

Yokogawa's Control/Production Systems Contributing to Global Energy Conservation and Environmental Preservation

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Yokogawa has been focusing on technologies for energy conservation and environmental preservation since even before the oil crises in the 1970s, and providing excellent products and solutions for industrial or social infrastructures. Thus, Yokogawa has been contributing to energy conservation and environmental preservation by customers through its products and solutions. This paper introduces ever-evolving control/production systems and their effective results, which form the basis of solutions for energy conservation and environmental preservation. Related software products are also described.

INTRODUCTION

Yokogawa has been focusing on technologies for energy conservation and environmental preservation since even before the oil crises in the 1970s, and providing excellent products and solutions for industrial and social infrastructures. Thus, Yokogawa has been contributing to energy conservation and environmental preservation by customers through its products and solutions. The majority of CO₂ emissions generated by the production activities comes from plant energy consumption, therefore, it is important for global warming measures to achieve energy conservation in plant production activities.

This paper describes control/production systems that form the basis of solutions for energy-saving production and environmental preservation. CENTUM VP Integrated Production Control System, a distributed control system (DCS) used in relatively large-scale plants, STARDOM Network-based Control System that is used in relatively small scale plants or for wide-area, remote monitoring control using a network, and related systems and solution packages are introduced from the perspective of energy conservation and environmental preservation.

CENTUM VP CONTROL SYSTEM CONTRIBUTING TO GLOBAL ENERGY EFFICIENCY IMPROVEMENT

The eighth generation of the CENTUM Series, CENTUM

VP, is a DCS that helps customers to achieve an ideal plant, VigilantPlant⁽¹⁾ with ideal operation. VigilantPlant aims to achieve optimal operation quickly and with high reliability by closely monitoring and predicting the market and plant production conditions and anticipating those changes. CENTUM VP is the core production control system for that purpose. In recent years, energy conservation and environmental preservation is a big challenge for customers, and CENTUM VP enables operation to achieve it.

To achieve energy-saving production in plants, it is important to not only save energy by increasing control performance and production efficiency but also to properly recognize the operation conditions of production equipment and how to operate stably and safely in response to various disturbances and load changes associated with production activity. Furthermore, since the full automating of plant operation is difficult, manual intervention is unavoidable. Accordingly, it is important to reduce the manual intervention, prevent operator errors, and lighten the operator load. This leads to the operation that does not generate losses. Features provided by CENTUM VP are described from these points of view.

CENTUM VP not only utilizes the latest IT and PC technologies, but also has DCS features based on a huge amount of knowledge relating to how to operate a plant efficiently and reliably, which was acquired through the experience of having delivered more than 20,000 systems since the release of the first generation of CENTUM in 1975. One typical feature is its highly reliable design and another is its human-machine interface functions.

Highly Reliable Design of CENTUM VP

The highly reliable design refers to a total performance that includes not only the highly reliable design of hardware

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Meanwhile, it is necessary to reduce unnecessary alarms and events in order to ensure efficient operation without losses. The Exaplog Event Analysis Package provides the solution to help perform analysis to identify the causes of those unnecessary alarms and events and remove them.

Exaplog focuses on the balance between the number of alarms and events generated (the number of required process operations) and the number of operators' actions (the number of operations) and analyzes the operation on basis of the imbalance between them. Analysis support tools are available, such as graph display that visually classifies the number of required process operations and list display in order of the number of occurrences. Almost no special training is required to perform analysis easily.

Figure 4 shows an example of an Exaplog screen. The upper left shows the trend of the number of required process operations and the right shows the classification and rates of the events generated in the selected scope.

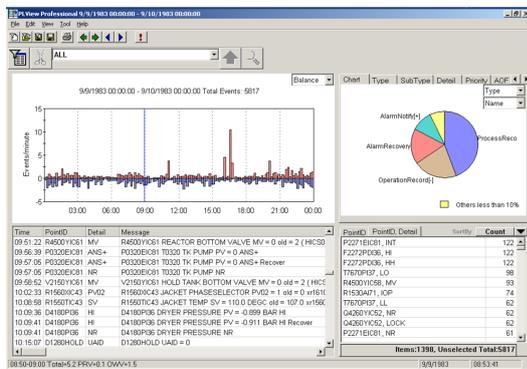


Figure 4 Exaplog Screen Example

■ Operation Support Using Exapilot Operation Efficiency Improvement Package

As mentioned previously, manual intervention is inevitable for plant operation, and reducing the operators' burden is important for efficient operation and to prevent operator errors. To deal with these problems, the Exapilot Operation Efficiency Improvement Package automates manual operations that cannot be automated only by DCS standard functions and provides a navigation function. (3)

Simple flow charts are used to create guidance for non-steady state manual operations and incorporate the operation knowledge of experienced operators into the system. They can be used not only for automation but also as the electronic Standard Operating Procedures (SOP). The Exapilot also have a variety of support functions, such as dual-direction interactive communication with operators, voice guidance and sending mail, and contribute to reduce the operators' burden and prevent careless mis-operations.

Figure 5 shows an example of an Exapilot screen. The upper part shows the main process at start-up, and the lower part shows a preparatory sub-process of that process. The operator can perform efficient operation without errors while looking at this screen.

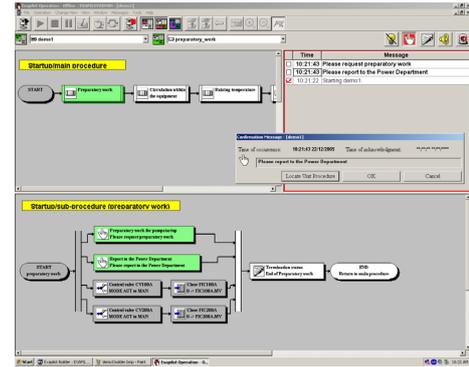


Figure 5 Exapilot Screen Example

Exaquantum Plant Information Management System Package

Exaquantum is a Process Information Management System (PIMS) that accumulates the process data and provides the information processed in various ways for the applications in the Manufacturing Execution System (MES) area. (4)

Different from general PIMSs, the Exaquantum is designed focusing on interconnectivity with DCSs, in particular, CENTUM. The data equalization function for the function blocks is one of its typical functions. The Exaquantum provides various functions, such as closing of the data, graphic function, link with spreadsheet software, data analysis, report generation, and real-time monitoring of the plant operation situation. It can also perform multifaceted operation analysis by collecting not only the process data but also alarms and events. Its Web browser function frees it from location restrictions.

Needless to say, the Exaquantum can be used to accumulate and process the data relating to energy consumption and conversion, as well as greenhouse gas emissions, accordingly, it can be utilized for energy conservation and environmental preservation.

For example, the Exaquantum can be used to perform the trend analysis of equipment. Figure 6 shows a display screen example of trend analysis of Yokogawa's cogeneration equipment. It shows the correlation between the total electric power generated by the equipment, the total reuse of waste heat, and the total gas consumption. This screen enables the operator to recognize the energy utilization efficiency and take measures to improve the efficiency.

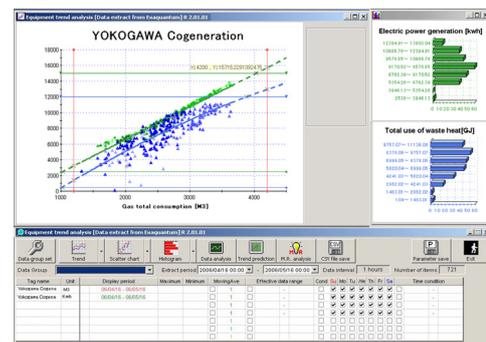


Figure 6 Exaquantum Screen Example

Advanced Process Control (APC) Package

In 1999, Yokogawa formed an alliance with Shell Global Solutions International B.V. regarding advanced process control, and since then has jointly developed products.⁽⁵⁾ Applying of advanced process control enables operation with the minimum energy and minimum CO₂ emissions under various restrictions, which directly leads to energy conservation and environmental preservation.

The following provides a brief overview of typical products. For details and application examples, refer to “Energy-saving Solutions by Advanced Process Control (APC) Technology” in this issue.

■ Exasmoc Multivariable Model Predictive Control Package^{(5),(6)}

Exasmoc predicts the process behavior several steps ahead by using a multi-input and multi-output model to control the target process. It enables products to be produced with the minimum energy, materials, and time according to the given product specifications, equipment restrictions, exhaust gas restrictions, economic restrictions, etc. In particular, it is possible to achieve excellent stable control performance in processes with disturbances, dead time, reverse response, and mutual interference. An Exasmoc controller consists of a process response model, predictive function, and optimization calculation function.

■ Exarqe Robust Quality Estimator Package^{(5),(6)}

In recent years, a method called a soft sensor or virtual analyzer is used, which estimates the composition of materials, products, and semi-finished products based on the process temperature, pressure, flow rate, etc. Exarqe is one of such methods.

For example, it can be used to estimate the flash point, Reid vapor pressure, octane value, melt index (resin fluidity), and density in oil and chemical industries. It enables to eliminate the analysis delay time of analyzers and improve control performance. As a result, it can reduce variations in the product quality and operation losses.

Exarqe has a built-in estimation model to estimate the quality with high precision and high robustness. It applies estimation logics, such as principal component regression (PCR), partial least square regression (PLS), or rule-based reasoning (RBR) using neural networks. Furthermore, since the Exarqe has a function to compensate (update) the estimated value using values from online analyzers or those obtained by analysis, the maintenance is not required for long periods of time.

STARDOM NETWORK-BASED CONTROL SYSTEM CONTRIBUTING TO SOLVING GLOBAL ENVIRONMENTAL PROBLEMS

STARDOM is a system that runs autonomous distributed control components in a coordinated manner on the network, and is a product designed for markets that require open scalability and flexibility. The STARDOM contributes to energy conservation and environmental preservation in markets, such as new energy and energy conservation, where keywords include distributed and remote.

Energy Conservation Solutions Using STARDOM

The STARDOM is used in applications related to energy conservation and environmental preservation as shown in Table 1, which can take advantage of the features of STARDOM whose controller FCNs/FCJs (Field Control Nodes/Field Control Junctions) are autonomous and can be easily added to existing systems. Furthermore, many STARDOM-based packages dedicated for energy conservation are available, which have been used for power-related energy conservation in many office buildings, plants, commercial facilities, etc. These packages are described in the “Energy Management and Control Systems” section.

Table 1 Examples of STARDOM Applications

Purpose	Application Example
Improve the control performance and contribute to energy conservation	Utility equipment monitoring and control, Batch reactor vessel control, Distillation equipment control, Furnace control
Monitor greenhouse gases and hazardous substance emissions and contribute to environmental preservation	Wastewater equipment monitoring, Plant environmental monitoring, Waste processing equipment monitoring
Utilize renewable energies and contribute to effective use of energy	Wind power farm remote monitoring, Dimethyl ether (DME) fuel cell testing, Hydrogen filling station control and monitoring, Small-scale hydroelectric power plant monitoring and control, Geothermal plant monitoring, Monitoring and controlling the supply of waste heat and carbon dioxide generated by the power plant to the greenhouse

Energy Conservation Examples of Oil and Gas Drilling Equipment in Remote Site

FCN/FCJ are autonomous controllers that have both the reliable control function inheriting a DCS and an IT function for information processing and transmission. The following presents examples of utilizing the information processing and transmission.

Oil and gas drilling equipment is often distributed in places where social infrastructure, such as a power grid and communication network, is underdeveloped. One of the global environmental problems in such oil and gas drilling equipment is the gasoline fuel consumption and CO₂ emissions due to vehicles that are used for periodic maintenance and inspection of equipment.

FCNs/FCJs, with reliable PLC functions, in addition, capabilities of various types of wireless communications and a logging function at onsite responding to narrow band and unstable communication infrastructure connecting remote places, work as intelligent PLCs/RTUs (Programmable Logic Controllers/Remote Terminal Units) for control and information transmission at the drilling site. The FCN/FCJ lineup includes an environmental resistant, low power consumption controller (FCN-RTU), which is driven by solar energy and can be used in harsh environments such as extremely high or low temperatures, high altitude, etc., and this type of FCN/FCJ is being applied according to the application.

The FCN/FCJ performs control and information transmission, while sending the data of field devices, such as control valves and differential pressure transmitters, to

Yokogawa's PRM (Plant Resource Manager) Integrated Plant Asset Management System installed in the control center via the FOUNDATION fieldbus, etc. Centrally managing the device information in real time using PRM enables the followings and reduces the frequency of periodic inspection patrol remarkably. Figure 7 shows the increasing of the efficiency.

- Real time monitoring of device information makes it possible to monitor conditions such as a performance decrease, and reduce the frequency of daily inspection and urgent inspection after rough weather conditions.
- The central management of equipment operation and inspection recording, etc. makes it possible to plan an efficient inspection patrol schedule.
- A device diagnostic function makes it possible to perform preventive maintenance.

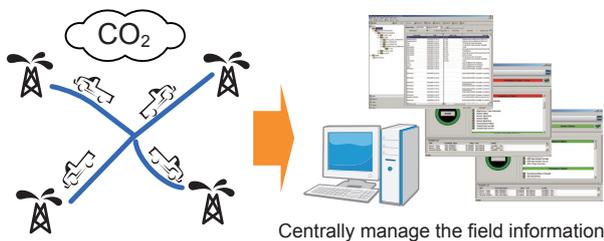


Figure 7 Increasing of Management Efficiency of Oil and Gas Drilling Equipment Using PRM

An example in North America required traveling approximately 1.5 million km per month for the daily inspection of thousands of places of gas drilling equipment distributed around an area of 100 km x 93 km. This translates to approximately 4,800 tons of CO₂ emissions per year. Achieving the asset excellence (maximum use of assets), one of the four excellences of VigilantPlant, using remote monitoring reduced (nearly halved) the travel cost and CO₂ emissions significantly.

ENERGY MANAGEMENT AND CONTROL SYSTEMS

Yokogawa provides customers with various systems and software packages for energy management and achieving energy conservation. The following describes their major objectives.

- Directly achieve the energy conserving operation of equipment and devices
- Monitor the energy consumption and the compositions and quantities of gases exhausted and utilize the data to plan energy conservation and environmental preservation measures
- Create an optimal equipment and device operation plan to meet the demand load
- Integrate the energy and production information and help save energy in the production process

Econo-Pilot Energy-saving Control Systems

Table 2 shows the lineup of the Econo-Pilot Energy-saving Control Systems and their respective control targets.

They can be easily added to existing systems and are able to achieve energy conservation at low costs. Table 2 also shows the energy conservation effects achieved by their introduction to plants, hospitals, commercial facilities, etc.

Table 2 Energy Conservation Effects Achieved by Introduction of Econo-Pilot

Name	Control Target	Energy Saving
Econo-Pilot	Secondary hot and cold water supply pumps for air-conditioning	Up to 90% power saving
Econo-Pilot HSP	Cold and hot water pumps and cooling water pumps for thermal transfer system	Up to 70% power saving
Econo-Pilot Comp	Compressors (compressed air)	Up to 30% power saving

For details on the Econo-Pilot HSP Heat Source Water Pump Energy Saving Control System, refer to “Econo-Pilot HSP Energy-saving System for Heat Water Source Pumps” in this issue.

InfoEnergy Distributed Energy Management System

InfoEnergy is a software package that collects data relating to the energy (electric power, gas, etc.) used in buildings and by equipment and the operating conditions of the equipment, and performs management and analysis to reduce the energy used. The InfoEnergy is based on the autonomous controller FCN/FCJ of the STARDOM, and enables visualization of energy-saving with its information processing and transmission functions at low costs. Figure 8 shows a configuration example.

- Achieving Visualization
The InfoEnergy links amount of energy consumption with production volume and equipment operating conditions and is able to perform per unit production management in a time range from an hour to a month. Due to the ability to perform monitoring using a Web browser, energy-saving activities in the production field can be promoted.
- Easy Installation and Expansion
Large scale investment is not required. With just installing one controller, tasks from data logging to report creation can be performed without using a dedicated PC. The information residing in multiple controllers, which are added arbitrarily, can be centrally managed on the Web browser. Also information from an overview to details can be viewed.

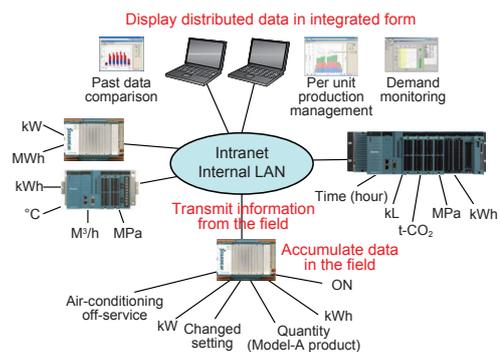


Figure 8 InfoEnergy Distributed Energy Management System

Application examples include that of a gas equipment manufacturer where the use of electric power for each production line was visualized and energy conservation was achieved, or that of a university campus where the use of electric power for each building in the campus was visualized and energy conservation was achieved.

Enemap Energy Prediction and Optimization System

Enemap is a software package that predicts the energy demand load based on the past operating results and weather forecast data, determines the best combination of using the electric power, city gas, fuel oil, etc., and creates the optimal operation plan to meet the demand load.⁽⁷⁾

- Predicting Demand Load

The Enemap predicts demand for electric power and heat till maximum of 48 hours ahead based on the past results, operating schedule, and weather forecast data imported from external sources. It applies prediction algorithms such as principal component regression (PCR) and multiple linear regression (MLR).

- Optimal Operating Plan

It creates an operating plan that satisfies the predicted demand load and minimizes the operating cost and CO₂ emissions, and supports and automates the plant operation. When creating the optimal operating plan, operating restrictions between equipment and devices, etc. are given as models, and it obtains the optimal operating pattern using mathematical programming with the models.

One application example is that of a utility plant, that uses city gas, fuel oil, in-house generated power, and purchased electricity as the energy sources, and supplies energy such as electric power, hot and cold water, and steam over the entire plant. In this application, the fuel cost was significantly reduced by saving energy and labor. Another example is that of an airport energy center, in which the optimal operating plan based on the demand load prediction was created, and energy-saving, environmental load reduction and cost saving was achieved.

Enerize E3 Factory Energy Management System

Enerize E3 is a newly developed software package that integrates the energy and production information to help save energy in the production process. The following describes the major features.

- Clarifying Energy Consumption by Product Model and Lot

The Enerize E3 integrates the production and energy information and clarifies the operating indicators of the plant energy utilization in order to help optimize the energy in the entire plant.

- Strongly Supporting Energy Conservation Activities with All Members Participation

Managing indicators, identifying waste, and confirming effects can be easily achieved by immediately providing the necessary information to those who need it, when they need it.

- Flexibly Responding to Frequent Upgrades of Equipment and Production Lines

A powerful engineering support environment (Visual Builders) enables engineers to flexibly respond to upgrades of the equipment and production lines.

The details are described in "Energize E3 Factory Energy Management System" in this issue.

CONCLUSION

The above described that Yokogawa's CENTUM VP Integrated Production Control System, STARDOM Network-based Control System, and related systems and solution packages help conserve energy and preserve the environment by ensuring safe and stable operation, improving the control performance, monitoring and controlling the energy consumption and greenhouse gas emissions, using renewable energies, and so on.

Energy conservation and environmental preservation is an eternal challenge for humankind to survive on the planet Earth with limited resources. Yokogawa will improve the products and solutions for that purpose and hopes to contribute to global energy conservation and environmental preservation.

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