Retrofitting and Upgrading of Supervisory and Control Systems for Large-capacity, Coal-fired Power Plants

—Takehara Thermal Power Plant No. 3 Unit of Thermal Power Department of Electric Power Development Co., Ltd.—

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OVERVIEW: In the event of upgrading the supervisory and control systems in a thermal power plant, the biggest challenge is to complete the work during the predetermined inspection period. Meanwhile, in the particular case of such systems for large-capacity, coal-fired power plants, prominent advances in control technology in terms of software and hardware have occurred simultaneously. In consequence, introducing the latest system technology and control technology during upgrading—that is, not just straightforward parts-exchange—is extremely effective in terms of streamlining systems, improving reliability and operability, and lightening loads on operators. In the present study, upgrading of the supervisory and control systems of Takehara Thermal Power Plant No. 3 Unit of the Thermal Power Department of the Electric Power Development Co., Ltd. is taken as an example. In this example, phased upgrading utilizing the special features of the HIACS-7000 (Hitachi Integrated Autonomic Control System 7000) control system to the full. As a result, the upgrading work was completed during the predetermined inspection period and, on top of that, an upgrading plan that realizes the above-mentioned effects was laid out and implemented.

INTRODUCTION

IN regards to a supervisory and control system for thermal power plants (which are the main source of a stable electricity supply), after its equipment has been running for a dozen years or so, the need for upgrading, from the viewpoint of preventative maintenance, becomes more urgent. When it comes to such equipment upgrading, the most important point is to complete the work during the predetermined inspection period. Moreover, to lighten the work load on operators, enlarging the automated range and improving monitorability and operability at the same time are being strongly demanded. In particular, in the case of large-capacity, coal-fired power plants constructed since the mid-1980s up till present, as a consequence of the large scale of these supervisory and control systems, on top of the need to solve the problems occurring during equipment upgrading, it is becoming all the more important to plan the upgrading with the entire system in mind. As an integrated plant manufacturer, we at Hitachi are proposing equipment-upgrading plans based on our know-how acquired over many years and with our supervisory and control system “HIACS-7000 (Hitachi Integrated Autonomic Control System 7000)” as a backbone component.

In the rest of this paper, while a case example of a large-capacity coal-fired power plant, namely, Takehara Thermal Power Plant No. 3 Unit of the Electric Power Development Co., Ltd., Thermal Power Department, is introduced, and the procedure for upgrading this supervisory and control systems is described (see Fig. 1).

OVERVIEW OF UPGRADE PLAN FOR SUPERVISORY CONTROL SYSTEM

The configuration of the supervisory and control system before upgrading is shown in Fig. 2. The system is configured of several major control systems, namely, an APC (automatic plant controller), an MBC (mill burner controller), an SQC (sequence controller), a

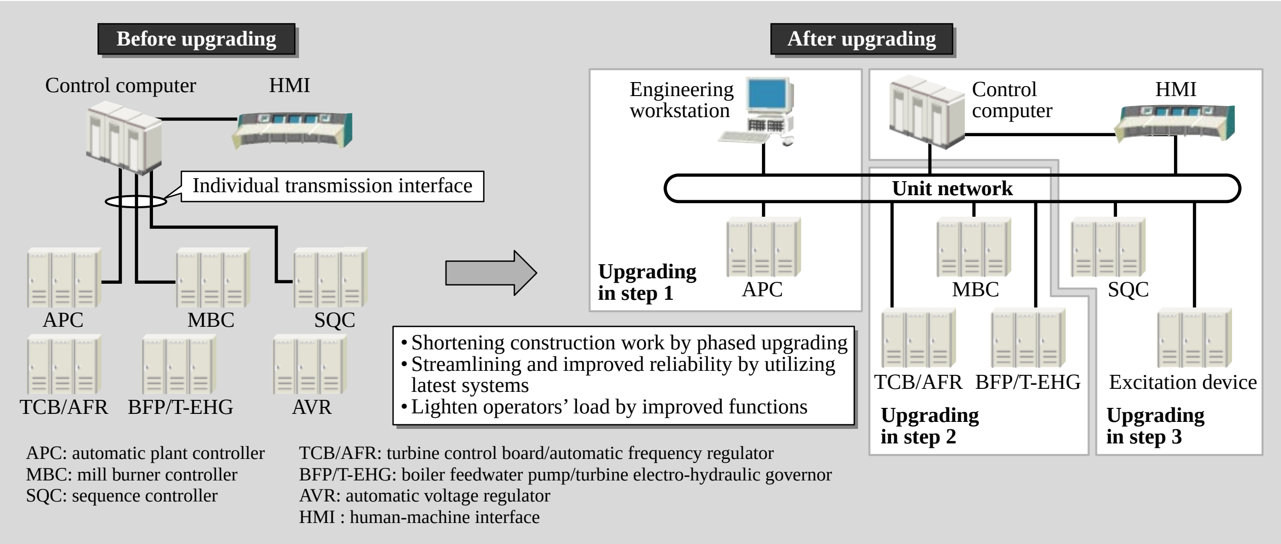


Fig. 1—Configuration of Entire Supervisory and Control System of Takehara Thermal Power Plant No. 3, of Electric Power Development Co., Ltd. before and after Upgrading.
As for upgrading of the supervisory and control system, a phased plan that allows upgrading during established inspection periods is set out, and embracing the latest system technology and control technology at the same time has improved reliability and functionality.

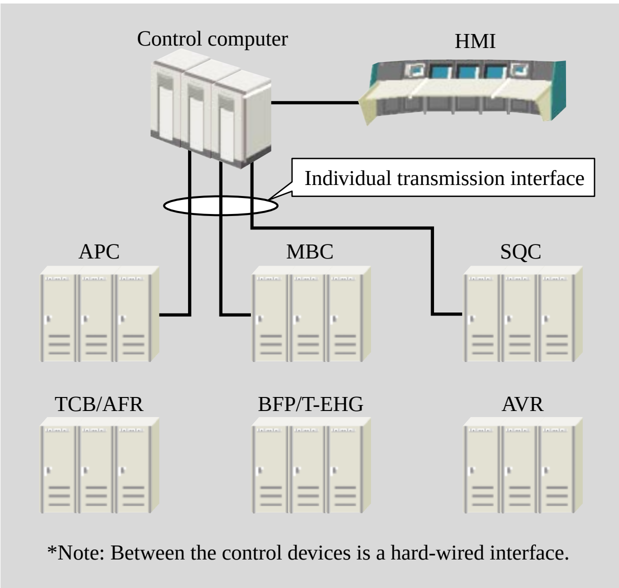


Fig. 2—Schematic Configuration of Supervisory and Control System before Upgrading.
The system is composed of control devices (such as APC and MBC systems) and a control computer.

TCB/AFR (turbine control board/automatic frequency regulator), a BFP/T-EHG (boiler feedwater pump/turbine electro-hydraulic governor), and an automatic voltage regulator, plus a control computer and HMI (human-machine interface) for supervision and operation purposes. On carrying out upgrading of this large-scale system, we planned not only "straightforward upgrading," namely, replacing structural parts of equipment while maintaining existing functions as is, but also "entire-system" upgrading, namely, embracing the latest system and control technologies with the whole plant in mind. The two main reasons for this approach are summarized as follows:

(1) Advances in system architecture since the introduction of existing systems have been remarkable, and as a result of embracing the latest network technologies and high-performance controllers, it has been possible to dramatically improve reliability as well as surveillance and control performance.

(2) Control technologies for coal-fired power stations have also advanced remarkably, and as a result of embracing the latest control technology during every upgrade of surveillance and control systems, operability is improved, thereby lightening the burden on operators.

In the case that the whole of a surveillance and control system is upgraded, completing the work within the specified inspection period becomes the most difficult challenge. To meet this challenge, we used a phased method that optimized the engineering works and materials in the course of implementing an efficient solution.

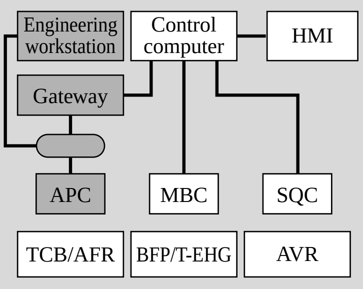
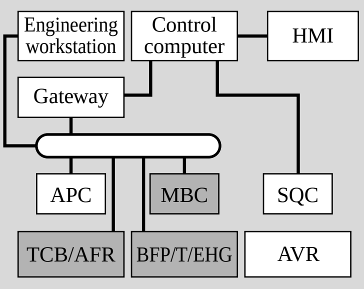
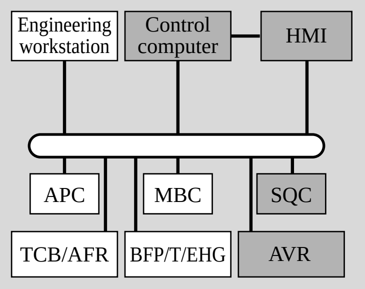
	Step 1	Step 2	Step 3
Configuration of supervisory and control system			
Upgraded devices	APC	MBC, TCB/AFR, BFP/T-EHG	Control computer, SQC, excitation device
Upgrade-sequence investigation results	• APC is extremely important in regards to plant operation. • Upgrading work scale is considered, and only the APC is upgraded in step 1. • By setting up a gateway for connecting to old and new networks, the transmission line during upgrading time in step 2 is assured.	• In regards to plant operation, MBC is the most important of the control devices not yet upgraded. • Although each of the TCB/AFR, BFP/T-EHG, and AVR have little effect on other devices and can be upgraded individually, in consideration of equalization of upgrading scale, TCB/AFR, and BFP/T-EHG are upgraded together.	• By placing the upgrading of the control computer last in the sequence, conversion of existing control computers during steps 1 and 2 hardly occurs. • As a result of step-conversion of upgrading SQC and control computers at the same time, introduction of progress-monitoring screens of the sequence master and required sequence-master logic for the screens can be implemented in a step-wise manner without waste.

Fig. 3—Phased Upgrading Plan for Supervisory and Control System.
The upgrading sequence was set up in consideration of the importance of devices.

UPGRADE PLAN FOR SUPERVISORY AND CONTROL SYSTEM

Plan for Phased Upgrade

To carry out engineering work and commissioning involved in an upgrade within a short time, all equipment is not upgraded in block; instead, a phased upgrading is planned. In regards to the phased upgrading, the upgrades of all the equipment are split up and performed in several set inspection periods; consequently, the required capital investment per inspection is reduced. Although doing the upgrade en bloc can suppress the total amount of investment, optimization is achieved according to the ingenuity of the upgrading sequence.

In this sequence, the following three points are evaluated in three separate steps (see Fig. 3).

(1) Level of importance of equipment

The upgrade is planned to start from equipment that is either extremely difficult or impossible to operate the plant in the case that parts in that equipment age and malfunction.

(2) Reconstructed sizes of equipment other than that upgraded

To upgrade existing equipment, temporarily upgrading equipment that is to be upgraded in the next inspection period or later is wasteful; therefore, an upgrade sequence that gives rise to a little temporary work as possible is set up.

(3) Completing upgrading work and sufficient testing within the predetermined inspection test period

Being different from a simple upgrading, the phased plan needs verification testing of functions newly adopted in enlargement of the automation scope, so an upgrading sequence that allows completion of upgrading work and sufficient testing within the predetermined inspection test period was laid out. In the phased upgrading, there are periods in which new and old networks exist together. Accordingly, existing pieces of equipment and the gateways for carrying their communications must be set up as temporary equipment until the entire upgrading is complete. Up till now, Hitachi has coordinated a repertory of gateways in response to various transmission methods we have commercialized, and phased upgrading of surveillance and control systems can be handled flexibly.

Streamlining of Engineering Works and Equipment

From the viewpoint of engineering work, the cable work is a limiting factor, so existing cable is diverted and work time is shortened. However, as regards the space between control devices, eliminating hard-wired interfaces and cutting back on PI/O (process input and output) modules is better in terms of streamlining than leaving existing cables. Consequently, on upgrading control equipment, already upgraded control devices and their interfaces are replaced with transmission interfaces sequentially.

From the viewpoint of equipment, as a result of upgrading for the high-performance controller of HIACS-7000, dispersed functions in several controllers of existing control devices are integrated, so the number of controllers is reduced (see Table 1). In the meantime, by duplicating the existing controller in the single configuration and by adopting a PCM (programmable control module) fitted with a rewritable ROM (read-only memory) that can operate independently even during failure of the head CPU, reliability is assured. At the same time, combining an RTB (remote terminal block), fitted with a signal-exchange function for every kind of signal and a field-LAN function, with a PCM enables the number of signal converters and relays (and their associated wiring) to be reduced, thereby streamlining the control-device hardware (see Fig. 4).

Efficient and Effective Improvement of Functions

Even if functions are improved by upgrading equipment, with due consideration paid to preventing wasteful conversion work as mentioned above, function improvement, i.e. significant reduction of load on operators, was achieved as well. The main function improvements are summarized as follows.

(1) APC: in/out service of boiler feedwater pump and coal feeder modified from control-computer direct control to APC

(2) MBC: automatic switching of resistor-damper opening change according to type of fuel

(3) SQC and control computer: introduction of sequence master and sequence-control-procedure display

(4) Control computer: enhancement of display content of graphic display for surveillance

Of these four improvements, (1), i.e. APC, aims to shorten the in/out service time by simplifying adjustment of the control system and by introducing a feedforward control circuit. In (3), by updating SQC and the control computer at the same time, surveillance capability is improved efficiently. Moreover, to improve surveillance capability [represented in (4) above] as required when upgrading the control computer, it is necessary to add a huge amount of surveillance input signals from devices that were not present in the existing systems. Accordingly, conversion work for upgrading the control computer was shortened by two methods: by performing the upgrading last or by providing "soft logic" (for transmitting signals required for future control computers in advance) when the control computer is updated at the early stage of the updating process. Furthermore, as a surveillance-function improvement measure that can be realized without large-scale reconstruction for the periods between control-computer updates, a warning surveillance function for simply following the details of causes of errors by on-

TABLE 1. Reduction of Controller Number by Function Integration

As a result of upgrading to high-performance controllers, the number of controllers is reduced by integrating functions.

Control device	Before upgrading	After upgrading
APC	18 units (1 duplex set; 16 single units)	6 units (3 duplex sets)
MBC	12 units (12 single units)	2 units (1 duplex set)
SQC	7 units (7 single units)	4 units (2 duplex sets)

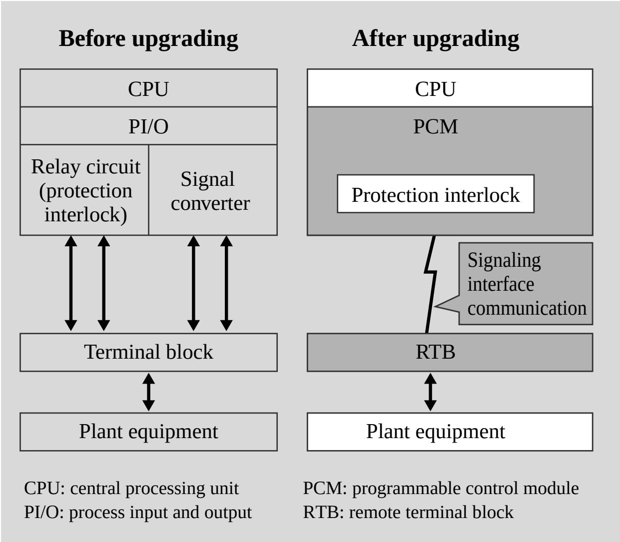


Fig. 4—Streamlining of Controller Hardware by Utilizing PCM and RTB.
Hardware is streamlined by combining PCM and RTB.

line logic monitor is fitted in the engineering workstation. As a result, the surveillance function is improved while keeping the conversion work on existing equipment to a minimum.

CONCLUSIONS

Taking the case study of Takehara Thermal Power Plant No. 3 Unit of the Thermal Power Department of Electric Power Development Co., Ltd, this paper described methods for upgrading of surveillance and control systems of a large-capacity, coal-fired power plant.

From now onwards, we believe that, as improvements of performance and functions are achieved, it will become even more important to determine how to streamline such upgrading of surveillance and control systems as described here. To satisfy these needs, planning that considers not only stand-alone component parts, such as control equipment and control computers, but also the plant in its entirety is vital. As a manufacturer of integrated plants, Hitachi will increase its efforts in order to put forward even better plans in the future.

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