Recent Technical Developments in Thermal Power Station Supervisory and Control Systems

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OVERVIEW: The rising importance of middle-range power operations and environmental preservation requirements at thermal power stations has brought the need for more sophisticated operation and control. Meanwhile, in response to the changing circumstances of the electric power industry, systems must be implemented that can also meet requirements such as cost-effectiveness and labor savings. As a result, Hitachi, Ltd. has developed a supervisory and control system that aims to deliver not only operability, reliability and maintainability, but also cost-effectiveness, while at the same time enabling labor savings in operation and maintenance. The new system has been applied to a state-of-the-art coal thermal power station and combined-cycle power station. Through enhanced interlock, expanded automation, on-site supervisory robots and other technological innovations, the system has enabled integrated operation from the central control room and labor savings. In addition, thanks to technical advances such as implementation of protective functions by printed circuit board, software configured alarm system and common sensor system, the system is not only highly reliable and easy to maintain, but also economical. On-site start up operations and commercial operations results have confirmed the effectiveness of these features. Hitachi intends to extend areas such as downsizing, with the aim of constructing even more economical and reliable systems.

INTRODUCTION

WHILE thermal power stations must ensure a secure power supply, recently efficient middle-range power operations and environmental preservation are also becoming increasing important issues. As a result, there is a need for more sophisticated operation and control to keep pace with the increase in supervisory and operational items. Moreover, changes in the

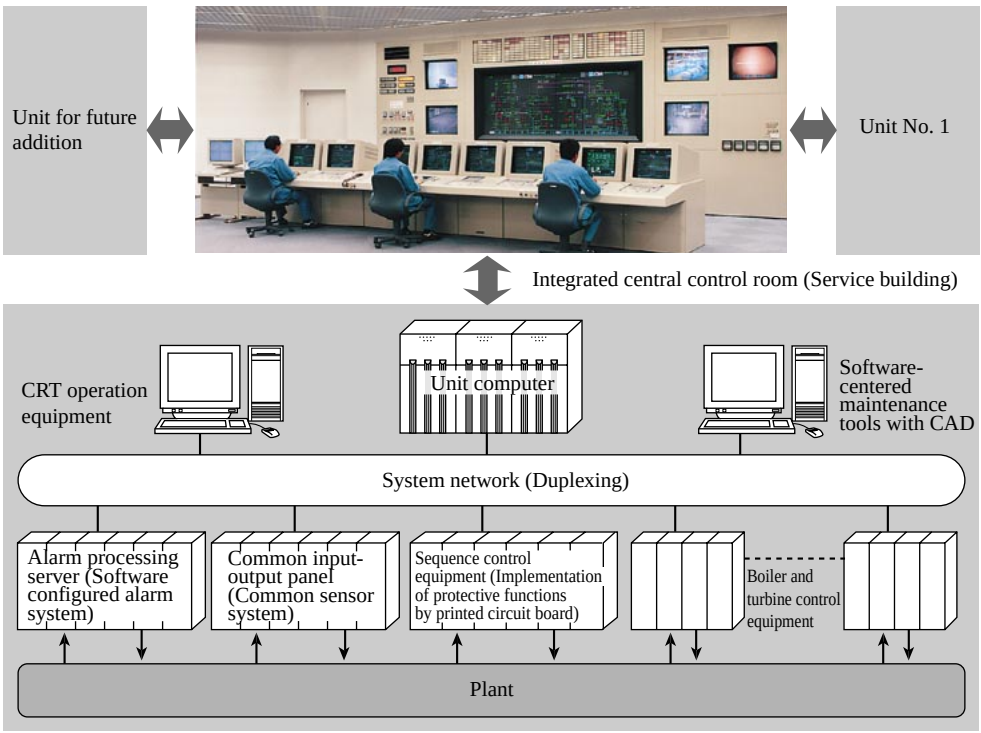


Fig. 1— Integrated Central Control Room and System Configuration (Unit No. 2) at Haramachi Thermal Power Station of the Tohoku Electric Power Co., Inc.
The central control room is located on the top floor of the service building. Application of CRT and large screens results in human interfaces that are easy for operators and maintenance engineers to use. In addition, with technical innovations such as software configured alarm system, common sensor system and implementation of protective functions by printed circuit board, the system is not only highly reliable and easy to maintain, but also economical.

electric power industry such as free competition and deregulation, mean that electric power companies are becoming increasingly keen to cut construction costs, operation and maintenance costs.

Against this background, Hitachi, Ltd. developed a supervisory and control system that not only maintains the high degree of reliability developed to date, but also seeks to be economical, while at the same time reducing the work of operators and maintenance engineers. Supervisory and control systems built around the Hitachi Integrated Autonomic Control System (HIACS) have been introduced to the Haramachi Thermal Power Station Unit No. 2 of the Tohoku Electric Power Co., Inc. and the Shin-Oita Power Station Group No. 3-1 of the Kyushu Electric Power Co., Inc. The systems are already being used in commercial operations.

This paper gives an overview of these systems.

SUPERVISORY AND CONTROL SYSTEM FOR LARGE-CAPACITY COAL-FIRED THERMAL POWER PLANT

The Haramachi Thermal Power Station Unit No. 2 (Output 1,000 MW, coal-fired) of the Tohoku Electric Power Co., Inc. is a state-of-the-art plant boasting the highest level of thermal efficiency in the world, raising both the primary steam temperature and reheating steam temperature to 600°C. Fig. 2 shows the requirements of the supervisory and control system and corresponding features. Of these, the following four special features are discussed below: (1) Integrated operation from central control room; (2) Implementation of protective functions by printed circuit board; (3) Common sensor system; and (4) Enhanced operability.

Integrated Operation from Central Control Room

With the aim of improving the working environment and saving labor, the central operation room that had previously been located on the turbine floor was relocated to the top floor of the service building and made into a single central control room including a unit for future addition. Since this increased the distance between the central control room and the site, supervisory robots were installed on-site to facilitate the work of on-site patrol. (Eight mobile robots around the boiler, six tilting robots at the turbine main valve, boiler water-supply pump and fuel pump room, and 28 stationary robots around the supplementary generator.) In addition, more routine field operations (such as automatic start-up tests of turbine oil pumps and generator stator coolant pumps) were converted to remote operations.

Furthermore, for the human interface system, full CRT operation system using large screens (two 70-inch types) and CRT was adopted. A C/S (client-server) system was applied, where the CRT is the client

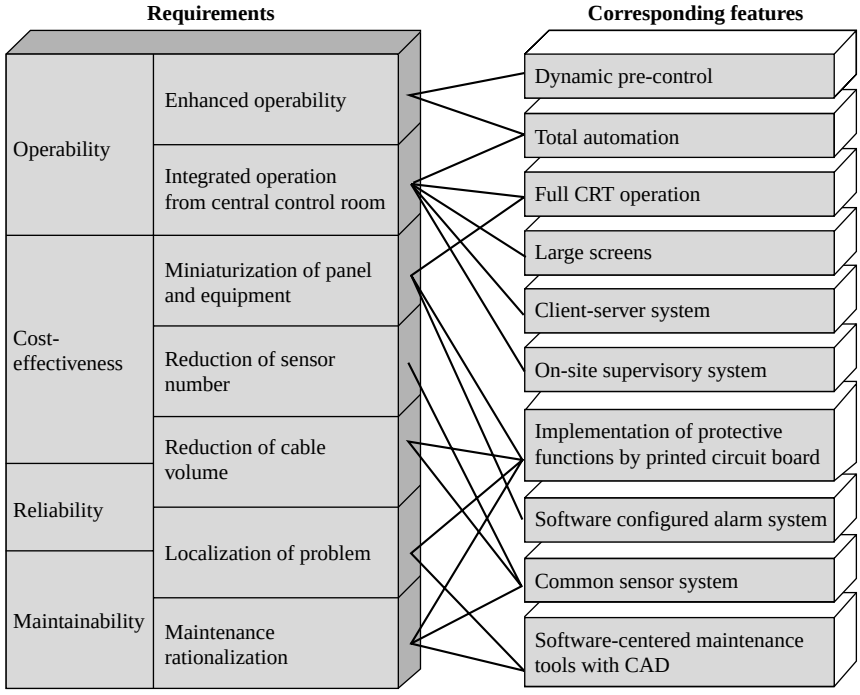


Fig. 2— Requirements of Supervisory and Control System and Corresponding Features.
Supervisory and control systems must not only be reliable and easy to maintain, but also economical.

and the control computer and CRT operation equipment are the server. The system allows operations to be carried out without switching screens, while supervision is carried out on a single CRT. Moreover, with the aim of downsizing central operation room equipment, the system eliminated virtually all hardware back-up switches except for emergency unit protection and emergency fuel shut-off.

Implementation of Protective Functions by Printed Circuit Board

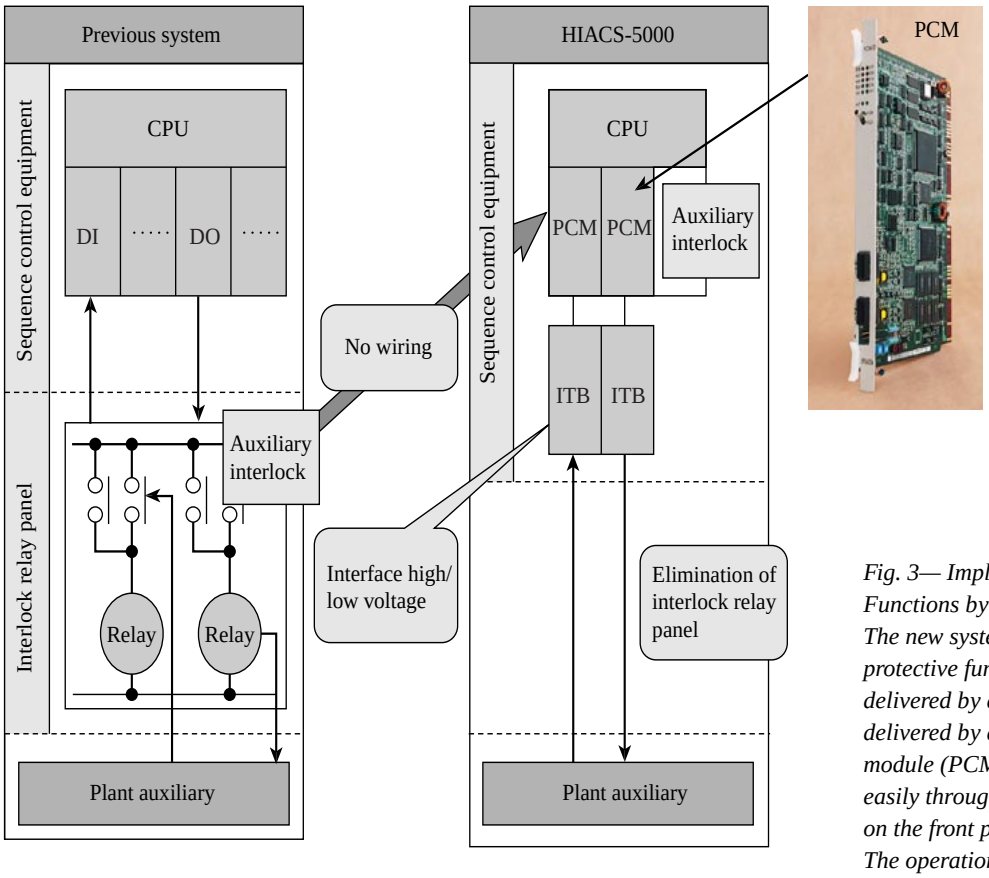
The process input-output circuit incorporates interlock relay panel to ensure interlock and protective functions even in the event of failure of the controller (Fig. 3). The production of a relay panel involves the mounting of many relays and wiring operations, and the manufacture, modification and regular maintenance inspection of relay panels require a great deal of labor. Furthermore, since the operation status of the circuit cannot be seen directly, localization of trouble in the event of failure is also time-consuming.

Therefore, Hitachi developed a visualized PCM (programmable control module) with intelligent PI/O (process input/output) that can operate even in the event of failure of the controller and has both interlock and protective functions for plant auxiliary as well as an operator interface. The visualized PCM has an in-built CPU (central processing unit) and ROM (read-only memory). The ROM houses the interlock and protective functions for plant auxiliary and can perform these functions independently even in the event of failure of the controller. The system enables real-time supervision of PCM operation status using maintenance tools and delivers greater visibility than previous systems. Moreover, modification of the interlock circuit can be performed simply through loading from the maintenance workstations.

In this way, the system not only offers more compact control equipment with fewer relay panels than previous systems, but it is also more reliable and rationalizes the manufacture, modification and maintenance inspection of relay.

Common Sensor System

To ensure reliability, previous systems were equipped with separate plant-status sensors for different applications. In other words, they were



DI: digital input DO: digital output ITB: isolation terminal block

Fig. 3— Implementation of Protective Functions by Printed Circuit Board. The new system enables interlock and protective functions that were previously delivered by a hardware relay panel to be delivered by a programmable control module (PCM). Modification can be made easily through operation of the lock switch on the front panel and maintenance tools. The operation status of the circuit can also be supervised using the maintenance tools.

equipped with separate sensors for supervision, control, alarms and protection, even at the same point. In previous systems, sensors used in closed-loop control (transmitters) and sensors for contact signals (local switches, etc.) used in interlock-circuit decision conditions were also provided separately.

As a result, previous systems were complicated, requiring at the same measuring point tap offs for installation of equipment including many transmitters and local switches, local racks to house these sensors and many cables. Furthermore, local switches and other equipment contacts may develop problems such as contact defects and errors due to plant operation status (temperature and vibration), or long-term fluctuation. Therefore, greater reliability and maintainability were also desired.

The new system streamlines sensor operations by using transmitters that can be shared for various applications in the case where many sensors are required at the same measuring point. (Three sensors for unit protection, two sensors for auxiliary protection, control and interlock, and one sensor for alarms and supervision only.) The measured signals from these transmitters are input into a common input-output board comprising three independent controllers. Following a levelling interrogation by the software, the results are passed on to the necessary equipment. In this way the system enables significant reductions in equipment such as local sensors, local racks and cables, higher reliability and rationalization of maintenance inspections.

Enhanced Operability

To improve load swing-rate, the system applies the latest technologies including predictive control and dynamic advanced parallel control. In high- and medium-load bands with no coal mill start-up and shutdown a maximum operation load swing rate of 5%/min has been confirmed against a planned rate of at least 4%/min. Meanwhile, in low-load bands a maximum rate of 3%/min has been confirmed against a planned rate of at least 2%/min. Moreover, the system can contribute to high-efficiency operations due to a control method that automatically sets the optimum O_2 level in according to the coal variation. In addition, the system incorporates automation and control-related technological innovations to enable unit re-startup after emergency shutdown within 100 minutes compared with 150 to 180 minutes, the time required by previous systems.

SUPERVISORY AND CONTROL SYSTEM AT LARGE-SCALE COMBINED CYCLE POWER PLANT

Operation Supervisory and Control System for Labor Savings

With the rapid development of computers, control equipment and human-interface technology, great advances have been made with labor saving and automation at thermal power stations, with the 1980s seeing the advent of total automation. However, operators are on duty in the central control room night and day, engaged in tasks such as supervising operation status, dealing with emergencies and defects and performing supplementary operations in the event of start-up congestion.

Recently, at the Shin Oita-Power Station (total output: 2,295 MW, liquefied natural gas fuel) of the Kyushu Electric Power Co., Inc., Hitachi has supplied a new labor-saving operation supervisory system aimed at rationalizing central control room operations. The system was designed in collaboration with the Kyushu Electric Power Co., Inc. based on an analysis of operations, the opinions of operators, a past alarm survey and other information. The system delivers: (1) Enhanced interlock for labor-saving operations; (2) Modification to reduce the frequency of alarms; and (3) Expanded automation of operations.

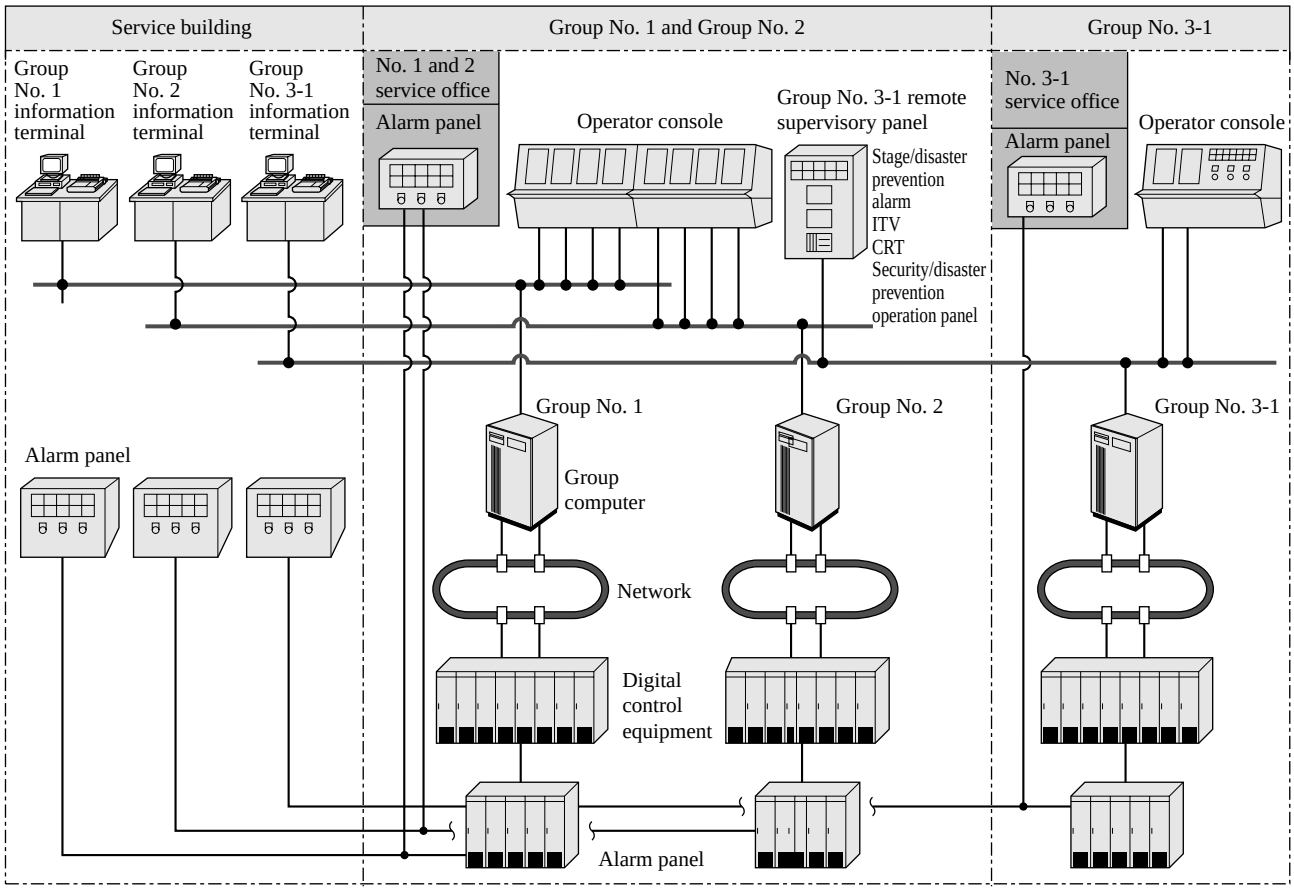
System Configuration and Features

Fig. 4 shows the configuration of the supervisory and control system at the Shin-Oita Power Station of the Kyushu Electric Power Co., Inc. Designed to achieve dramatic labor-savings, the system design takes the following points into account:

(1) A remote supervisory and control panel with supervisory functions of stage emergency shutdown and security/disaster prevention operations for the Group No. 3-1 is installed in the existing central control room for Group No. 1 and Group No. 2. In this way the system allows supervision of Group No. 3-1 from the central control room for Group No. 1 and Group No. 2.

(2) The remote supervisory panel has a CRT that is connected to the Group No. 3-1 computer, thus enabling supervision of individual alarms.

(3) Not only is the maintenance section office located next to the central control room, thereby



ITV: industrial television

Fig. 4— Configuration of Supervisory and Control System at Shin-Oita Power Station of the Kyushu Electric Power Co., Inc.
A remote supervisory panel capable of Group No. 3 operations is installed in the central control room for Group No. 1 and Group No. 2, which then serves as a centralized control room.

strengthening the security system, but installation of an alarm panel and CRT terminal for all group computers enables control of operation information for the entire power plant.

Equipment Modification

To rationalize operation supervision, security and protection interlock must be enhanced, alarm frequency reduced and automation expanded.

First, interlock was enhanced for the items of emergency shutdown, load run-back, urgent shutdown, exclusion of demand control from central power dispatching center and auxiliary shutdown. Under the new system, interlock automation is applied to all items that previously involved supervision, inspection, manual operation and manual adjustment.

To reduce the frequency of alarms, a survey of past alarms for group No. 1 and No. 2 was conducted and equipment was modified with respect to frequently occurring alarms except: (1) Those affecting generating power; (2) Those affecting the environment; and (3) Those affecting main equipment (gas turbine, generator, etc.).

Further advances under the new system include expansion of automation to cover 19 items, automation of stage schedule calculation and registration, automation of group minimum load operations, automation of BOG (boil-off gas) processing and supplementary steam operations, and automation of generator voltage control in conjunction with central power dispatch center. Moreover, through measures such as the detailed automation progress display screens and reinforcement of data-management functions, the system also delivers superior supervisory functions.

CONCLUSIONS

This report has introduced the new technologies applied in labor-saving systems that as a thermal power plant supervisory and control systems aim to be economical while maintaining a high degree of reliability and that also facilitate the work of operators and maintenance engineers.

The systems discussed are the first to meet the need for a remote centralized supervisory and control system and result from a successful fusion of the latest digital control equipment and transmission systems, computer technology and the excellent operational skills built up by electric power company. Hitachi is looking forward to applying further these results to both Japanese and overseas projects and contributing to higher plant efficiency.

In future, power plants will be expected to be even more economical and environmentally friendly. Meanwhile, facilities such as coal-gasification combined cycle power plants that make effective use of fuel are hastily being constructed. In response to these needs, we intend to step up our efforts to develop the optimum supervisory and control system to operate plants safely and efficiently.

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