They are converted and evaluated to enable the supervision of the temperature and heat distribution of the battery in longitudinal, transversal (crosswall) and vertical direction. Average curves from multiple measurements can be made and compared against each other, heating flue temperatures „out of range“ or outside of limit or reference curves are detected, the temperature „slope“ is analysed and alarmed if the temperature increase from pusher side to coke side is not ok, etc.

This means, the system checks at regular intervals the temperature distribution within the battery block to detect misadjustment of the under firing system which may lead to undercoking of the coal in specific areas of the coke mass resulting in bad coke quality.
and pollution during pushing. Besides alerting to problems in the crosswall, the vertical temperature distribution is especially important in high oven chambers. This is achieved by a long flame over the full height of the flue. The flame is influenced by the gas and air distribution to the heating flue which has to be properly adjusted. Changes in the air distribution (i.e. changes in the stack draft) without proper countermeasures may have disturbing influences to the length of the flame (vertical heat distribution) and ultimately may lead to uneven coking, to roof carbon, and worst of all ultimately to “sticker ovens”. Autotherm™ is able to quickly detect vertical heating problems while taking temperatures in three levels of the oven chamber during each push. Detection of these problems helps to improve the heating system which leads to better environmental protection, higher coke quality, higher production efficiency (=gas/energy savings) and less stress to the brickwork (= longer service life of the battery).

The following example shows the temperature distribution of the battery, sliced thru one vertical layer in one comprehensive overview. The colored segments shaped like a mosaic show the heating flues. The color itself is a measure for the temperatures, whereas each color represents a specific temperature range. The temperature scale starts with dark brown colour (<900 °C) up to white colour (>1250 °C). The example below shows a very good and even temperature distribution in all wall sections with just a very few areas to be monitored in detail.

The most recent Autotherm™ graphics can be displayed on the CokeMaster® HMI to the operators for process control and as a trouble-shooting tool, but are also available in PSI’s coke plant operation management system to the plant managers in a long term archive for process monitoring, optimisation and historical surveys. The graphs display the crosswall chamber wall temperatures and consist of 40 measurements, one for each heating flue of one oven. In contrast to the Manutherm measurements, there are 6 temperature curves, because Autotherm measures the left and right chamber walls at low, middle and high levels of the walls. Also different is the temperature range. Chamber wall temperatures are appr. 150 °C to 200 °C lower than heating flue temperatures, representing the surface temperature of the process medium, the coke.

Fig. 15: Evaluation Software - AutoTherm™ Battery Temperature in one Level

Together with the chamber wall temperatures (Autotherm™), measured while the pusher ram pushes the coke out of an oven, simultaneously the torque needed for this action is measured on the ram drive motor. This torque is provided from the frequency converter unit which controls the motor speed and motor torque and is converted in the CokeMaster® system into a pushing force. The system is called Ramforce™ and provides excellent informations about the mechanical maintenance situation of the ram drive system and the coking condition of the coke cake. If the ram force increases over a period of time, a mechanical or a heating problem can be assumed and calls for attention and further evaluation for trouble shooting. Most recent Ramforce™ graphics can be displayed on the CokeMaster® HMI to the operators for process control and as a trouble-shooting tool, and are also available in PSI’s coke plant operation management system to the plant managers in a long term archive for process monitoring, optimisation and historical surveys. These values are measured while the pusher ram pushes the coke out of an oven. Reference curves are archived and used as upper limits for each new pushing force measurement. If there are limit violations this will be reported by sending an SMS or an e-mail to the coke plant operation by PSI’s coke plant operation management system.

Fig. 16: AutoTherm™ curves
BatControl™ - automatic control of the heating situation

The Battery Heat Quantity Control (BatControl™) System is designed as shown in the below benefit graph.

A theoretical heat calculation model determines the required underfiring heat (Qcalc). This heat is corrected by the actual production performance (correcting for delays, “speed up”, lost production, etc.) and the actual heating performance (correcting for heating flue (HF), coke or wall temperatures which are outside the target range). The calculated heat (Qcalc) dynamically corrected by production and heating performance (Qcorr) will determine the set point for the underfiring heat required (Qset). The actual underfiring heat (Qact) can be influenced by changing the heating gas flow, the calorific value of the gas (by mixing) or the heating time (by making a pause during reverse). The above figure shows the model concept.

Usually, a combination of pause time and flow (pressure) control is used to control the actual underfiring heat. The base heat quantity is controlled by benefiting or decreasing the “time on gas” (pause time heating). Fluctuations in the actual heat input (by fluctuations of the gas quality) are continuously compensated by the underfiring gas flow (pressure) controller to reach exactly the desired heat quantity in one reversing cycle (calculated by the model).

Typical Trend Plot – changing coal moisture

The above figure is a trend graph of the heating control results. Whenever the coking time (CT), the quality of the heating gas, the quality and quantity of the coal or battery temperature (measured by Manutherm or Autotherm) changes, the heat quantity control reacts by creating a new underfiring heat set point (Qset) mostly by changing the pause time. In the example given, the pause time is increased from 120 to approx. 165 seconds by the heat quantity model to match a declining heat demand (Qset) due to a general decrease in the coal moisture from 12 to 7%. The coal moisture is measured on-line by an automatic moisture analyser installed above the supply belt running into the coal bin... Keeping the underfiring heat quantity under control will ensure less heat consumption and a quick and automatic response to operation troubles. This will keep the battery temperatures in balance, reducing heating problems and avoid pushing emissions.

PushSched™ - Pushing and Charging Schedule

To supervise and manage the oven machine operation, a sophisticated Pushing and Charging Schedule System (PushSched™) has been developed. Based on actual oven status a new schedule will be calculated after each oven pushing, taking into consideration aim operation parameters (coking time) and special oven status (idled, stop operation, goes into operation, on delay, etc.). The next figure shows the operation interface mask for a 5/2 schedule. All necessary pushing and charging operations, i.e. last pushing time, next pushing time, last coking time, next coking time, time in cycle, charging weight, special oven operations for repairs, machine interlocking...
and operating modes, etc. are shown. The coking progress is displayed in bar graphs and various reports.

![Fig. 20: PushSched™ Operation](image)

In this picture, the dark greens are “ready to push” and the yellow bars are ovens recently charged. The operation is on oven no. 38 which was just pushed and waits to be charged. The red bars indicate soaking ovens. The purple bar on oven 16 shows an oven scheduled to stay out of operation in his next cycle. The pushing and charging schedule is interconnected with the machines and each machine will only act according to the schedule. Every machine activity automatically triggers a recalculation of the complete daily schedule, will update the schedule and activate the next operating cycle. Besides the on-line control of the machines as described above, a simulation mode is available and can be used to perform operational planning for five days in advance without interfering with the actual operation.

The Pushing and Charging Schedule System on the CokeMaster® model computer continuously calculates the “next oven to push” and “next oven to charge” and send these data to the PROven® system (PROven=Pressure Regulated Oven) to execute the disconnection of the oven from the collection main (for pushing) or execute the reconnection of the oven to the collection main (for charging). The pushing and charging schedule is closely linked to the PROven® System to enable automatic operation of the oven machines and to optimize the control of the oven pressure setpoints. The system releases the operator from complicated and time consuming scheduling work, thus making the scheduling and plant operation more safe, smooth and close to the target. It provides an important input parameter to the Battery heating control system (BatControl™).

![Fig. 21: Data Communication for BatControl/PushSched and PROven](image)

The layout and interlocking of all systems is shown in the following diagram.

**GasControl™ - Process Model for Gas Treatment Plants**

In the gas cleaning plant area mainly closed loop control functions are realised in the Distributed Control System (DCS). The DCS usually displays the process values and realises the closed loop control with PID controllers. Adjustment of the local controllers is done by the operator, who has to adjust the controllers to new operation conditions manually based on his operation experiences, not always with the best results. Uhde has developed a process model system to calculate the controller setpoints automatically. Optimisation of the gas cleaning plant can only be done by placing a higher level control strategy on top of the local controllers. Cyclically, this higher level controller will be re-adjusting the nominal values of the existing local single loop controllers.

The utilisation and adjustment of the local controllers to the environment of the gas cleaning plant, especially the H2S/NH3 Scrubber, Deacifier, Ammonia Still, H2S04-plant, Saturator, Final Cooler, and Naphthalene Removal plant, is done with a dynamic column simulation model. The “dynamic column simulation” (further called GasControl™) calculates on-line the current operation condition of the above described gas cleaning plant units by using the on-line process values from the DCS as input values. These input values are used to calculate mass balances, energy and chemical balances as well as phase balance from column tray to column tray for each column.

With this the GasControl™ can (based on the actual process values) calculate the cleaning efficiency, energy consumption, environmental balances etc. for a given time period in advance. Depending on the targets defined by the user of the system, the GasControl™ calculates the setpoints for the given process
controllers. Using the process reactions on each controller setpoint change, the GasControl™ for example automatically calculates the best setpoint for each single loop controller (steam flow rate, water to condenser, etc.) to reach the optimum operation results (e.g. NH3-remains, minimum steam flow, etc.) with minimized efforts or constraints (e.g. energy, resources, pollution, etc.). With this approach it is possible to optimize and control especially all plant units which are dead time effected and which have non-linear reaction characteristics.

Since only the standard process values as column top temperatures, steam volume, cooling water flow, crude gas quantity, etc. are used as input and output values to the model, no special and expensive on-line analysers are needed for the GasControl™. The capital investment costs for sophisticated analysers are reduced accordingly.

The GasControl™ can be used as a simulation tool as well. An exact copy of the on-line model but with a separate user interface is used and a “snapshot” of the actual process and operation status is copied into this “off-line” model. Now, the user has a virtual plant at hand and can experiment by setting values by hand or using pre-configured simulation strategies, running as batch jobs, watching how the virtual plant behaves. An example for a simulation strategy would be to set raw gas flows in a cyclical way. The simulation strategies can be modified by the user as needed for testing and training purpose. The configuration of the GasControl™ system including the Simulator (called SimuGas™) is shown in the following figure.

The GasControl System optimises individual control loops or plant units in accordance with clear-cut requirements (e.g. highest possible benzole scrubbing in BTX scrubbing unit) without any economic consideration. It is up to the plant operator to manually set the requirements for each control loop in the Gas-Control System individually until the overall economic efficiency has been reached (in the a.m. example operators themselves would have to calculate whether the proceeds from higher benzole scrubbing are at all economic in view of the current price for consumables). This optimisation surely is technically beneficial for an individual plant unit, but maybe less optimal for the overall plant economics.

Therefore the process model has been expanded with an additional feature called EuroOpt™. The economic optimum is determined in an evolution process. Numerous mathematical computations are done to determine the exact optimum from the view of economic efficiency based upon costs of consumables, profit for products and still keeping the process in close control.

**Conclusion**

PSImetals coke plant operation management system in combination with Uhde’s online process control is a powerful software solution. From coke plant operation
level up to the coke plant management PSImetals is used. And the application is still extending to satisfy the users’ requests.

**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autotherm™</td>
<td>Automatic measurement of chamber wall temperatures during oven pushing</td>
</tr>
<tr>
<td>BatControl™</td>
<td>Automatic control of battery heating</td>
</tr>
<tr>
<td>CokeMaster®</td>
<td>Online process control system</td>
</tr>
<tr>
<td>DCS</td>
<td>Distributed Control System</td>
</tr>
<tr>
<td>EuroOpt™</td>
<td>Economic Optimization Model</td>
</tr>
<tr>
<td>GasControl™</td>
<td>Model for gas treatment plants</td>
</tr>
<tr>
<td>HF</td>
<td>heating flue</td>
</tr>
<tr>
<td>HMI</td>
<td>Human machine interface</td>
</tr>
<tr>
<td>KBS</td>
<td>Schwelgern Coke Plant Operating Company</td>
</tr>
<tr>
<td>Manutherm™</td>
<td>Manual flue temperature measurement using a hand-held infrared pyrometer</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>PDF</td>
<td>Portable Document Format</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>PID</td>
<td>Proportional-Integral-Derivative Controller</td>
</tr>
<tr>
<td>PIMS</td>
<td>Plant Information Management System</td>
</tr>
<tr>
<td>PROven®</td>
<td>Pressure Regulated Oven</td>
</tr>
<tr>
<td>PushSched™</td>
<td>Pushing schedule calculation,</td>
</tr>
<tr>
<td>Qact</td>
<td>Actual heat quantity</td>
</tr>
<tr>
<td>Qcalc</td>
<td>Calculated heat quantity</td>
</tr>
<tr>
<td>Qcorr</td>
<td>Dynamically corrected heat quantity</td>
</tr>
<tr>
<td>Qset</td>
<td>Heat quantity setpoint</td>
</tr>
<tr>
<td>RamForce™</td>
<td>Pushing resistance measurement</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control and Data Acquisition</td>
</tr>
<tr>
<td>SimuGas</td>
<td>Simulation System for Gas Treatment Plants</td>
</tr>
<tr>
<td>SMS</td>
<td>Short Message Service</td>
</tr>
</tbody>
</table>

**Acknowledgements**

We wish to thank KBS for their support during installation and operation of our coke plant operation management system.