

Instrumentation and Control System Solutions to Support Stable Operation, Energy Efficiency and Environmental Conservation

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ABSTRACT

Stabilization and sophistication of operation, improvement of energy efficiency and environmental conservation are common issues shared by customers in various fields. To address these issues, Fuji Electric makes full use of its 60-plus years of experience with instrument to offer instrumentation and control system solutions. In the steel industry, they support stable operation of iron mills, improvement of energy management efficiency and stable production of high-quality products. In the chemical, food and pharmaceutical industries, they facilitate high-mix low-volume production, safe and stable operation, preventive maintenance and ensured product manufacturing records. In addition, they contribute to safe and stable operation and environmental measures in garbage processing plants, boiler facilities and cement plants.

1. Introduction

Fuji Electric's instrumentation and control technologies were launched in 1951 when we released measuring equipment such as flow meters and gas analyzers, and they have been developed into panel instrumentation where the measuring equipment are combined with receiving instruments and adjusting instruments. Fuji Electric delivered a computer control system in 1963 for the first time in the instrumentation industry, and launched its first distributed control system (DCS) in 1975, having a history that spans over 60 years so far. Throughout our history, we have been considering, "What issues are our customers facing?" and "How Fuji Electric can solve these issues?" and have actually provided instrumentation and control systems as solutions for the customers. Specific issues addressed include stabilization and sophistication of operation, improvement of energy efficiency and environmental conservation.

In this paper, we will introduce the solutions Fuji Electric has offered for the steel, chemical, food and pharmaceutical industries and incineration processes.

2. Instrumentation and Computer System Solutions in Steel Industry

Fuji Electric has delivered a variety of instrumentation and control systems for steel plants, from pig iron making through steelmaking, rolling and process lines, contributing to stable operation, energy efficiency and environmental conservation in steelworks.

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2.1 Surrounding circumstances

The steel industry, which produces materials for other industries and construction materials, is one of Japan's key industries. In recent years, we have been experiencing huge environmental changes such as the rapid economic advance of China and mergers and reorganizations of domestic manufacturers. In order to maintain and enhance its international competitiveness and make further progress under such conditions, the steel industry is facing urgent needs to positively incorporate domestic demand, actively develop new demand overseas and improve production efficiency.

2.2 Issues encountered by industry and Fuji Electric's solutions

(1) Stabilized operation of converters

An oxygen converter gas recovery (OG) system, part of a converter, is shown in Fig. 1. In the OG system, linz-donawitz converter gas (LDG), which is generated in the process of a refining reaction in a converter, is recovered in a gas holder without being burned. LDG is high-temperature and combustible gas whose main ingredient is CO and it contains much dust. It is used as fuel for facilities in steelworks. OG systems have risks of explosion due to air inflow, deteriorated

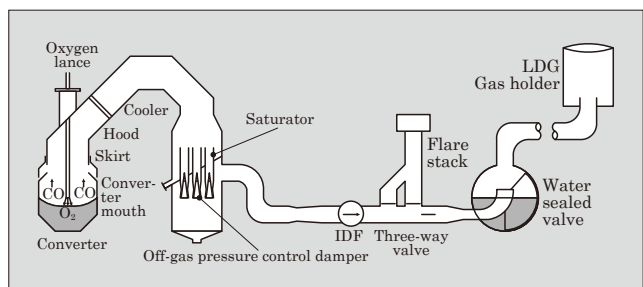


Fig.1 Outline of OG system

energy recovery rate due to the issuing of LDG and environmental contamination due to a leak of poisonous gases containing dust. To prevent such risks, it is necessary to restrict disturbances to the minimum level to keep the pressure at converter mouth (P0) constant.

Fuji Electric is providing new control of P0 (NCP0), an instrumentation and control system, as a solution to such challenges. The NCP0 is a control system where, in addition to an optimal regulator, an adaptive regulator such as disturbance pattern judgment and hunching detection is adopted and a feed forward regulator based on estimated flow values of gas generated in an oxygen converter is combined. This system makes it possible to automatically change control gains and various parameters used for the control of disturbances, thereby minimizing the fluctuation of process gains, furnace pressure and gases generated in an oxygen converter.

(2) Enhanced energy operational efficiency

Various types of energies used in steelworks are generally classified into purchased energy, such as city gas, oxygen and electric power, and by-product energy, such as by-product gases, steam and electric power. The most important tasks in energy management at steelworks are to control a balance between demand and supply through optimally operating energy and to minimize useless consumption of energy.

As solutions to such challenges, Fuji Electric provides “Steel EMS package” (see Fig. 2), a solution package of demand/supply forecasting (visualized future) and optimization (realization of energy-efficient operation)⁽¹⁾.

With this demand/supply forecasting system, energy fluctuations will be estimated based on track record data gained from DCS, operation plans according to manufacturing execution system (MES) and manufacturing plan data. This will enable operators to perform energy-efficient operation according to the estimated energy demand and supply from a few minutes ahead through a few days ahead.

In addition, with this optimization system, energy cost will be minimized through the particle swarm optimization (PSO) method, the latest metaheuristics optimization technology, based on the data estimated

by the demand/supply forecasting (plant-by-plant and energy-by-energy data). This PSO method will make it possible to extract optimal operation patterns for in-service facilities based on the collected track record data. With the conventional method, it was difficult to adjust the operation patterns in the event of an unintended operation or an operation method change. In contrast, with this PSO method, we can find optimal solutions, and this makes it possible to maintain a balance between demand and supply and minimize useless consumption of energy.

(3) Stable manufacturing of high-quality products

The tasks for overall steelworks include stabilized operation, securing of product quality and enhancement of energy efficiency. Detailed management of quality information, precise analysis of collected information and minimization of downtime at the time of updating a system are required for a computer control system. Fuji Electric offers quality information management systems and operation analysis systems as an approach to these tasks.

(a) Quality information management system

As a quality information management system in steel process lines, we provide the process data collection system (PDCS) package. With this package, the length quality data of coil products will be collected from each sensor and managed with appropriate resolution. This package will precisely record conditions during coil manufacturing, thereby enabling stable operation and securing product quality.

(b) Operation analysis system

Analyzing the operation track record data collected by PDCS will identify operation factors affecting product quality. Fuji Electric is providing the following systems as operation analysis systems contributing to stable manufacturing.

(i) Bayesian analysis system

Bayesian analysis system is a system developed based on a Bayesian network utilizing a probabilistic inference algorithm in which a complicated relation between an effect and its cause is denoted by conditional probability. By analyzing past operation track records with this system, we will identify significant factors in a manufacturing

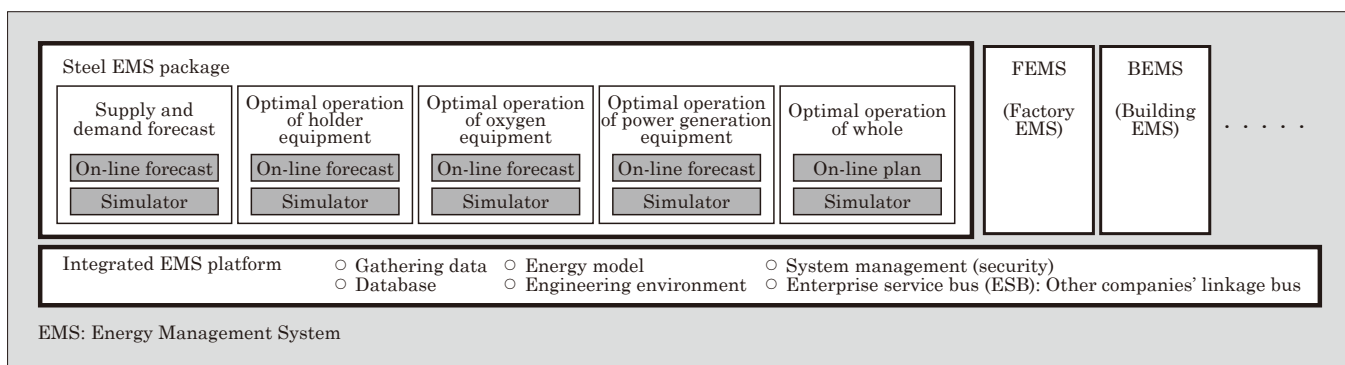


Fig.2 Steel EMS package

process which may affect product quality.

(ii) "MainGATE MSPC"

By using multivariate statistical methods, MainGATE MSPC will detect abnormalities which cannot be detected merely with the setting of upper/lower limits, and identify key factors which will affect product quality most to improve the quality.

(c) Effective updates of computer systems

It becomes difficult to enhance or remodel computer systems for stable operation when the production of existing hardware is discontinued. Therefore, they must be renewed in a shorter span compared to other control devices.

Fuji Electric is providing an updating technology utilizing virtualization, which makes it possible to easily install new functions at the time of replacing an existing system with new hardware. This system has the following functions to make operation tests easy, and they contribute to effective updates of computer systems:

- Simultaneous parallel operation of old and new computer systems
- Comparison of results output from old and new computer systems

With this updating system, we can cut down the cost and duration required for updating to half and replace an old system with a scalable one while securing product quality.

3. Instrumentation System Solutions in Chemical, Food and Pharmaceutical Industries

3.1 Surrounding circumstances

In spite of the fact that the chemical, food and pharmaceutical industries are producing products indispensable for our daily life, they are facing difficult conditions: skyrocketing raw material costs in recent times; a decline in domestic demand due to the falling population; declining birth rate and aging of society; and diversified needs of consumers, etc. For those reasons, competitiveness needs to be further enhanced. Furthermore, as a result of the reorganization of chemical corporations in Europe and the U.S.A., international competition is being intensified.

In addition to the need to ensure safe and stable operation, domestic plants are facing problems of aging operators and a reduction in their number.

3.2 Issues encountered by industry and Fuji Electric's solutions

Common issues shared by the chemical, food and pharmaceutical industries and Fuji Electric's solutions for them will be described here.

(1) Accommodation for high-variety low-volume manufacturing

As a measure to respond to stagnant demand, di-

versified needs of users and rising raw material costs, high-variety and low-volume manufacturing is being applied. Under such circumstances, it is necessary to establish a manufacturing system which can easily accommodate the addition and change of products.

In order to solve this issue, Fuji Electric is providing ISA 88-compliant recipe management system as a batch control system for high-variety and low-volume manufacturing. This system can be installed in "MICREX-NX," Fuji Electric's DCS. With this system, we can promptly and adequately respond to changes of recipes in association with the addition of product or improvements in products. An example of MICREX-NX's recipe management functions is shown in Fig. 3.

Moreover, we have developed "HEART," an engineering tool which makes it possible to create software with the use of general-purpose OA software (Excel, Visio*1). By using this tool, we can unify the management of specifications and software and realize its in-house manufacturing, thereby reducing the running cost required in association with product improvement and making it possible to promptly release new products.

(2) Safe and stable operation

We used to be dependent on operators with experience and skills for safe and stable operation so as to stably supply products. In order to respond to the declining number of experienced operators in the future, applying machinery and systems to secure safety and enhance stable operation is required.

In recent years, starting with Europe, there have been increasing tendencies to promote activities intended to secure safety for whole components and facilities through new safety-securing methods which are based on specifications regarding functional safety and mechanical safety (safety design, safety approval and safety management). These activities are attracting attention in Japan, too.

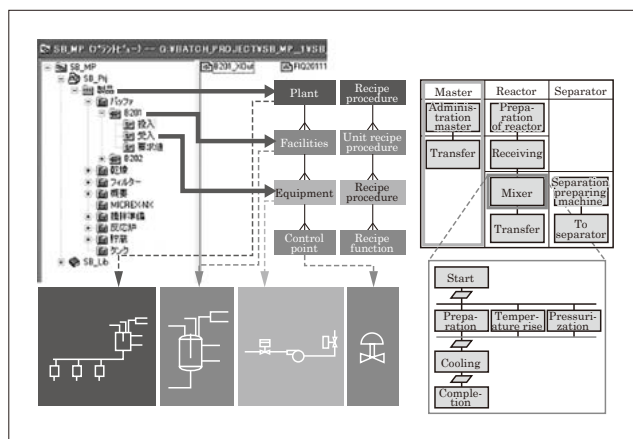


Fig.3 Example of MICREX-NX's Recipe management functions

*1: Excel, Visio: A trademark or a registered trademark of Microsoft Corp., U.S.A.

Fuji Electric is providing safety instrumented systems to secure safety at manufacturing sites. The safety instrumented systems protect humans, the environment and facilities from unexpected accidents or troubles at plants. MICREX-NX's safety instrumentation system corresponds to SIL 3, a safety integrity level.

With the introduction of the safety instrumented systems, facilities will be shut down in the event of safety-related abnormalities without being damaged. In this way, it becomes possible to restart the facilities without problems, and this contributes to stable operation, too.

(3) Preventive maintenance

Improvement and preventive measures against a variety of issues are being implemented at manufacturing sites. However, in some cases, events that show signs of trouble may not be revealed, which could result in sporadic failures or accidents. It is necessary to predict or estimate such unrevealed events to prevent failures and accidents, and thus production downtime should be minimized.

Fuji Electric's MainGATE MSPC will detect abnormalities which cannot be detected merely with the setting of upper/lower limits. By comprehending signs of troubles according to correlations among various events generated at workplaces, this system will contribute to preventive maintenance, accident prevention and minimized production downtime.

(4) Saving of product manufacturing record

In product manufacturing, saving manufacturing process records (traceability) and making use of them for improvement are important tasks.

Fuji Electric's MICREX-NX is compatible with ER/ES*2 including FDA21 CFR Part11*3 to secure traceability of manufacturing processes at plants. With this system, the necessary data will be recorded digitally, which makes it easy to save and manage the data.

4. Instrumentation and Computer System Solutions in Combustion Process

Instrumentation system solutions for Combustion processes at garbage disposal facilities, boiler facilities and cement plants will be described here.

4.1 Surrounding circumstances

(a) Garbage incinerator plants

*2: ER/ES: Regulations regarding electronic records and electronic signatures used at the time of applying for approval or permission for using pharmaceutical and food products.

*3: FDA 21 CFR Part11: Regulations established by the Food and Drug Administration (FDA). Requirements to be observed regarding electronic records and electronic signatures used at the time of applying for approval of sales of pharmaceutical and food products are specified there.

Garbage incinerator plants have an extremely high public nature and are required to treat general waste in a stable and effective manner. In addition, there is increasing social demand for environmental countermeasures and utilization of waste heat.

(b) Boiler facilities

After the Great East Japan Earthquake, the importance of electric power supply and the securing of power have been reaffirmed. As a result, the demand for safety and stable operation has been increased further in areas from boilers at thermal power plants of a very public nature through heat supplying-type thermal boilers to supply heat and electric power within factory.

(c) Cement plant

The Basic Environment Plan of the Ministry of the Environment states that our ideal society is a sustainable one. In the cement industry, too, with the aim of achieving this goal, efforts for a sustainable society, including global warming countermeasures and effective use of waste and by-products, are required.

4.2 Issues encountered by industry and Fuji Electric's solutions

(1) Safe and stable operation

The challenges to overcome for safe, stable, efficient and effective operation of plants and facilities are as follows.

(a) Garbage incinerator plant

In order to treat waste in a stable and effective manner, it is necessary to comprehend precisely the overall operation circumstances of facilities.

(b) Boiler facilities

In accordance with turbine load, etc., prompt and effective supply of high-temperature and high-pressure steam is required.

(c) Cement plant

Stable and product-feature-based production of high-quality cement products is required.

As a solution to such tasks, Fuji Electric is providing "MICREX-VieW XX" that enables safe and stable operation. Features of the system are:

- High-speed and highly reliable system
- Up-to date monitoring function with drastically improved usability
- Cross-sectionally integrated component, including aspects from measuring, driving, power generation, energy management system (EMS) through factory automation (FA) and process automation (PA) (systems from high-speed control through process automation systems are integrated into the same component)
- High-efficiency engineering function
- Globally capable
- Inheriting of customer's existing properties (Hardware & Software)

We are developing solutions for various incin-

eration processes with MICREX-VieW XX and control packages.

(a) Garbage incinerator plant

MICREX-VieW XX enables the integration of electric, instrumentation and computer systems. With this system, we can precisely comprehend overall operation circumstances of garbage disposal facilities, from extra-high-voltage electric distribution facilities through incinerators and control computers. Thus, we will be able to find abnormalities of facilities within the plant at an early stage and promptly remove the causal factors to restore operation, thereby achieving safe and stable operation.

A configuration example of a garbage disposal facility system with MICREX-VieW XX is shown in Fig. 4.

(b) Boiler facilities

With the MICREX-VieW XX system, the functions of turbine governor control device, high-speed control device, and boiler control device, instrumentation and control system, are implemented via the same component. Coordination between the boiler control and turbine control functions will be enhanced as a result, and this enables sophisticated boiler/turbine cooperative control. Consequently, a boiler can supply steam in accordance with the level

of turbine load more promptly in an effective and stable manner.

(c) Cement plant

Fuji Electric is providing the following packages for production facilities at cement plants, and these packages will promote stable production of a variety of high-quality cement products:

- (i) Raw material ratio control depending on the type of cement products (limestone, auxiliary material)
 - (ii) Raw material formulation-adjustment control based on analysis data gained from X-ray fluorescence analyzers
 - (iii) Ratio and delivery control of clinker, gypsum and mixture depending on the type of cement product
- (2) Environmental countermeasures and measures to alleviate environmental impact

In order to protect the environment, which is a social requirement, it is necessary to comply with the exhaust gas regulations. Furthermore, taking measures to further alleviate environmental impact such as CO₂ reduction is our task.

(a) Garbage incinerator plant

To promote the neutralization of toxic HCI contained in exhaust from garbage incinerators, slaked

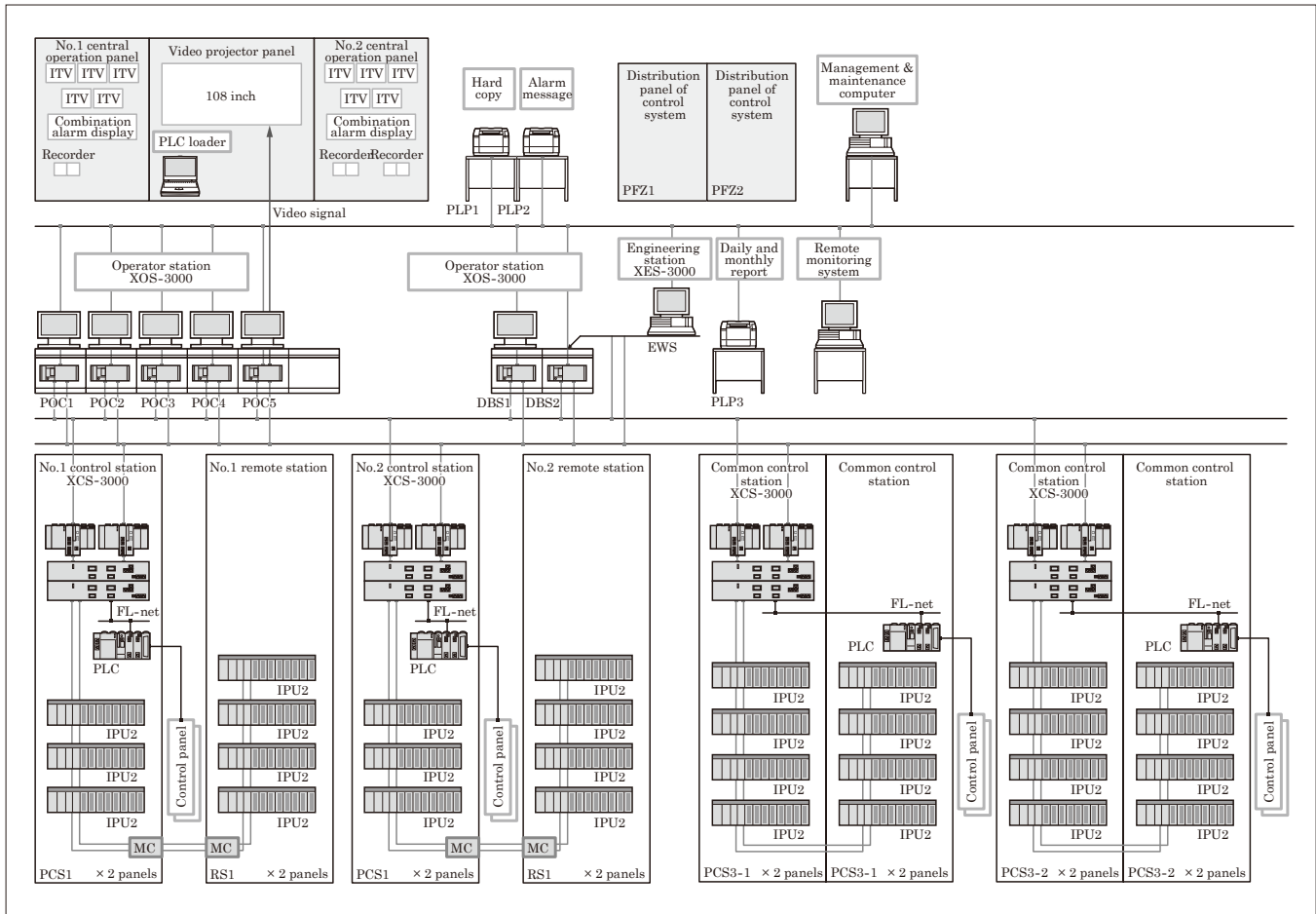


Fig.4 Configuration example of a garbage disposal facility

lime is injected in accordance with its concentration. As a device to detect the concentration, Fuji Electric is providing laser gas analyzers. Conventional infrared gas analyzers require two to three minutes until the measurement after the collection of exhaust gas. Therefore, redundant time control and sample PI control had been implemented to prevent hunching during the concentration control. On the other hand, the laser gas analyzer can measure the concentration at high speed, within one to five seconds, which enables real-time control and further decreases the HCl concentration in exhaust.

(b) Boiler facilities

- (i) By controlling CO in exhaust with high-speed response raiser-type CO analyzers and controlling O₂ in exhaust with zirconia O₂ analyzers, exhaust heat loss can be reduced and the fuel consumption of a boiler can be lowered, resulting in a CO₂ emission reduction.
- (ii) In some boilers where the by-product gas and by-product oil generated from factory can be used as fuel. By automatically selecting a boiler of higher efficiency (if there are two or more boilers) based on by-product fuel generation prediction and model prediction, and by automatically controlling the amount of by-product fuel in an optimal way, we will minimize operation cost and reduce CO₂ emissions.

(c) Cement plant

In cement plants, waste is positively reused as sources for heat energy and sewage sludge as cement raw materials, which helps reduce environmental impact.

However, when waste is used as fuel, it becomes necessary to monitor exhaust, because the components of the waste fluctuate greatly. As a solution to this, Fuji Electric is providing high-temperature and high-dust-concentration exhaust analyzers to be installed on exhaust stacks.

5. Postscript

We have outlined instrumentation and control system solutions contributing stable operation, energy saving and environmental conservation.

We, Fuji Electric, will do our best to offer our customers solutions for safe and stable operation, cost reduction and environmental countermeasures by making use of our integrated abilities which can provide systems from software to heavy electrical machinery through a one-stop service.

Reference

- (1) Narumi, K. et al. "Steel EMS Package" Optimizing Energy Management at Steelworks. FUJI ELECTRIC REVIEW. 2013, vol.59, no.3, p.165-169.





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