INTEGRATED CONTROL OF POWER GENERATION FACILITIES IN PAPER PLANTS

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In general, a pulp and paper plant is comprised of a pulp factory, paper machines, coaters, and utility facilities for power generation, wastewater treatment, and so on. Although it does not play a direct role in the paper manufacturing process, the power generation facility is critical for ensuring the continuous running of the pulp and paper plant. The power generation facility is comprised of units, each of which is composed of a boiler, a turbine, a generator, and auxiliary equipment, and each unit is traditionally controlled by an independent system.

This paper presents an application of the Yokogawa CENTUM distributed control system that embodies integrated control as well as consolidated operation and monitoring of such a power generation facility, and also introduces implementation of new control methods required by these power facilities due to the diversification of fuel and reduction of global-warming gas emissions.

INTRODUCTION

The power generation facility in a pulp and paper plant is comprised of units, each of which is composed of a boiler, a turbine, a generator, and auxiliary equipment, and these pieces of equipment were traditionally controlled on a unit/equipment basis. This paper presents an application of CENTUM, Yokogawa's distributed control system (DCS) that integrates the independent control systems of such power generation facilities to achieve labor saving through operations via CRT display and keyboard It also introduces boiler types corresponding to diversified fuels and outlines the commitment to new control methods necessary for power facilities due to reduction of gas emissions causing global warming.

BOILER TYPES AND FEATURES

Traditionally, black-liquor recovery boilers and oil-fired boilers were used in pulp and paper plants. However, after the oil crisis, the construction of coal-fired boilers increased. In recent years, the construction of biomass boilers has been on the rise in response to the effectuation of the Kyoto Protocol, contributing to the suppression of global warming.Today, there are cases where excess generated power is sold to power producers and suppliers (PPS) due to the liberalization of electric power regulations.

The following introduces the features of the combustion methods of boilers adopted for power generation uses. The boilers adopted by most pulp and paper plants are natural recirculation boilers, with common steam conditions being pressure of several megapascals (MPa) to 16 MPa, and temperature of approximately 500°C.

Black-liquor Recovery Boilers

Black-liquor recovery boilers are also called soda recovery boilers. A black-liquor recovery boiler recovers caustic soda (NaOH) from waste liquor (black liquor) by burning the waste liquor discharged from the pulp manufacturing processes and generates steam for power generation by making use of combustion heat. A feature of this type of boiler is its strong corrosive nature, which therefore was said to cause difficulty in raising main steam temperatures. Recent black-liquor recovery boilers have come to realize steam temperatures as high as 500°C or more, however, realizing steam conditions equivalent to those of other fuel-fired boilers.

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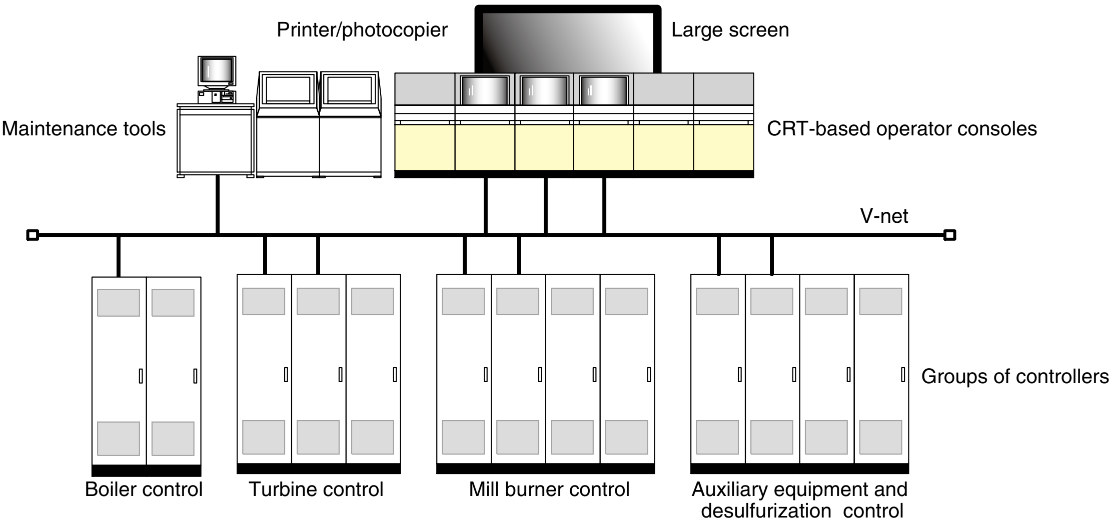

Figure 1 Example of the Implementation of an Integrated Control System for a Power Generation Facility

This type of boiler is used for operations with constant loads because of its main objective to recover caustic soda. Because black-liquor recovery boilers are difficult to control, advanced control such as char bed optimization and soot blower optimization has been adopted in some situations.

Oil-fired Boilers

Oil-fired boilers feature good load follow-up capability, which enables them to be operated flexibly. They have the additional merits that they require fewer pieces of auxiliary equipment, the boilers themselves are simple in construction, and their construction costs are low. They were therefore at one time used as boilers for power generation in pulp and paper plants. However, due to recent substantial increases in fuel costs, the number of oil-fired boilers that have been shut down or positioned as standby units have increased. It is also predicted that the replacement of oil by other fuels will continue and the shutdown of oil-fired boilers increase, due to rising crude oil prices attributable to recent worldwide energy circumstances.

Coal-fired Boilers

As mentioned above, the oil-fired boilers, being inexpensive to construct and superior in operability, were frequently manufactured in the past, but after the oil crisis the construction of coal-fired boilers has also been on the rise. Coal-fired boilers, however, require much auxiliary equipment (smoke exhaust control, coal handling, ash sluicing, etc.), making it difficult for small-capacity coal-fired boilers to be cost-effective. Therefore, coal-fired boilers with relatively large capacities of 100 tons per hour or more have been frequently constructed. In comparison with oil-fired boilers, they have more auxiliary equipment, including coal pulverizers, which thereby further complicates their operation and control. Furthermore, their boiler characteristics change depending on the types of coal used, and delays can occur in the follow-up capability of coal pulverizers and other equipment, all of which contribute to their reputation of being difficult to control.

Biomass Boilers

Construction of biomass boilers has been on the increase in recent years due to corporate commitments to global environmental measures and from the viewpoint of conserving resources. Biomass boilers are circulating fluidized-bed combustors capable of burning various types of fuels. They have low emission levels of environmentally harmful gases such as nitrogen oxides (NOx) and are therefore superior from an environmental viewpoint. The main fuels used are wood chips, waste tires, refuse paper and plastic fuel (RPF), paper sludge, etc., and biomass boilers with a capacity of several tens to 300 tons per hour have been constructed. Being intended to consume biomass fuels and inferior in follow-up capabilities to the oil-fired boiler, they are often employed for base-load operations.

IMPLEMENTATION OF INTEGRATED CONTROL SYSTEMS FOR POWER GENERATION FACILITIES

Traditionally, when analog control devices were in the mainstream, boiler operations were performed on BTG boards (BTG is the abbreviation for boiler, turbine, and generator). BTG boards were equipped with manual setting and control devices called selector stations and the operators manipulated these stations for boiler, turbine, and auxiliary equipment operations. Therefore, the operation pattern in those days is referred to as the so-called. Moreover, operations of the turbine and auxiliary equipment were also performed in the same manner, using stations and switches on the BTG boards.

Move to DCS

With the coming of the 1980s, power generation facilities started to be converted to DCS form. However, because this conversion to a DCS was on an equipment basis, a large number of displays were placed in a row, with a degree of the traditional BTG board operation retained at the same time. This

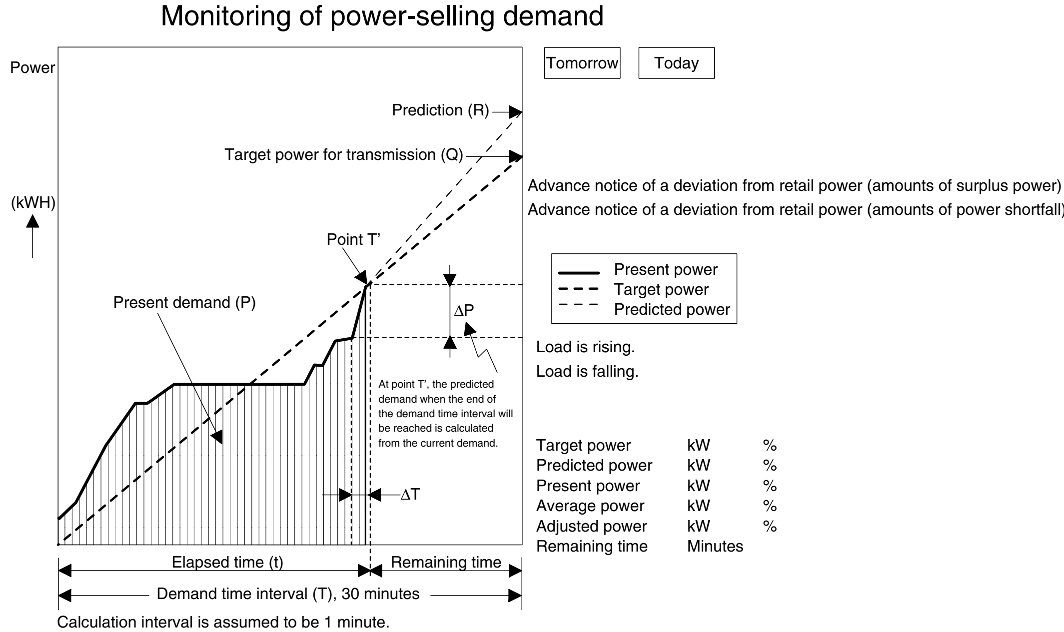

Figure 2 Example of the Demand Monitoring Window

configuration resulted conversely in an even more complicated operation control system, with the result that ultimately only a few power generation facilities were replaced their monitoring and control systems with DCSs.

Move to CRT-based Operations

When the 1990s came, a system of operation using only CRT displays gradually increased, with the system coming to be more frequently adopted as the reliability of DCS gained a high reputation. Plants also appeared that integrated their CRTs. To achieve this, it was necessary to integrate all of the plant's equipment using the same DCS. Furthermore, for equipment which requires dedicated control equipment such as turbine governors, connection through communication enabled a governor control device to be configured as if it was part of the DCS. This type of system configuration enabled the operator to perform all operations and to monitor them via a single CRT-based operation system. As coal-fired and biomass boilers require many pieces of auxiliary equipment, the application of a DCS has realized significantly reduced operator loads.

An example of the implementation of an integrated control system for a power generation facility is shown in Figure 1. This control system has integrated boilers, turbines, mills (pulverizers), burners (automatic burners), flue gas desulfurizers, etc. using Yokogawa's CENTUM CS integrated production control system.

Integration of Multiple Boilers and Multiple Turbine Generators

The power generation facilities in quite a number of pulp and paper plants have multiple boilers and turbines (generators). The majority of these plants has BTG boards and a group of operators for each unit of power generation facility equipment; however, it was possible to convert each control unit of equipment to DCS and to connect them to a CRT operation system, resulting in a decreased number of operators required to control power generation facilities.

EXAMPLE OF POWER-SELLING CONTROL

With the exception of some plants, the majority of pulp and paper plants generate their own power using their power generation facilities, purchasing any shortfalls from power companies. To that effect, conventional demand control monitored only the reception of purchased power to prevent the use of more power than that which was contracted.

However, power producers and suppliers (PPSs) have emerged due to changes resulting from the liberalization of power, and there are now users who conversely sell their surplus power to these PPSs. From this situation arose the need to be able to conduct demand control for selling power, in order to maintain a contracted power selling pattern with the PPSs. In this case, demand control is intended for controlling power generation to match the power transmission with the power-selling contract pattern. An example of monitoring power-selling demand on a graphic window for power-selling demand control is shown in Figure 2, and an example of a power-selling planning pattern is shown in Figure 3. The system generates power so that a contract pattern that has been set according to the season and days of the week is kept; the system must have a calendar function. The controller controls generator output so that the power-selling pattern is maintained, and realizes simultaneous power balancing control. It is anticipated that the construction of boilers intended for this type of power selling will increase in the future.

CONNECTIVITY WITH PLC INSTRUMENTATION

The power generation facilities are not necessarily entirely controlled by a DCS, and programmable logic controllers (PLCs)

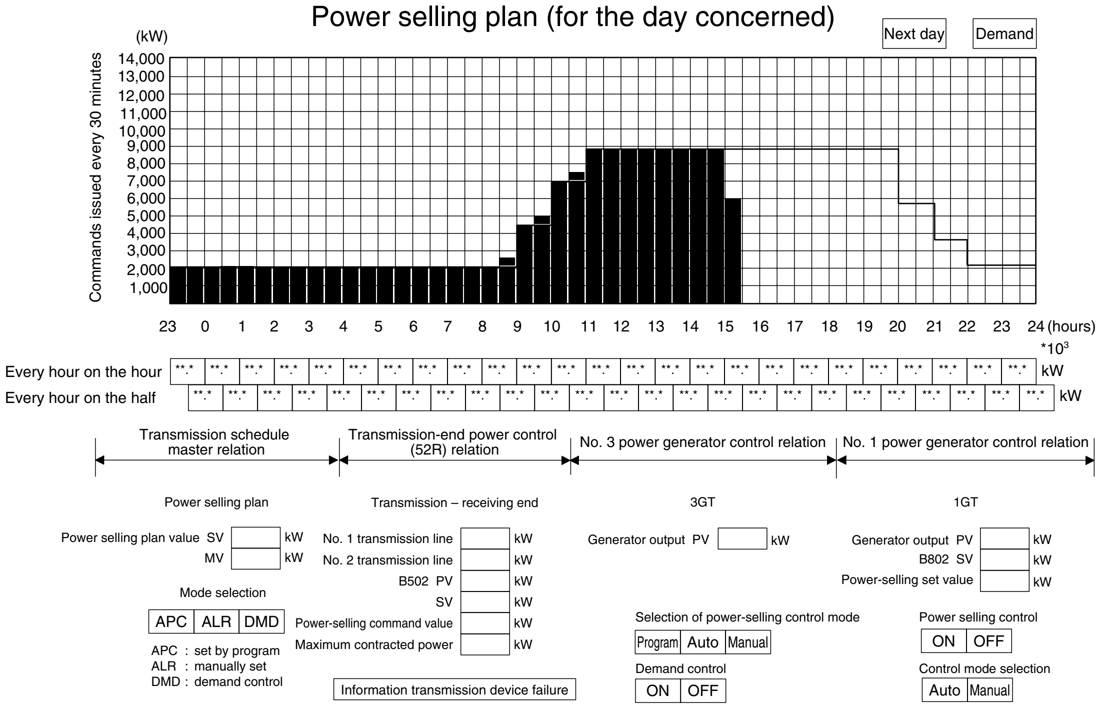

Figure 3 Example of a Power-selling Planning Window

are often used for auxiliary equipment. In particular, PLCs are used for demineralizers, ash treatment systems, and coal handling systems as they mainly require sequence control. Auxiliary equipment of this kind is not always operated from the central control room of the power generation facility, and there are cases where it is controlled by independent systems. In the future, when more efficient operations and labor saving are considered, situations integrating the DCS and PLCs for auxiliary equipment are expected to increase. However, the mere interconnection of the DCS and PLCs is insufficient if time-out monitoring and other time-critical functions are taken into account, although integrated CRT-based operation may be achieved. Thus, it is necessary to determine optimum task assignments to the DCS and PLCs.

UPGRADING FROM DCS TO DCS (MIGRATION)

The power generation facilities that employed a DCS in the 1980s are already in need of updating. Although there are systems that have already been updated, there are still many that have not. Yokogawa has proposed migration when users consider renewal of their existing DCS. This migration allows the existing DCS hardware such as the CPUs and input and output modules to be upgraded while leaving the existing external wiring unchanged. The use of tools for converting application software also allows the present functions to be reliably reproduced, realizing dependable updating at minimal cost. Moreover, migration offers the latest GUI-based operation technologies in the human interfaces.

CONCLUSION

This paper has introduced an integrated control system for the power generation facilities of pulp and paper plants. Recently, the use of display-based operations (once called CRT-based operations) has become commonplace.

In upgrading old power generation facilities, there may be many cases where upgrading is planned that adopts only display-based operations from now on. DCS engineering, such as the creation of graphic windows for display-based operation systems can these days be performed in the Windows environment, allowing operators to create screens independently. Moreover, report development which used to need special software packages now can be conducted using a widely used application such as Microsoft Excel, enabling the users to add or modify reports. These features have contributed to a reduction in total costs.

Problems indicating that operation know-how cannot be inherited, however, are starting to be manifested due to the retirement of skilled operators. These problems are known as “year 2007 issues,” among the public. In particular, in the paper and pulp industry where much operation know-how is required, there is an apparent demand for the further development of control systems.

We anticipate continuing to be of assistance in achieving increasingly stable operations of the power generation facilities of pulp and paper plants in the future as well. ◆