Operational Efficiency with SIMATIC PCS 7

SIEMENS

White Paper

Which contributions to "operational excellence" and efficient operation of process plants can be expected from automation with SIMATIC PCS 7?

September 2011

You want to maximize throughput, availability and product quality of your plant, and at the same time minimize operating costs and maintenance costs, energy consumption and raw material consumption, off-spec product and emissions, safety risks and environmental pollution?

This whitepaper gives a survey, which functions, features and add-on products are offered by SIMATIC PCS 7 to reach these goals: from transparent process operation, supervision of product quality and performance indicators to process optimization, from simulation and operator training to safety, security, service and support.

Contents

1 Introduction

In general, efficiency describes a result in relation to the effort or resources needed to achieve it, in mathematical terms, efficiency is a quotient of the valuable result and the resources consumed.

Typical examples for efficiency indicators are efficiency factor as a ratio of performance and consumption, or energy efficiency as a ratio of production amount and energy consumption.

Companies operating process plants are concerned with economic efficiency of plant operation as ratio of earnings and costs. All factors that contribute to the numerator of this fraction have to be maximized: throughput, availability and product quality. All factors that contribute to the denominator of this fraction have to be minimized: operating cost and maintenance costs, energy consumption and raw material consumption, off-spec products, emissions and garbage amounts, safety risks and environmental pollution.

$$\begin{matrix} \mathit{operational} \\ \mathit{efficiency} \end{matrix} = \frac{\begin{matrix} \mathit{throughput}\uparrow \\ \mathit{availability}\uparrow \\ \mathit{product\ quality}\uparrow \end{matrix}}{\begin{matrix} \mathit{operating\ costs}\downarrow \\ \mathit{maintenance\ costs}\downarrow \\ \mathit{energy\ consumption}\downarrow \\ \mathit{raw\ material\ consumption}\downarrow \\ \mathit{off\ spec\ product}\downarrow \\ \mathit{emissions}\downarrow \\ \mathit{safety\ risks}\downarrow \\ \mathit{environmental\ pollution}\downarrow \end{matrix}}$$

In other words [3.]: "Operational efficiency is the ability for an organization to execute its tactical plans while maintaining a healthy balance between cost and productivity. In other words, it's your ability to get things done without costing the company an arm and a leg.

In the following sections, individual aspects of process automation are discussed, that have a direct impact on economic efficiency, e.g.

- Alarm management,
- Advanced process control,
- Asset management,
- Performance monitoring and KPI calculation,
- Energy management,
- Simulation,
- Safety and Security,
- Service and support,
- Innovative application know-how,
- Standard- and sector-specific libraries, incl. control modules.

The goal is to offer a first quick survey of the topics addressed. More detailed information can be found in the literature cited in the text, e.g. dedicated whitepapers on individual topics.

2 Transparent Process Operation

The distributed control system (DCS) is the "window to the process", the human-machine interface. Any action in the process plant can be operated and controlled via the DCS. The ergonomic and clearly structured graphical user interface of SIMATIC PCS 7 [1.] offers an excellent overview of the entire production process and provides safe and comfortable process operation - in process plants of any size.

Considering the overall supply chain of a production plant from raw material supply via production to product delivery, the production itself is the central step, and the DCS is the central data source for information on production. The integration of the DCS into the IT processes of supply chain management is the foundation of cost transparency in production, such that the financial effect of specific operation sequences can be accounted or predicted.

In the following sections several topics will be addressed that are relevant to transparent process operation.

2.1 Advanced Process Library

The "Advanced Process Library" available since PCS7 V7.1 is developed based on the PCS 7 Standard Library, and considers long time experience of engineering experts and plant operating companies, current Namur recommendations (Namur: "Interessengemeinschaft Automatisierungstechnik der Prozessindustrie", international user association of automation technology in process industries, http://www.namur.de) and PNO specifications (PNO: Profibus user organization, http://www.profibus.com/community). Comfortable, visually attractive graphical user interfaces make interaction with the process plant easy. The Advanced Process Library offers a lot of new features to improve process operation, e.g.:

- Process values are treated as data structures with measured value and signal status (according to PROFIBUS PA profile e.g. "good", "uncertain", "bad", "simulated"), and the complete data structures are wired in continuous function charts (CFC). Value scale and physical unit are also linked from the channel input drivers to the following signal processing function blocks.
- Different behaviour patterns of a function block can be selected via feature bits.
- New operating modes "Out of service" (deactivated for maintenance) and "Local operation" are supported by all function blocks.
- Block internal simulation of measured values (manual input of process values in faceplate) and block external simulation (simulated values are linked to channel drivers and temporarily used instead of real measured values).
- New faceplate views: "Preview" shows state information e.g. on linked signals or automatic commands that are not yet active, view "Notes" stores temporary information of operators that can be delivered to following operators, or can be collected as function block related operator know-how.
- The interlock function blocks show the causes for interlocks and offer manual override.
- Additional free message input variables of function blocks and the management and display of additional user-defined analog-values in faceplates offer possibilities for individual extensions of function blocks.
- New function blocks e.g. dosing function, motor with frequency converter, two-way valve and control valve have been developed based on user requirements.
- Embedded Advanced Process Control (cf. section 4.1) augments the opportunities for optimization of process operation and feedback control.

Operator Station (OS)

- There are several variations of each function block picture symbol for the OS, e.g. especially compact or very informative.
- Direct links from one faceplate to another can be realized using buttons. Some direct links are automatically generated based on the connections of function blocks, e.g. from a PID controller function block to the related control performance monitoring block.
- For any operation in a faceplate, a standard operation area is opened below the faceplate. The operation area can also be

opened directly from the picture symbol, without the need to open the faceplate first.

- Each analog value in a faceplate shows symbolically if it can be operated, if the related messages are suppressed and which is the current status value.
- Two-step or three-step operation of values can be centrally selected for the whole project.
- Individual operating elements of faceplate are greyed automatically if the related function block input variable is not connected.

2.2 Alarm Management

An efficient alarm management integrated into the DCS [2.] allows controlling and minimizing risks in process plants. This improves not only safety of plant operation, but also presents economic advantages.

In view of the increasing number of statutory requirements and with regard to the insurance aspects, plant operators nowadays can no longer avoid having to deal with the topic of alarm management systems. They should however also do it in their own interest: A carefully planned and optimally set alarm system provides a clear advantage for cost effectiveness and safe and stable operation in production plants in all branches. A professional alarm management system contributes decisively towards increasing the process safety and the availability of a plant, ensuring the product quality and simultaneously reducing costs.

The ideal way to ensuring improved handling of alarms is the relief of the operator load and his systematic guidance during ongoing operation. Strict avoidance of useless and unimportant alarms and early focusing on the important points while drawing up the alarm philosophy helps in avoiding excessive demands on operators and unsettling of operators, and instead supplies them with specific information about relevant deviations in the process or plant. The reduction in the alarm occurrence rates provides the operating personnel with more time and the necessary freedom to ensure reliable and safe process control. The support of professional alarm management by the DCS and the seamless integration of alarm management functions into the DCS represent the optimal solution since this ensures that the load on the operator is not increased by an additional system.

In SIMATIC PCS 7 there are three message types:

- Control system fault messages (monitoring of the DCS),
- Process messages (process monitoring),
- Operating messages (parameter modifications by operator input in faceplates),

and 16 predefined message classes with or without acknowledgement, e.g.

- Upper and lower alarm/warning/tolerance (HH alarm, H alarm, L alarm, LL alarm etc.),
- AS/OS control system fault or disturbance,
- Maintenance request,
- Operator request, operation message,
- Status message AS/OS

SIMATIC PCS 7 offers the following functions for alarm management:

- Alarm annotation: the operator can type a comment to an alarm that has occurred, e.g. "unnecessary", "caused by alarm xy", "recommended action: xy", etc. Permanent collection of such comments supports the build-up of operator know-how.
- Alarm filtering by plant/area/unit.
- Alarm priorities: Priority 1...16, can be used as additional sorting criterion in the message archive.
- Flexible sorting functions in message archives, e.g. "hotlist" sorted by frequency of alarms.
- Alarm suppression by logical operations and connection of binary signals.
- Alarm hiding depending on operation state e.g. start-up, normal production, shutdown, maintenance etc.

2.3 Reduction of Operator Workload

There are several ways to reduce operator workload. This allows increasing the plant area to be monitored by one operator, i.e. one operator can take care of more process tags. The following functions of SIMATIC PCS 7 help to reduce operator workload significantly:

- Operator guidance via picture tree and overview display. "Loop-In-Alarm": by clicking into the main alarm line in the overview section, the operator is guided to drill down into lower levels of the picture tree to find the cause of the disturbance.

- Operator specific process operation: several operators with separate responsibilities can define their individual combination of operator screens.
- Operative process control – HMI+ (cf. section 2.4)
- Intelligent alarm management, reduction of nuisance alarms (cf. section 2.2).
- Advanced Process Control (cf. section 4.1), especially if this contributes to avoid manual operation of feedback loops.
- Automatic route control (cf. section 4.4).

In some cases this allows pooling of several process plants into one central operator control room. Several process plants that are coupled by material flows are better monitored from one common operator control room instead of several single control rooms.

The large bandwidth of scalability of SIMATIC PCS 7 via three orders of magnitude supports such concepts - within quantity structures from 100 to 120000 process tags.

2.4 Operative Process Control with User-centered Process Visualization

Together with some key account customers further innovative concepts for user-centered process visualization are developed.

Operators' primary task is operative process control based on process and plant information related to the main production plant and logistics and supporting processes [5.].

The goal of operative process control is to sustain intended plant operation and safe plant operation, maximize production availability despite singular disturbances, and to ensure inspec product quality despite variations in throughput and raw-material quality, and despite perturbations.

Increasing complexity of production processes and working environment in process control rooms makes it ever more difficult for the operator to create a holistic mental model of the plant and the processes to be monitored. A solution to these problems is offered by user-oriented and task-oriented concepts: [4.]. These concepts aim at holistic design of operator systems, i.e. they intend to optimize the application of technology, organization and user qualification altogether in a balanced way. The following general issues to improve process visualization have been derived from those concepts:

- Supplementary application of abstract operator screens that are not based on process topology, e.g. process oriented overview pictures with important plant performance indicators, in a combination of hybrid displays with tolerance and limit value visualization that supports pattern recognition. About 80% of process monitoring and control during normal operation are performed inside these overview screens.
- Partial replacement of alpha-numeric displays by analog displays, hybrid displays (analog value and status display) and trend curves.
- Complexity reduction of process flow diagrams by task oriented and process state oriented selection of process values to be displayed (dedicated selections for plant start-up, shutdown, normal production, load change and diagnosis).
- Consequent application of a color scheme inclusive alarm colors.
- Process flow diagrams as part of operator station organization.
- Display of information instead of data, e.g. new display objects for temperature distributions or trend curves for situation description and decisions support with respect to operating strategies.

The concept is based on the guidelines stated by VDI/VDE 3699 "Process operation by computer displays".

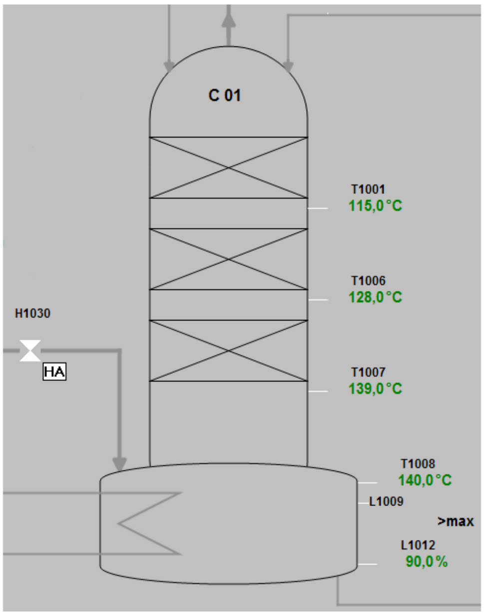

Figure 2-1: Typical conventional view of a distillation column with display of temperatures as analogue values

An example for the visual assessment of process values is the display of temperatures in a distillation column. The assessment of process state based on the analogue temperature values is only possible using expert know how. Are the temperatures of Figure 2-1 in the optimal operating area?

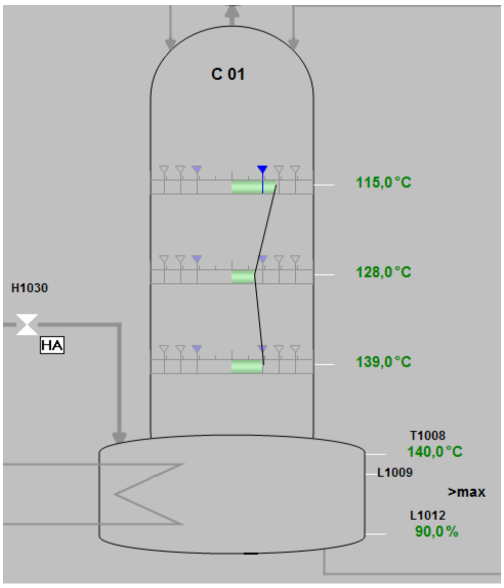

Figure 2-2: Visualization of a distillation column with vertical temperature profile

If instead the temperatures are displayed as a vertical temperature profile, where the optimal operation area is visible, the assessment is self-explaining from the operator screen.

All display bars in Figure 2-2 are scaled such that the setpoint or optimal value is exactly in the center of the bar. The restrained green bars show the deviations. The uppermost temperature is not in the optimal operation area. Not before the deviation becomes larger and reaches the warning limit, the operator's attention will be attracted by color change to yellow warning color.

2.5 Trend Displays with Additional Functions

Trend displays allow visualizing the time trend of variables. Trend displays are available

- Pre-configured in function block faceplates,
- Online configurable on the OS,
- Configurable in ES for OS,
- In CFC.

Properties of the trend displays are defined in the context of engineering, but can be modified by the operator at runtime, incl. data source and access to swapped archive variables.

Value range and physical units as defined in the PLC function blocks are used for automatic scaling of trend curves in the OS. A ruler allows displaying numeric values for a given time instant as a table.

Statistical evaluations of trend curves in specified time ranges are offered online e.g. mean value, maximum, minimum and standard deviation. Several curves can be plotted with a common ordinate axes into one trend window, or several individual axes can be defined for one trend window. Both OS trend curves and CFC trend recorder are able to export data as *.csv files.

2.6 Multi Control Room Concept for Distributed Hierarchical Plant Structures

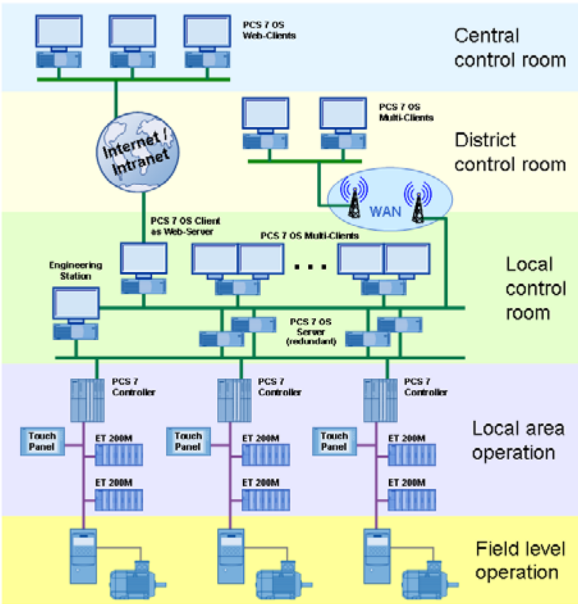

Figure 2-3: System configuration for multi control room concept with 5 levels in SIMATIC PCS 7

Some industry branches and special requirements call for dedicated solutions for hierarchical plant structures and the related administration of operating permissions. Especially in the context of water supply, wastewater treatment, desalination and soil watering, the plants are typically distributed geographically in a certain region and structured in several hierarchy levels with different operation permissions, e.g. area main station, district main station, local waterworks, local operation at unit- or machine-level.

The solution [6.] realized in SIMATIC PCS 7 supports hierarchical operation in up to 8 control room levels. Each level can get hold of the control and operation authority via a faceplate or a local key switch function. Control authority is restricted to one operation level only at a time (e.g. area main station) to avoid operation conflicts in the plant and achieve clear responsibilities with high flexibility. All other operation levels (e.g. district main station, local waterworks) can observe the active operation level and their commands.

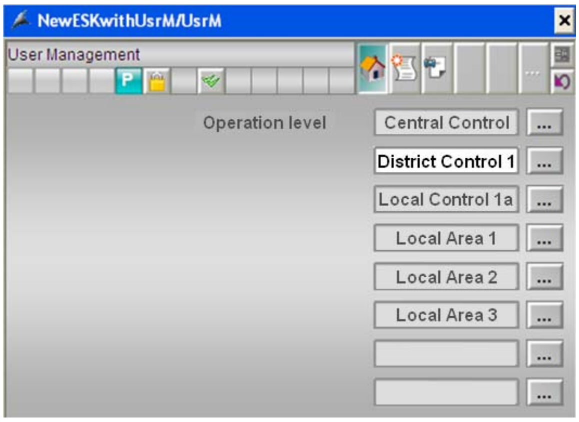

Figure 2-4: Faceplate UserManager

From the user's point of view the operation level switchover e.g. from local control room to machine local control is triggered simply via clicking in faceplate of the UserManager. The UserManager from the PCS 7 water library [7.] is the central function block for administration and organization of operation levels. The function block is deployed in each of the PCS 7 CPUs in the plant and the related faceplate can be located in one or in all OS pictures. The machine local control can grasp highest operation permission from administration point of view by using the key switch function, such that faulty operations from higher level control rooms are blocked during this time.

2.7 Data Analysis and Distribution

In the context of SIMATIC PCS 7 there are several possibilities to generate and distribute reports ("reporting function") or to make DCS data accessible in an office environment via intranet or internet:

- Report Manager (integrated in reporting functionality)
- Software options like DataMonitor
- Add-ons like PM-Quality, Acron
- Microsoft SQL Reporting Services (integrated in SQL Server 2005 functionality)

The reporting and exporting functionality will be significantly expanded with the new SIMATIC Process Historian announced for PCS 7 V8.0 .

2.7.1 DataMonitor

The software option DataMonitor [11.] is used for display, analysis, evaluation and distribution of actual process states, historic data and messages from the DCS database. DataMonitor makes PCS 7 process data available for all company function levels via web.

DataMonitor offers a number of internet tools for visualization and evaluation that support all common security mechanisms like Login/Password, Firewalls, encryption etc.:

- Process Screens: view only via PCS 7 OS pictures.
- Trends & Alarms: display and analysis of archived process values and messages in form of trend curves or tables.
- Excel Workbooks: display of archived process values in an MS Excel worksheet for evaluation and storage in a web server or as printout format for reports.
- Published Reports: time or event-triggered generation of reports in Excel format or as *.pdf file.
- WebCenter: central information portal for the access to PCS 7 data via user specific views, user groups with individual user rights for reading, writing and generation of WebCenter pages.

3 Monitoring of Product Quality and Key Performance Indicators

3.1 Monitoring of Product Quality

3.1.1 Integrated Batch Control (SIMATIC BATCH)

The integrated software package SIMATIC BATCH [13.] enables flexible automation of any batch processes, from simple to complex. Its modular architecture combined with optimum scalability in the area of hardware and software guarantee an optimum match for the respective plant size and individual production requirements. It can be used from small lab scale processes through to large scale production facilities.

The automatic, reproducible sequence of all recipe steps is the basis for reproducible product quality.

SIMATIC BATCH supports plant-neutral recipes for simpler recipe management and validation as well as hierarchy recipes according to ISA S88.01 for recipe creation in process engineering

Batch data are comprehensively recorded and archived.

3.1.2 SIPAT

PAT means "Process Analytical Technologies" especially in the pharmaceutical industry. The term was defined by the US Food & Drug Administration (FDA) in a manual dated 2004.

PAT supports the analysis and control of critical quality and performance attributes of raw materials, process materials and process steps based on real-time measurements, in order to guarantee end product quality.

This offers the following advantages:

- Monitoring of product quality in real time without laboratory samples.
- Improved process understanding.
- Improved production performance achieved by less deviations from specifications.
- Reduction of production costs, production risks and efforts for end product control.
- Reduction of off-spec products.

Siemens SIPAT [14.] is a software framework for realization of PAT solutions. The basic approach is to evaluate a reference model (generated offline) with actual measured data, in order to predict relevant quality parameters.

The following figure shows the structure of SIPAT. SIPAT consists of four modules: configuration module, model builder, execution module and data archive. SIPAT includes a number of interfaces to different automation functions, measurement devices and external software tools.

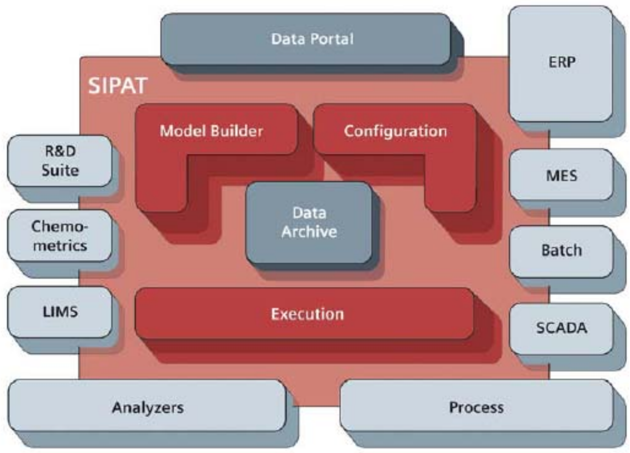

Figure 3-1: Software architecture of SIPAT

- Configuration module: allows the configuration of all algorithms and connected measurement devices via a graphical user interface.
- Model builder: different model types are generated, validated and optimized based on historic data. There are 4 model types:
  - Analyzer Model: model of an analytic device.
  - Unit Operation Model: model of a specific unit.
  - Process Model: model of several units in a production line.
  - Product Model: process model combined with clinical data.
- Execution Module: executes all runtime functions like reading data, storing in archive, data synchronisation, prediction,

analysis and visualization, handover of calculated data to specified interfaces.
- Data archive: all relevant data are stored here.

Interfaces to:
- MES, DCS, ...
- Process analytics,
- Chemometric software tools: integration in modelling and evaluation steps.

The mathematical algorithms for analysis, modelling and prediction are not part of SIPAT, but can be found in one of the following external software tools that can be connected:

- Umetrics: Simca-P, Simca-P+ (multivariate analysis and calibration), Simca QP+ (prediction),
- CAMO: Unscrambler (PCA: principal component analysis, clustering etc.),
- MATLAB: visualization, analysis, numeric calculations.

3.1.3 R&D Topic Statistical Monitoring of Batch-Processes

Online analysis of batch data will allow predicting end product quality while the batch is running, enabling early detection of errors. If possible, errors can be corrected, otherwise batches that cannot be rescued any more can be aborted at an early stage. This goal is achieved using algorithms of mathematical statistics: principal component analysis, transformation, synchronisation, statistical evaluation with confidence intervals.

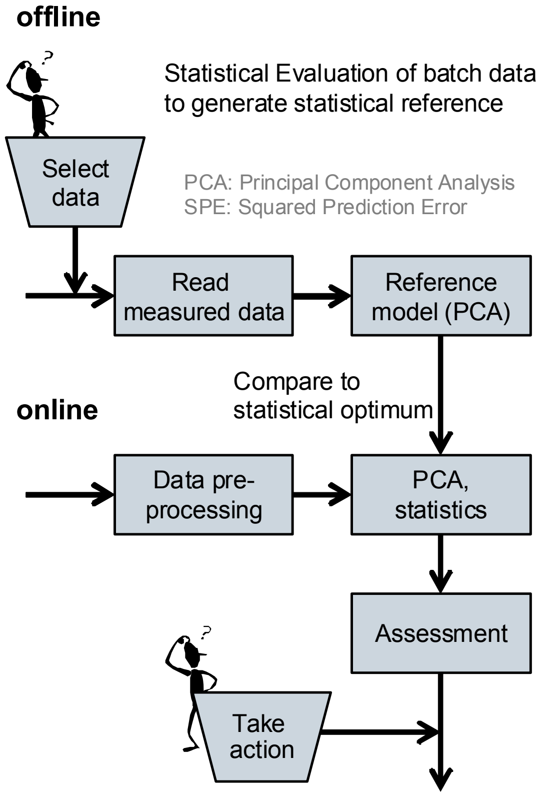

Figure 3-2: Statistical monitoring of batch processes

The algorithms are implemented as software prototype by the advanced R&D group and tested with real world batch data. The software will be available by the end of 2011 for interested pilot customers.

3.2 Plant Asset Management and Performance Monitoring

While productivity is defined as ratio of real output to real input, "performance" is defined as ratio of real output to a specified (standard or benchmark) output related to input [15.]. In other words: the term performance includes an assessment of results and efforts with respect to relevant targets, standards or references. Performance is interpreted as grade of reaching targets.

Plant performance management aims to answer the following questions:
- In which state, at which performance level is the process and its technical assets running?
- How far is the process from optimum, or from production specific benchmark?
- What are possible root causes for deviations?

- How long will it take to reach a critical or economically inacceptable process state?
- Which actions should be taken into consideration, or have urgently to be taken?

With respect to methodology and primary objective there are two different approaches:
- Condition monitoring: identification and monitoring of plant state and plant components state. Signal source is plant component behaviour; objective is to maintain component availability and to protect components.
- Performance monitoring: identification of plant or component performance (signal source) and monitoring of process operation. Objective is production "quality"; deviations in component behaviour cause disturbances or degradations (deteriorations).

Strategies and software tools are alike. Typically the same process measurements are evaluated. Actually, condition monitoring and performance monitoring are two different views of the same object. The following illustrative explanation shows the relation of condition monitoring and performance monitoring using the example of a human being:

- Condition monitoring of human being, e.g. taking somebody's temperature: an additional signal source (e.g. sensor, otherwise model) delivers information on human body state (condition, health). This allows for indirect implications on performance, because a sick person suffering from fever typically does not achieve its optimal performance any more.
- Performance monitoring of human being, e.g. 100m sprint: performance is measured directly during "operation". This allows for indirect implications on state (condition), if there is reference information on performance in good (healthy) state. If performance falls significantly below optimum, bad condition can be presumed to be the reason (cause) for that.

Performance indicators can be calculated on different levels of an automation hierarchy, with reference to different objects in a process plant including automation system.

- Performance of field devices,
- Performance of control loops („Control Performance Monitoring“),
- Performance plant components/units („Unit-oriented Key Performance Indicators“),
- Performance of mechanical assets (pumps, heat exchangers, compressors etc.),
- Performance of the overall process,
- Performance of alarm system.

3.2.1 Maintenance Station

The Maintenance Station [17.] integrated in SIMATIC PCS 7 process control system provides a complete status overview of all plant components and offers an effective diagnostics, service and maintenance of the plant. The SIMATIC PCS 7 Maintenance Station maximizes the economic value of the plant assets by helping to reduce unplanned downtime and efficiently use maintenance investment, this way contributing to reduce "Total Cost of Ownership" and increase the efficiency of plant operation.

The Maintenance Station is focused on Plant Asset Management and enables preventive and predictive diagnostics, maintenance, and service of the production plant. In parallel with process control, the Maintenance Station makes available consistent maintenance information and functions for all system components (assets). While the plant operator obtains all relevant information that is necessary for focused intervention in a process via the operator system, maintenance and service personnel can check the hardware components of the automation system and process their diagnostic messages and maintenance requests. The Maintenance Station not only provides the information that a fault has shown up, but provides detailed guidance to the maintenance personnel so that necessary corrective or preventative action can be performed.

The Maintenance Station provides the maintenance engineer access to:

- Electrical components in the plant, such as intelligent field devices and I/O modules, field bus, controllers, network components and system bus, as well as servers and clients of the operator systems.
- Mechanical assets, such as pumps, motors, centrifuges, heat exchangers, and closed-loop control loops, which are represented by proxy objects in which the diagnostic rules are stored, c.f. next sections.

3.2.2 Asset Management of Mechanical Assets

Mechanical assets and rotating machines are important components of each process plant: pumps, valves, heat exchangers, compressors etc. In relation to the electrical assets of process measuring and control technology, mechanical assets and plant components are typically more valuable for the plant owner, but they are more vulnerable to wear and tear due to high mechanical stress. However they are typically not yet integrated into Plant Asset Management systems - in contrast to intelligent field devices, "non-intelligent" mechanical assets without their own electronic and communication interface do not appear by themselves as active objects in a distributed control system (DCS). Ready-made function blocks [18.] for certain classes of common mechanical assets provide reliable condition and performance monitoring. This is much more cost efficient than the installation of additional condition monitoring systems. Intelligent evaluation of sensor signals already available in the DCS helps to avoid an installation of additional dedicated condition monitoring sensors like structure-borne sound or vibration sensors.

Centrifugal Pumps

The diagnostic function block PumpMon is used for monitoring and analysis of centrifugal pumps. Limit violations of rated pump operation area and deviations from expected characteristic lines are reported to the operator via messages, and provided for further logical evaluation via linkable block output variables. The characteristic lines of delivery height, hydraulic power and efficiency depending on flow are displayed. Monitoring of suction pressure and medium vapor temperature provides early detection of cavitation danger. Moreover PumpMon supports optimization of pump design by statistical evaluation of operating data (load profile), and offers possibilities to detect potential for energy savings.

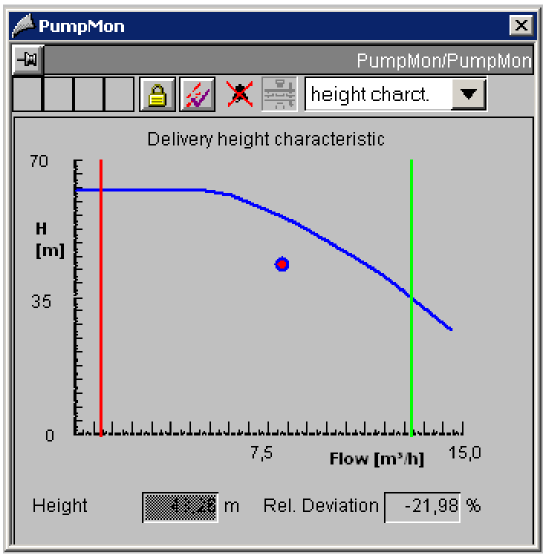

Figure 3-3: PumpMon faceplate, delivery height losses caused e.g. by gas conveyance

Control Valves

Valves are one of the most common actuators in process plants. The condition of the valves has a significant influence on the availability and safety of the complete plant. Valves are affected by different signs of wear and tear, such as wear of valve cone and/or valve seat (abrasion, cavitation, corrosion) or fouling (material caking, build-up). The function block ValveMon offers a solution for monitoring and diagnosis of control valves (valves that can be fully or partially opened or closed by continuous valve position control), based on the valve signature, i.e. the characteristic line of flow depending on valve position, assuming normalized pressure difference.

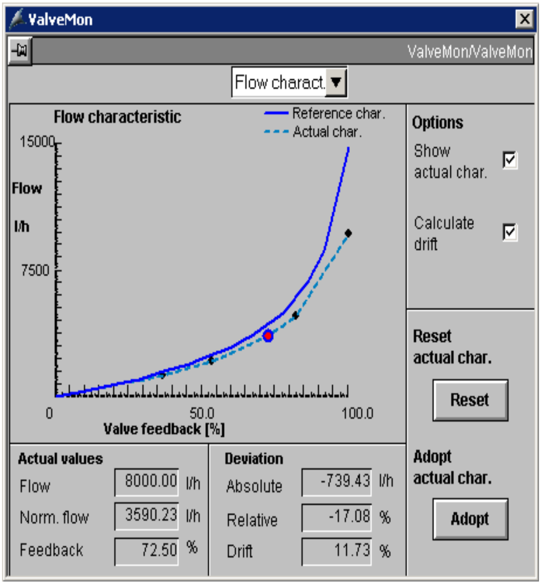

Figure 3-4: ValveMon faceplate, flow characteristic in case of material caking at valve body

Heat Exchangers

Heat exchangers need frequent maintenance or cleaning, but up to now they are not sufficiently monitored by plant asset management systems. The main problem is called fouling, including all sorts of contaminations in heat exchangers, e.g. sedimentation, corrosion, reaction fouling or bio fouling that reduces heat transfer efficiency. The preferred application area of HeatXchMon is fluid-fluid tube bundle heat ex-changers. The diagnostic function block calculates the efficiency based on deviations of actual heat flow from reference heat flow in clean condition. This is used to estimate and display the energy losses per day and the financial losses caused by energy losses, such that these aspects can be considered in maintenance planning.

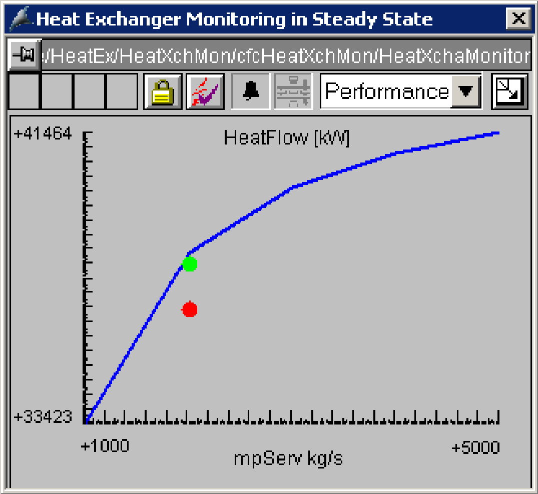

Figure 3-5: HeatXchMon faceplate in nearly clean state, i.e. the actual heat flow (green dot) is close the reference characteristic (blue)

Further condition and performance monitoring function blocks are implemented for:

- Turbo compressors: CompMon.
- Filters and other flow resistances depending on differential pressure: PressDropMon.

3.2.3 Control Performance Monitoring

In order to maintain efficient plant operation, the performance of a large number of control loops in a plant has to be automatically and permanently monitored, allowing to schedule specific maintenance activities or selective controller re-tuning in a timely manner if the performance of single control loops is decreasing or troubles are developing. For monitoring in the sense of a non-invasive diagnostic, only the measurement data of regular process operation are evaluated.

In the process tag types of the PCS 7 Advanced Process Library, each control loop already contains its ConPerMon function block for control performance monitoring. The ConPerMon faceplate can be opened by a side jump from the related PID controller faceplate.

The main principle of the approach described for the first time in [16.] is to evaluate both stochastic and deterministic features of control performance, and to select automatically the appropriate features depending on operating state.

Process value variance in a sliding time window is permanently calculated and compared to the variance really measured at the individual control loop under consideration in good condition, e.g. after commissioning. The so called "Control Performance Index" (CPI) is calculated from the ratio of reference variance and actual variance. Mean value of control deviation, mean value of manipulated variable and an estimation of steady state process gain are also calculated in the moving time windows.

If a setpoint step is detected in a control loop, the following deterministic features are identified: relative overshoot with reference to setpoint step height, rise time, settling time and settling ratio.

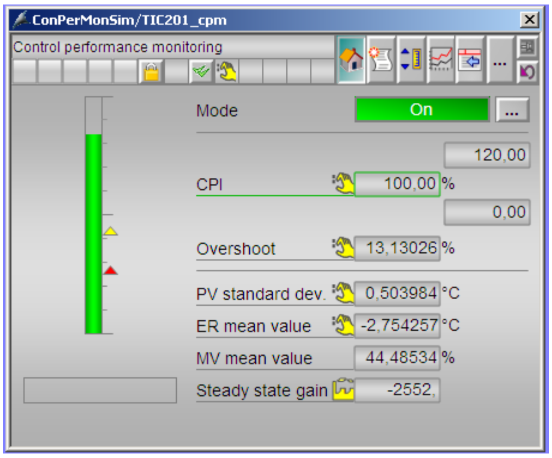

Figure 3-6: ConPerMon faceplate from PCS 7 Advanced Process Library

Indicators for control performance (ConPerMon block symbols with indicator light function green/red) can be monitored together with other KPIs (Key Performance Indicators) of a process plant and displayed in target group oriented overview pictures on the OS.

4 Process Optimization

4.1 Advanced Process Control

APC (Advanced Process Control) methods are a tool of vital importance to improve operational efficiency of process plants with respect to productivity and economics, product quality, operability and availability, agility, safety and environmental issues. APC solutions can be realized much more cost effectively due to a DCS embedded implementation with standard function blocks and pre-defined CFC templates as offered by Siemens in the PCS 7 Advanced Process Library [8.]. Now APC solutions are available for many standard applications.

Improved controller tuning (e.g. using a PID-Tuner software tool) allows to avoid unnecessary actor movements and improve energy efficiency (e.g. reduce compressed air consumption) and reduce wear and tear (e.g. wear of valves).

Several extensions to PID control are provided as CFC templates and can be applied efficiently if needed, e.g.:

- Override control, if two or more controllers share one common actor.
- PID gain-scheduling for nonlinear process behaviour.
- Smith predictor control for deadtime processes.
- Dynamic disturbance compensation (lead-lag feedforward) if there is a known disturbance acting on the process, whose cause can be measured.

A model based predictive controller (MPC) reduces the variances of manipulated and controlled variables by holistic consideration of the whole plant unit (multivariable control) and forward-looking planning of manipulated variable moves.

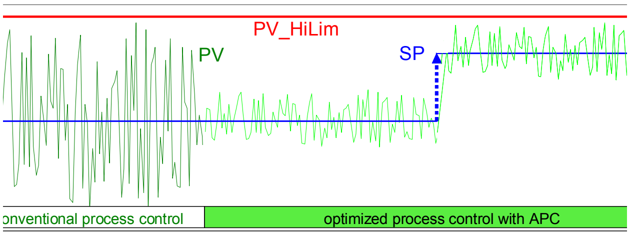

Figure 4-1: Optimized process operation by "constraint pushing" with Advanced Process Control

The reduced variance (standard deviation) allows moving the setpoints closer to critical constraints without the risk of frequently violating the constraints. This is called “constraint pushing”: make the most of the process (improve operational efficiency) by using the full physical capabilities of the plant e.g. to maximize throughput or minimize energy consumption.

The model predictive controller is enhanced by an integrated economic online optimization of the steady state operating point. The economic profit of plant operation per time unit can be explicitly formulated in the performance index (target function) of the optimization and maximized by finding an optimal operating point in the permissible control zone.

Considering a distillation column as an example, the energy consumption can be minimized by zone control of product quality (head and bottom temperature) with simultaneous minimization of the manipulated variable hot steam flow - resulting in an automatic optimal reduction of reflux ratio.

4.2 Energy Management

Energy management as defined in DIN 4602 is the predictive, organized and systematic coordination of the procurement, conversion, distribution and use of energy to cover requirements while taking account of ecological and economic aims. The term thus describes actions for the purpose of efficient energy handling.

All the different aspects of energy management are discussed in [9.].

SIMATIC powerrate is available as an add-on for SIMATIC WinCC and SIMATIC PCS 7 and is used for standardization, visualization and archiving of energy and output averages with time stamps. The plant consumption data is gathered via the field bus and compressed and buffered in the SIMATIC S7-CPU. The transparency of the energy consumptions is a basic prerequisite for an optimization. Energy management is thus anchored alongside the operator station and the maintenance station as the third pillar of the process control system.

4.3 Batch Scheduling

The transformation of production orders to a detailed schedule of batches on certain plant units at given starting times contains optimization potential in the sense of efficient plant operation. Several optimization targets have to be pursued at the same time while considering limited production resources (continuously stirred tank reactors etc.):

- Compliance with delivery dates and specifications of product quality.
- Maximization of capacity utilization or throughput.
- Minimization of cleaning effort when different products are run in the same tank reactor.
- Avoidance of peak loads in energy consumption.

SIMATIC BATCH contains functions for batch planning and automatic execution of planned batches. The individual optimization however is left to the user.

4.4 Route Control

The optional software package SIMATIC Route Control [19.] in PCS 7 masters the automatic control of material transport in plants with numerous branching pipelines or extensive tank farms and transport routes with high flexibility, this way supporting efficient plant operation. Route Control is working similarly to a "navigation system" for material transports: Route Control will find the optimal route automatically based on a specification of transport source and transport target. In case of disturbances, a suitable detour is searched automatically ("detour of traffic jams"). Throughput of material transport is optimized ("Debottlenecking"). The operator is relieved from manual planning of material transport.

Preferred application areas:

- Plants in chemical industry, petro chemistry or food & beverage industry in the medium and upper performance range with extensive route/pipeline networks.
- Frequent revamping and extension of route network incl. actuators and sensors.
- Transport routes with high flexibility: constantly changing materials, or dynamic specification of the source and destination of the material transport (including reverse direction with bidirectional transport routes).
- Numerous simultaneous material transports.
- Plant projects in combination with SIMATIC BATCH.

5 Simulation, Operator Training

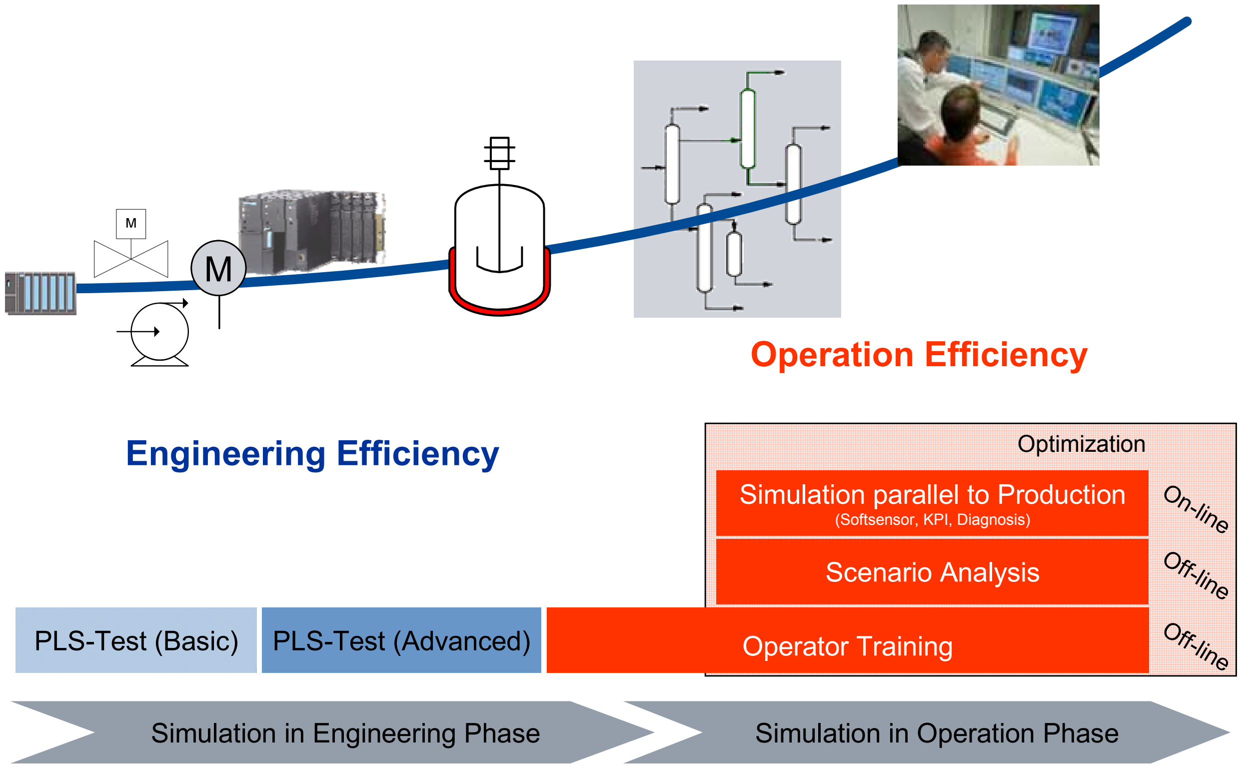

Figure 5-1: Application phases of simulation in process automation

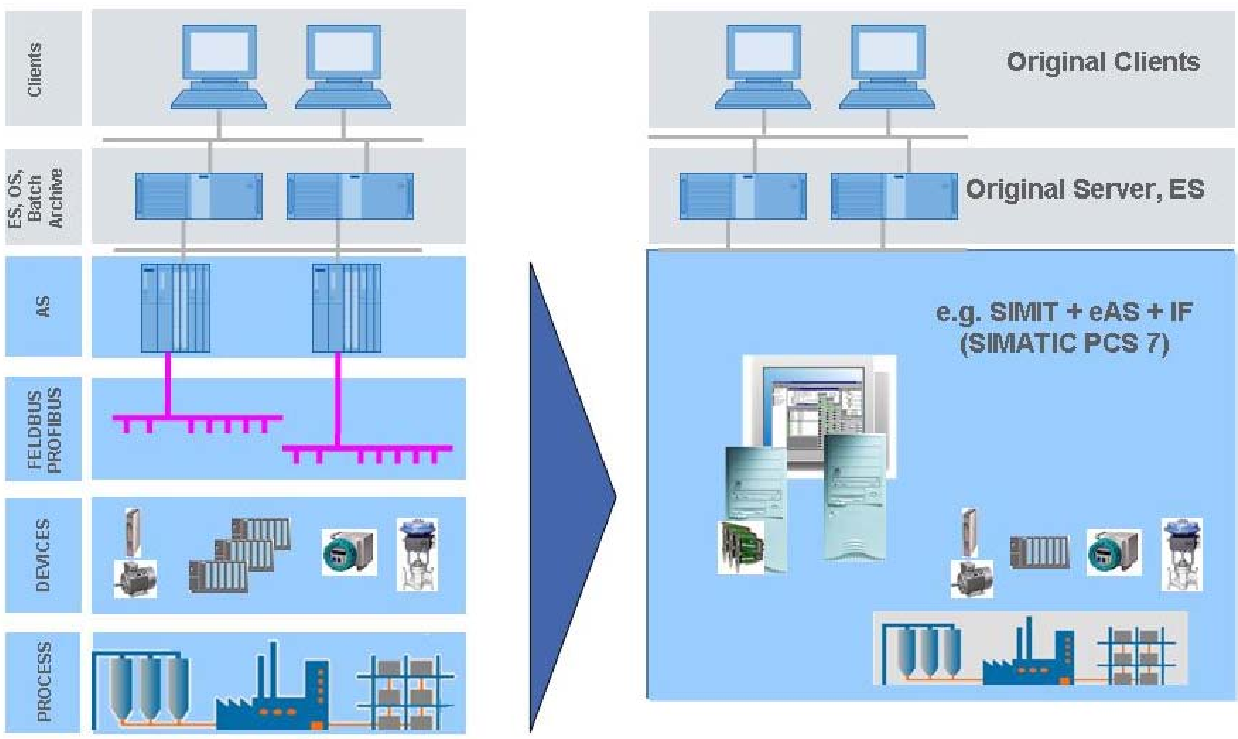

Figure 5-2: Architecture of operator training system [20.]

Simulation is a technology to replicate processes using a simplified copy of reality (model). Simulation helps to increase efficiency in different phases of plant life cycle.

In early stages of DCS engineering simulation is mainly used by DCS engineers to test DCS software (DCS test basic und advanced). Main goal is to increase engineering efficiency and accelerate plant commissioning. In later stages (DCS operating phase) the main goal is to increase plant operation efficiency. In this context, Operator Guidance Systems (OGS or "lean" OTS) and Operator Training System (OTS) are applied for training of operators using simulation models. Moreover simulations are applied for process- or control engineering optimizations during operation phase of a plant, e.g. optimization of control concepts or evaluation of new operation trajectories to accelerate product grade changes or startup and shutdown procedures. In context of simulations running in real time parallel to the real process there are application scenarios like soft-sensors, model based KPI calculations or model based monitoring and diagnosis.

If new plants are realized, and simulation methods are used right from the beginning in all plant life cycle phases, the benefits of simulation become apparent in problem free plant startup, fast and efficient commissioning. The early preparation of the operator team using a realistic simulation and the early test of DCS software contribute to these advantages.

An OTS typically contains the same OS pictures as the real plant, in combination with real or PC-emulated controllers, in order to provide a realistic training environment for operators. Instead of the real process, a dynamic process simulator is linked to the controllers. This allows efficient and realistic operator training and repeatable training scenarios without safety risks. Typical areas of application:

- Training of DCS operation,
- Training of operation procedures and DCS operation during plant startup and shutdown,
- Training of process dynamics and operation procedures in normal operation (steady state, load change and product grade change),
- Training of operator actions in case of plant disturbances, component defect etc.,
- Demonstration of technology to licensees (technology transfer).

Additional benefit if simulation is available before commissioning:

- shorten commissioning time,
- verify startup procedures,
- training of manual operator actions for startup

Additional benefit if simulation is applied for process optimization of legacy plants:

- Improvement and extension of automation concept,
- Controller optimization and tuning,
- Design and test of APC concepts,
- Optimization of standard operation procedures and transient trajectories,
- Scenario analysis, predictive simulation.

The products described in the following sections are available for realization of operator training systems in the context of SIMATIC PCS 7, and are supported by appropriate professional services.

5.1 Simulation- and Emulation Platform SIMIT

SIMIT [21.] is an open platform for testing automation software. Using scalable models of the technical process, the correct functioning of the automation system can be ensured, e.g. in context of a FAT (Factory Acceptance Test). SIMIT was developed in the domain of power plants and is in the meanwhile successfully applied in different branches including chemical industry. The goal of SIMIT is to open an application oriented access to process simulation for people with automation technology background, without the need to enter the complexity level of process engineering simulators. If the modelling features of SIMIT are not sufficient, or there are external process models already existing, SIMIT offers interfaces for co-simulation.

5.2 Simulation System SIMBA Profibus

SIMBA is applied to connect a SIMIT simulator to a SIMATIC PCS 7 Controller.

The simulation system SIMBA Profibus [22.] consists of a plug-in card for a PCI slot in a PC, that is connected to the field bus of a DCS controller instead of decentral periphery, such that the DCS assumes that the signals arrive from a real Profibus from the real plant, while in fact they are generated on the SIMBA-PC via software.

For simulation of field busses the PCS 7 Add-On "SIMBApro FAT" is available. This Add-On with a lot of features for FAT is based on the simulation system SIMBApro PCI. It allows the simulation of decentral periphery up to component level. Component typels (valves, motors etc.) are ready-made for plant FAT. Import functions for periphery configuration (Step 7 HW-Konfig) and component addressing (symbol table) provide comfortable and fast implementation of FAT solutions.

5.3 Emulation of Controllers on PC Hardware: PLCSIM and WinAC

During FAT it is mandatory to test the real DCS hardware. However in the context of an OTS there is choice of using original DCS controllers or emulation on PC hardware.

WinAC RTX [23.] offers the full functionality of SIMATIC CPU in a Windows PC environment. This offers advantages for automation tasks that require high flexibility and efficient integration into the overall system. Such tasks include the connection to simulation, data processing or logistic systems, or the interfacing to technological sub-units like motion control systems or vision systems.

If an OTS for a plant with several controllers is planned, it must be taken into account that there can be only one WinAC instance running on one PC.

S7-PLCSIM is a software option of STEP 7 that can execute any user application program implemented in CFC/SFC in an emulated PLC on PC hardware for testing. There is no additional hardware required because the emulation is completely integrated into STEP 7 Software. PLCSIM offers a simple interface to STEP 7 applications and allows monitoring and modification of different objects like input and output variables.

In context of OTS development PLCSIM offers the possibility to emulate several instances (SIMATIC CPUs) in one PC. On the other hand, PLCSIM does not feature all communication channels of a real CPU. Currently there is no communication outside of the PC where PLCSIM is installed, i.e. PLCSIM can only be used by a PCS7 Engineering System residing on the same PC that plays the role of OS server at the same time.

Therefore Siemens I IS is also offering a solution called "SIMIT Emulation Platform" (formerly SoftPLC), that is configured individually for each OTS project.

6 Safety and Security

The goal of safety engineering is to avoid accidents and consequential damages after occurrence of errors, in order to achieve maximal safety for humans, process and environment.

Operation and construction of process plants with risk potential have to comply with the international standard IEC 61511 for functional safety of safety instrumented systems. The procedure description for implementation of functional safety follows the plant safety lifecycle that consists of the following phases: analysis, realisation, operation and maintenance.

A "Safety Instrumented System" (SIS) is a combination of sensor, logic devices (e.g. PLC) and actuators that detects abnormal situations and drives the process back to a safe state. Classification of Safety Instrumented System is defined by SIL (Safety Integrity Level) according to EN 61508, which is a measure of system reliability, that has to be selected depending on risk potential. There are sector specific norms based on IEC 61508, e.g. IEC 61511 for process industry, which are relevant for engineering teams and plant operators.

Besides functional safety, plant operators also have to care about IT security, i.e. protection against un-authorized access to automation systems.

6.1 Flexible Modulare Redundancy

High availability of a DCS can be achieved by redundant hardware. Different redundant system parts can be combined in flexible way:

- Redundant servers, e.g. OS server, batch server, archive server,
- Redundant controllers S7-400H or S7-400FH,
- Redundant system bus (Industrial Ethernet, ring topology),
- Redundant and/or switchable decentralized periphery,
- Redundant field bus (Profibus DP and Profibus PA, coupler redundancy or ring structure).
- Module and channel granular redundancy in the decentralized periphery ET 200M.

6.2 Safety Integrated

SIMATIC PCS 7 is able to combine standard and fail safe functions in the same controller and at the same PROFIBUS. This provides

- homogenous integration of fail safe technology into the DCS,
- engineering of standard and fail safe functions with a common engineering tool (CFC),
- direct communication of standard and safety application programs.

There is an optional STEP 7 software package for hardware configuration and engineering of safety oriented applications according to IEC 61511 in S7-400H Controllers. Engineering of safety applications is supported by an "F-library" containing ready-made and TÜV certified functions blocks according to SIL3 IEC 61508. Documentation of safety applications is supported by administration of electronic signatures. An optional burner library for steam boilers contains TÜV certified SIL 3 failsafe function blocks for industrial gas burners, oil burners and mixed operation burners.

6.3 Safety Matrix

With SIMATIC Safety Matrix [25.], Siemens offers a TÜV certified safety lifecycle tool for safety applications up to SIL 3 according to IEC 61508. The safety matrix is also called "cause & effect matrix".

SIMATIC Safety Matrix can be applied in all phases of safety lifecycle. The achieved rationalisation effects contribute to reduce plant CAPEX (Capital Expenditure) and OPEX (Operational Expenses).

SIMATIC Safety Matrix consists of the following individual products that differ with respect to functionality and area of application:

• Safety Matrix Editor to create, engineer, test and document the safety matrix logic.

• Safety Matrix Engineering Tool to create, engineer and compile a safety matrix, transfer it to the project, compile, download, operate and control a safety oriented CFC application.

• Safety Matrix Viewer to operate and control the safety oriented CFC application on the OS.

6.4 IT Security

IT security, namely the protection against unauthorized access, is one of the most discussed topics not only in the IT office environment, but also in the world of automation.

Security in industrial automation can only be achieved by close cooperation of hard- and software suppliers, users and plant operators [26.]. An important part of the collaboration is to create uniform international standards that are the basis for future security concepts and solutions. Currently the most important standard is the developing IEC 62443 „Industrial communication networks – Network and system security", because it considers the specific requirements of industrial automation and covers all aspects of a security management system [27.]. The German guideline VDI/VDE 2182 "Informationssicherheit in der industriellen Automatisierung" is integrated into this draft standard. IEC 62443 is also known as ISA-99.

The highest priority in automation is the unconditional maintenance of control over production and process by the operating personnel, even in the event of security threats. Preventing or limiting the spread of a security threat for plants and networks has to be performed while maintaining full operator controllability and observability of production and process.

The "security concept PCS 7 and WinCC" [28.] is intended to ensure that only authenticated users can perform authorized (permitted) operations through operating option assigned to them for authenticated devices. These operations should only be performed via defined and planned access routes to ensure safe production or coordination of a job without danger to humans, the environment, product, goods to be coordinated and the business of the enterprise. The security concept is based on the strategy "defense-in-depth", which is much more effective than „security by obscurity" (information hiding). The document collection [28.] is intended to facilitate the cooperation of network administrators of company networks (IT administrators) and automation networks (automation engineers), allowing the exploitation of the advantages provided by the networking of process control technology and the IT infrastructure of higher production levels without increasing security risks at either end.

The following elements are (among others) part of the safety concept:

- Segmentation of the plant in "security cells",
- "Defense in depth" architecture,
- Windows security patch management,
- Service access and remote maintenance,
- Anti-virus software and firewalls,
- User administration and permission administration,
- Active directory, domains and workgroups,
- IP hardening.

6.5 Emission Monitoring and Emission Reduction

6.5.1 Process Analytics

Gas analyzers, especially continuous process gas analysers [32.], are applied for precise monitoring of emissions and for measurement of compositions in exhaust gas flows. There are extractive and in-situ measurement methods.

Extractive process gas analysis is characterized by the fact that a sample is extracted from the process line and conveyed to the analyzer. Typically, the sample is extracted by a probe, then transported through a (typically heated) sample line and conditioned before being processed to the analyzer. The Siemens devices of the series ULTRAMAT 6 and ULTRAMAT 23 perform selective measurement of IR active gases, e.g. CO, CO_2, NO, SO_2, NH_3, H_2O, CH_4 and other hydrocarbons in off gas, using an NDIR method (non dispersive infrared).

In-situ analysis in contrast to extractive gas analysis does not require taking samples, because the physical measurements is working in the flow of a process gas, directly in the actual process gas line. This way a much faster measurement dynamic is achieved. The LDS 6 by Siemens works with a fibre coupled diode laser and integrated reference gas cell filled with the gas to be detected. Up to two different components from the set of reference gases (O_2, NH_3, HF, H_2O, CO_2, CO, HCl) can be measured fast and non-intrusively directly in the process or the chimney.

6.5.2 Lambda Control

The lambda probe (λ-probe) is a sensor that measures the remaining oxygen concentration in combustion exhaust gas, in order to control the ratio of combustion air and fuel such that neither fuel nor air are left in excess. Therefore lambda control is important for efficient operation of burners in process plants, and also minimized emissions.

The measurement devices of the Siemens Oxymat family [33.] are intended for measurement of remaining oxygen in exhaust gases i.e. for combustion control. These devices apply the robust and long-term stable paramagnetic alternating pressure method. There are device types using the classic λ-probe (ZrO_2 sensor) as well.

7 Service and Support

7.1 Life Cycle Services

The costs arising in the operation phase of a process plant constitute a significant share of the overall life cycle cost e.g. in a time period of 15 years.

The baseline for profitable life cycle costs is high plant availability, achieved by a robust DCS with solid application software based on standards, and by preventive plant maintenance.

Service costs for engineering support, maintenance and upgrades play an important role as well. Consequently, the main requirements for a comprehensive service package include:

- Investment protection through service products,
- System availability by ensuring serviceability,
- Serviceability using suitable migration concepts,
- Minimizing of costs throughout the entire life cycle,
- Obsolescence management.

System obsolescence is related to the proclamation (market withdrawal) of technical components or software versions.

The SIMATIC PCS 7 Life Cycle Services package ([29.] , [30.]) fulfils these requirements and is therefore be regarded as a vital element of the overall PCS 7 system in a holistic view. The modular structure of the SIMATIC PCS 7 Life Cycle Services portfolio covers the various requirement specifications which arise in practice. The Basic Services included in every module, such as access to Online Support or Technical Support can be supplemented with add-on modules including:

- On-call service for corrective maintenance,
- Inspection and maintenance,
- Spare parts warehouse for plants and obsolescence management,
- Modernization (updates / upgrades).

Options for each add-on module complete the SIMATIC PCS 7 Life Cycle Services:

- Extended Service Time 7/24,
- Software Update Services (SUS),
- Extended Exchange Options,
- Asset Optimization,
- Technical Support Agreements,
- Remote Support Services.

7.2 Availability of Components and Spare Parts for Long Time Periods

In order to maintain availability of process plants, fast and reliable availability of spare parts is required - note that the word "availability" in this sentence has two different meanings: correct function, and deliverability. High financial losses can be the consequence if the decisive spare part is missing.

Siemens offers a worldwide network for spare part supply with optimal logistic chains, 24 hours a day, 365 days a year [31.]. Original spare parts guarantee system compatibility and are kept in stock for long time periods (up to 10 years after product proclamation).

Normally spare parts are delivered in a cost optimal way, but in case of unplanned plant shutdown there is the possibility of time optimal delivery by express or courier. Moreover, there is an emergency service with special logistic (courier or pick-up service).

The products of Siemens Industry Automation run through a product life cycle consisting of three main phases:

- Active marketing,
- Phase-out and
- Proclamation (market withdrawal).

The following explanations have to be considered as general orientation, because both time frame and support options may vary depending on product type and circumstances:

Phase-out product: after announcement that a product will be phased out, there are two time frames that may vary depending on product family:

- Phase 1: **Still sold from list**: for all products there is the intention, but not a warranty, that they will be available for one more year for buying in typical purchase order quantity.

- Phase 2: **Type-deleted**: after one year, the products are delivered as spare parts only, sometimes based on 1:1 (repair and replacement), during the phase-out time frame. There are differences with respect to length of phase-out time: it spans 10 years for most SIMATIC products, and 5 years for PC-based systems.

The technical support available also depends on product lifecycle. After proclamation, production and support are stopped.

8 Installed Base and System Integrators

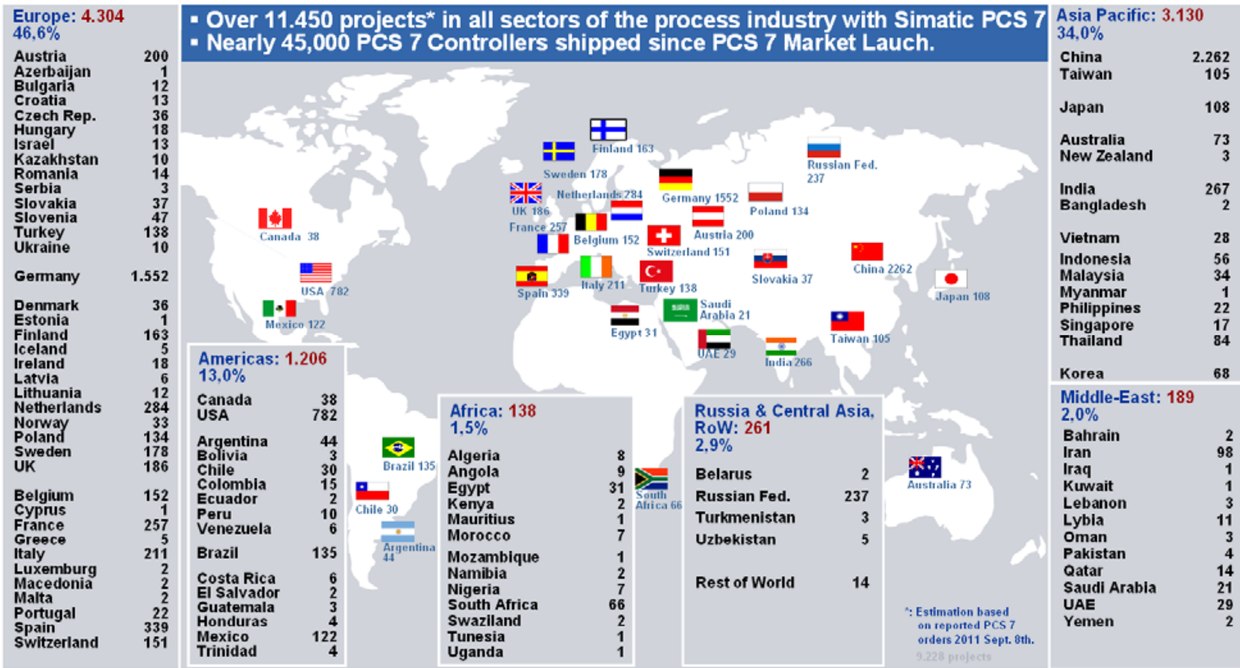

Figure 8-1: Installed base of SIMATIC PCS 7, by August 2011

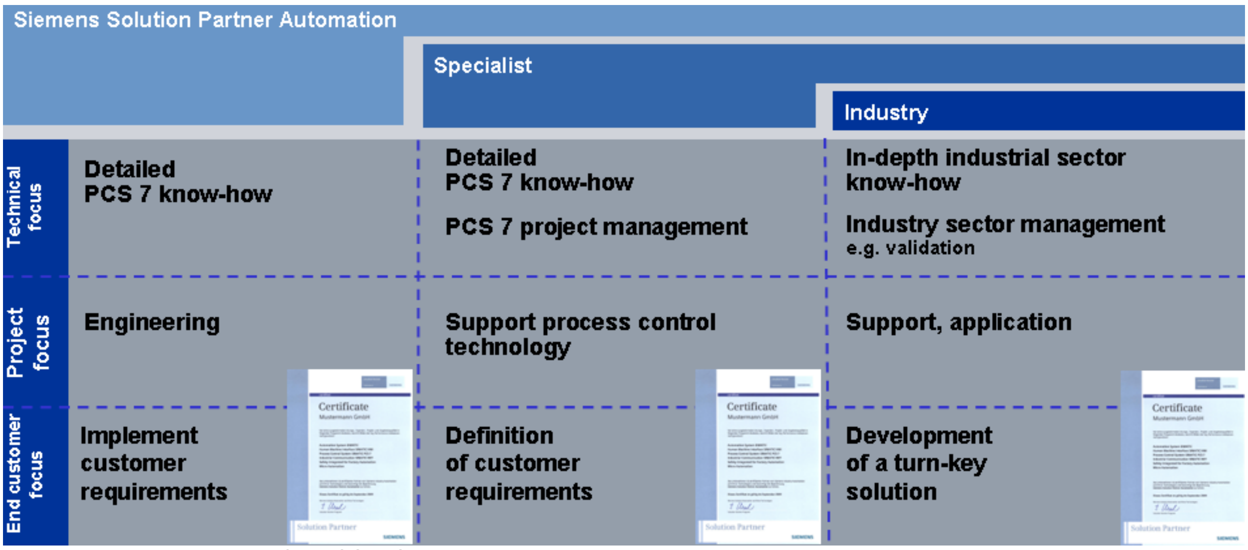

Figure 8-2: Requirements for PCS 7 Solution Partners

SIMATIC PCS 7 is delivered since 1997, and accordingly in the meanwhile boosts a large installed base: more than 11300 PCS 7 projects in all sectors of process industry, and more than 42300 sold PCS 7 Controllers worldwide: Figure 8-1.

Besides the service oriented units of Siemens, there is a worldwide network of system integrators available for SIMATIC PCS 7. Siemens Solution Partners are selected, certified system integrators around the world who provide consistent solutions for Siemens products in the sectors Automation and Product Lifecycle Management. They exploit both their professional product and systems know how and their excellent application and domain knowledge.

The connection of automation system in the process industry with business systems at the enterprise level becomes more and more important. Therefore DCS system integrators are growing to become real enterprise system integrators.

The Solution Partner Program by Siemens is structured in modules for efficient solution of customer requirements.

There is the right partner for any task:

- **PSC 7 Solution Partners** have experience with PCS 7 projects and implement automation applications for customers.
- **PCS 7 Specialists** have long time practical experience with our DCS and are focused on the area of process automation.
- **PCS 7 Process Safety Specialists** offer special know how in the area of functional safety and safety instrumented systems.
- **Industry Partners** are PCS 7 Specialists that offer excellent domain know how besides certified product and system knowledge.

The special requirements for PCS 7 Solution Partners shown in **Figure 8-2** have to be fulfilled besides the general requirements for Solution Partners.

As much as Solution Partners are committed to SIMATIC PCS 7, Siemens feels the obligation to intensify the cooperation with the partners and transfer Siemens knowledge to the partners. Therefore Siemens offers a number of exclusive services to partners, starting from technical workshops via premium technical support up accompanying marketing activities.

Qualification: High universal quality standards for solution partners are established by mandatory certification workshops and audits depending on qualification rank:

- Solution Partners have to successfully finish the Workshop "SIMATIC PCS 7" after signing of contract.
- SIMATIC PCS 7 Specialists: Solution Partners with focus on DCS can achieve the rank of a specialist after an evaluation by Siemens via intensive audits. During the audits, technical competence and project management competence is investigated.
- Industry Partners (based on PCS 7) need an industry sector specific certification. Moreover the partner provides evidence of his competence by market position and successful projects in the relevant sector.

Siemens customers will profit from universal support by Siemens and Solution Partners along the complete production process, with obvious advantages in each phase of production life cycle. Close cooperation with Siemens Solution Partners and the resulting synergy effects lead to significant reduction of time-to-market of new products in new production processes and an innovation margin in realized solutions.

In order to find a qualified Solution Partner, who supports the fulfilment of requirements on the automation and offers appropriate reference projects, there is the so called "Partner Finder" on the Siemens internet pages:

https://www.automation.siemens.com/providerv2/partnerfinder/SolutionPartner.aspx?lang=en

More information on the Solution Partner Programme can be found in [34.].

9 Innovative Application Know How

With many years of experience, a wide portfolio of solutions for automation, power generation and distribution, as well as expertise in process control and optimization, Siemens is the right partner for customers from the process industry worldwide: [36.]. Thanks to intelligent automation and service concepts, Siemens helps to reduce the time-to-market as well as the total cost of ownership. With all processes Siemens contributes to the creation of value - focused on plant availability and profitability, process and plant safety, maximum flexibility, and quality; all with the objective of safeguarding investments and securing competitiveness in the future.

[37.] offers access to Siemens Engineering & Consulting for **chemical and pharmaceutical industry, food and beverage industry**. The services range from design and planning up to the implementation of production and laboratory facilities. In the initial phase, Siemens Engineering & Consulting supports in the development and selection of appropriate procedures, afterwards in the planning of plant or assets, while handling the complete project management for basic and detail engineering, construction and commissioning. Siemens Engineering & Consulting supports to minimize design cost and time, maximize equipment uptime, and further improve and optimize existing chemical plants.

Chapter 5 of [9.] shows some case studies where the efficiency of chemical processes has been improved by innovative application know how of Siemens.

The GMP Engineering Manual for PCS 7 [38.] is guideline for management of automation projects in GMP environment ("Good Manufacturing Practice" according to FDA), i.e. for plants in **pharmaceutical industry** that need validation

The CEMAT [39.], high-performance distributed control system based on SIMATIC PCS 7, was developed in close cooperation with the **cement industry** so that it meets all cement production requirements - and it has proven itself by operating for many years in harsh cement production environments. CEMAT helps reduce cement production costs through resource management and productivity monitoring - from raw materials to finished products. Additional CEMAT benefits for the cement industry include excellent operation and integrated diagnostic features, which help detect potential faults early - before a problem occurs - and minimize downtimes.

Further CEMAT software tools support cost and time minimization during the engineering phase, and migration from older versions.

Water supply and wastewater disposal induce high and specific demands on plant automation and engineering – and thus also on process automation. As an answer to these demands, Siemens has developed the SIMATIC Water Library [7.]. It is a library containing approximately 100 well-tested function blocks and faceplates. The function blocks are running on S7-400 and S7-300 controllers and are therefore well suited to integrate package units into SIMATIC PCS 7.

The SIMATIC water library offers the chance to standardize application software of water plants, delivering a lot of advantages. Look & feel is directly based on the SIMATIC PCS 7 process control system. Since the SIMATIC Water Library is provided and updated centrally, corresponding efforts for system integrators do not apply. In particular, the standardized and reusable blocks and example applications reduce the engineering and commissioning efforts.

The water library supports:

- A multi control room concept with integration of local panels, c.f. section 2.6,
- Integration of SIMATIC S7-300 controllers in SIMATIC PCS 7 projects,
- Integration of Package Units, even based on SIMATIC S7-300,
- Enhanced measured-value monitoring, e.g. measured value with 8 limits.

A general survey of sector specific solutions is offered in [35.]. For different industry branches there are individual solutions and professional services.

PA-Branches (Process-Automation)

http://www.siemens.com/entry/industry/cc/en/index.htm

- Chemicals
- Pharmaceuticals
- Food & Beverage
- Glass & Solar
- Water/Wastewater

- Biofuels

DT-Branches (Drives Technologies)

http://www.industry.siemens.com/industrysolutions/global/en/Pages/home.aspx

- Metals Technology
- Pulp & Paper
- Cement
- Mining
- Marine

Energy-Branches

- Oil and Gas

10 Summary

Automation with SIMATIC PCS 7 contributes significantly to "operational excellence" and supports efficient operation of process plants by a lot of innovative functions, features and options. Using SIMATIC PCS 7 you can maximize throughput, availability and product quality, and at the same time minimize operating and maintenance costs, energy and raw material consumption, off-spec products, emissions, safety risks and environmental pollution.

11 Literature

[1.] Internet-Portal SIMATIC PCS 7
www.siemens.com/simatic-pcs7
-->

https://www.automation.siemens.com/mcms/process-control-systems/en/distributed-control-system-simatic-pcs-7/Pages/distributed-control-system-simatic-pcs-7.aspx

[2.] Siemens AG, Sector Industry, Industrial Automation: White Paper "Alarm-Management"
https://intranet.automation.siemens.com/mcms/process-control-systems/SiteCollectionDocuments/efiles/pcs7/support/marktstudien/Whitepaper_Alarm_Management_EN.pdf

[3.] Quotation Operational Efficiency

http://www.linkedin.com/answers/business-operations/quality-management-standards/OPS_QMA/623387-26896725

[4.] Kempf, S., Glathe, L.: Moderne Anlagenleitstände und Bedienkonzepte - HMI+ unterstützt operative Prozessführung industrieller Produktionsprozesse durch benutzerzentrierte Prozessvisualisierung. VDI-Kongress Automation 2011, Baden-Baden. VDI-Berichte 2143, VDI-Verlag, Düsseldorf.

[5.] NA 120 „Operator-Arbeitsplatz aus Sicht der Mensch-Prozess-Kommunikation"

[6.] Wieser, R.: Multicontrol concept with SIMATIC PCS 7. ProcessNews - The Magazine for the Process Industry, Siemens AG, Issue 3/2011.

[7.] Water-Library

http://www.automation.siemens.com/mcms/water-industry/en/simatic-water-library/Pages/default.aspx

[8.] Siemens AG, Sector Industry, Industrial Automation: White Paper „How to Improve the Performance of your Plant Using the Appropriate Tools of SIMATIC PCS 7 APC-Portfolio?"

http://www.automation.siemens.com/w2/efiles/pcs7/support/marktstudien/WP_PCS7_APC_EN.pdf

[9.] Siemens AG, Sector Industry, Industrial Automation: White Paper „ Energy management and energy optimization in the process industry".

www.siemens.com/simatic-pcs7/energy-management

[10.] Siemens AG, Sector Industry: PCS7 AddOn catalogue, available at:
www.automation.siemens.com

[11.] DataMonitor

http://www.automation.siemens.com/mcms/human-machine-interface/en/visualization-software/scada/wincc-options/wincc-datamonitor/Pages/Default.aspx

[12.] Dittmar, R., Pfeiffer, B-M.: *Modellbasierte prädiktive Regelung - Eine Einführung für Ingenieure.* Oldenbourg Verlag, München, 2004.

[13.] SIMATIC Batch

https://www.automation.siemens.com/mcms/process-control-systems/en/distributed-control-system-simatic-pcs-7/simatic-pcs-7-technologies/batch-automation/Pages/batch-automation.aspx

[14.] Siemens AG: Whitepaper "Integration of SIPAT, the Siemens PAT (Process Analytical Technology) software solution into manufacturing and development architectures", Nov. 2006.

[15.] Pfeiffer, B-M., Grieb, H., Bettenhausen, K. D.: Prozessnahes Performance-Management - vom Plant Asset-Management zur optimierten Betriebsführung. VDE-Kongress, Aachen, Okt. 2006. Tagungsband 2, VDE-Verlag, Berlin, S. 325-330.

[16.] Pfeiffer, B-M.: Control Performance Monitoring mit einer Kombination aus stochastischen und deterministischen Merkmalen, GMA-Kongress 2005, Baden-Baden, VDI-Berichte 1883, VDI-Verlag, Düsseldorf, S. 411 – 420

[17.] PCS 7 Maintenance Station

https://www.automation.siemens.com/mcms/process-control-systems/en/distributed-control-system-simatic-pcs-7/simatic-pcs-7-system-components/maintenance-station/Pages/maintenance-station.aspx

[18.] Schmitt, S.: Bausteine für optimalen Durchblick - Condition Monitoring mechanischer Assets in der Prozessindustrie. VERFAHRENS-TECHNIK 11/2010.

https://www.automation.siemens.com/mcms/process-control-systems/de/simatic-pcs-7/simatic-pcs-7-systemkomponenten/maintenance-station/Documents/236_10_schmitt_verfahrenstechnik_11_2010.pdf

[19.] Brochure SIMATIC Route Control

https://www.automation.siemens.com/mcms/process-control-systems/en/distributed-control-system-simatic-pcs-7/simatic-pcs-7-technologies/route-control/Pages/route-control.aspx

[20.] Lorenz, O.: Anwendung und Vorteile von Simulation in der Prozessautomatisierung. VDI-Kongress Automation 2009, Baden-Baden. VDI-Berichte 2067, VDI-Verlag, Düsseldorf.

[21.] Simulationssystem SIMIT

http://www.industry.siemens.com/industrysolutions/global/en/IT4Industry/products/simulation/simit/Pages/Default_tab.aspx

[22.] Module SIMBA Profibus

http://www.industry.siemens.com/industrysolutions/global/en/IT4Industry/products/simulation/SIMBA_Profibus/Pages/default_tab.aspx

[23.] SIMATIC WinAC RTX

https://eb.automation.siemens.com/goos/catalog/Pages/ProductData.aspx?catalogRegion=DE&nodeid=10001344&tree=CatalogTree&regionUrl=/&language=en&activetab=order#topAnch

[24.] SIMATIC PLCSIM

https://eb.automation.siemens.com/goos/catalog/Pages/ProductData.aspx?catalogRegion=de&region-Url=/de&nodeID=5300101%23activetab%3dproduct&language=en&activetab=#topAnch

[25.] Brochure SIMATIC Safety Matrix, Siemens AG, I IA, Sep. 2010.

http://intranet.automation.siemens.com/mcms/simatic-controller-software/en/programming-options/s7-f-fh-systems/safety-matrix/Pages/Default.aspx

[26.] Palmin, A., Kästner, J.: Ganzheitliches Security-Konzept für die industrielle Automatisierung. Automation 2008, Baden-Baden. VDI-Berichte 2032.

[27.] Kobes, P., Gummersbach, J.-L., Palmin, A., Talanis, T., Schönmüller, B.: Security Management in der industriellen Automatisierung. Automation 2011, Baden-Baden.

[28.] Siemens AG, Automation & Drives, Whitepaper: Security concept PCS 7 and WinCC, basic document and detailed documents, 2008.

https://support.automation.siemens.com/WW/llisapi.dll?aktprim=100&lang=en&referer=%2fWW%2f&func=cslib.cssearch&siteid=csius&extranet=stan-dard&viewreg=WW&groupid=4000002&objaction=cssearch&content=adsearch%2Fadsearch%2Easpx

[29.] SIMATIC PCS 7 Life Cycle Services

http://support.automation.siemens.com/WW/llisapi.dll?aktprim=1&lang=en&referer=%2fWW%2f&func=cslib.csinfo&siteid=csius&nodeid1=42347016&groupid=4000002&extranet=standard&viewreg=WW&objaction=csopen

[30.] Siemens AG, Sector Industry, Industrial Automation: White Paper "Life Cycle Services for SIMATIC PCS 7". Okt. 2010

https://intranet.automation.siemens.com/mcms/process-control-systems/en/intranet/services/Documents/Whitepaper%20Life%20Cycle%20Services%20En.pdf

[31.] Siemens Automation, Drive and Building Technology Service and Support Portal: spare parts.

http://support.automation.siemens.com/CH/llisapi.dll?func=cslib.csinfo&nodeid1=16611927&lang=de&siteid=csius&aktprim=1&extranet=standard&viewreg=CH&objid=16611927&treeLang=de

[32.] Siemens Gas-Analysis

http://www.automation.siemens.com/w1/automation-technology-gas-analyzer-gas-analysis-19001.htm

[33.] Oxymat oxygen measurement device

http://www.automation.siemens.com/w1/automation-technology-oxygen-19009.htm

[34.] Siemens Solution Partner Portal

https://www.automation.siemens.com/mcms/solution-partner/en/home/Pages/Default.aspx

[35.] Process automation from A to Z, with useful hints of branch solutions.

https://www.industry.siemens.com/topics/global/en/process-automation/Pages/Default.aspx

[36.] Product, system, solution, and services for the chemical industry

http://www.industry.siemens.com/verticals/global/en/chemical-industries/Pages/chemical-industries.aspx

[37.] Siemens Engineering & Consulting for the chemical industry

http://www.industry.siemens.com/verticals/global/en/chemical-industries/chemical-industries-services/chemical-industries-engineering-consulting/Pages/Default.aspx

[38.] GMP Engineering Manual for PCS 7

http://www.industry.siemens.com/verticals/global/en/pharma-industries/gmp-validation/gep/Pages/Default.aspx

[39.] CEMAT Process control system for the cement manufacturing

http://www.siemens.com/cemat

www.siemens.com

Siemens AG

Sektor Industry, IA AS S MP 7
Östliche Rheinbrückenstr. 50
D-76181 Karlsruhe