New Process Control System for a Steel Plant

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1. Introduction

The global demand for steel, especially in Eastern Asia, has been increasing rapidly in recent years. Japanese steel manufacturers, dependent on the healthy automobile industry, are transitioning from general steel material to high-class steel material, while preserving the crude steel production amount.

Large-scale capital investment for the renovation of blast furnaces at each plant has been completed, but the renovation and improvement of aging facilities is ongoing, and planned spending on capital investment projects has been revised upward for 2005. As a result, although demand for distributed control system (DCS), which forms the core part of the control system of a steel plant, is low in new plant construction, demand is expected to increase for the renovation of aging plants.

This paper describes an example application of Fuji Electric's MICREX-NX new process control system to a steel plant.

2. Characteristic Features of Steel Plants

2.1 General description of a steel plant

Typically located on a large compound and comprised of various facilities, steel-working plants consume large amounts of supplies and services (including water, energy, and the like). The plant processing is subdivided into the categories of iron making, steel making, and rolling. In the iron making process, iron ore is melted by hot air blown into a blast furnace, with coke as a reducing agent, to produce hot metal. Next in the steel making process, in a basic oxygen furnace (BOF), carbon is removed from the hot metal, and alloy elements are mixed in as necessary to form non-brittle molten steel, which is then cast. In the rolling process, the intermediate cast product is formed into various steel products such as heavy plates, thin plates, various shapes, steel pipes, and so on, and is surface-treated (plated, coated, polished) to form a finished product.

A steel plant is configured from tens of different types of equipment, each of which is controlled independently by a control system. Moreover, each control system is connected via a host computer to the main system (production management system) so that production plans can be managed comprehensively for the entire facility.

2.2 Challenges for steel plant DCS

The steel industry was one of the first manufacturing industries to adopt computer-based control and information control systems. Fuji Electric delivered its first DCS, the central part of a control system, in 1977 to a continuous casting facility at a steel plant. Subsequently, as steel plants developed, Fuji Electric's DCS also evolved, and Fuji Electric began selling the MIC REX-NX in 2004 as a 5th generation DCS. A control system is configured from DCS, programmable controller (PLC) for electronic control, and computer for production control and for connecting to the main system.

Present challenges facing the DCS required by steel plants are described below.

(1) Steel plants are configured from many different types of equipment. Moreover, facilities are often expanded on a small-scale in order to improve product quality and productivity, and in doing so, many various control systems are installed additionally, thereby increasing the complexity of the configuration. Consequently, DCS is required to be easily connectable to control systems and devices made by different manufacturers, and to be capable of constructing a control system that can be connected to old DCS made by different manufacturers in an existing system.

(2) Steel plants operate continuously for 24 hours per day, and DCS downtime must be avoided in order to maintain stable and safe operation. However, in the case where the plant is down, the DCS must ensure fail safe facility and help to minimize the downtime.

(3) When updating an existing DCS, it is required that existing hardware and software assets can be utilized effectively, and that they can be replaced in minimal time.

(4) Equipment maintenance plays an important role in ensuring stable operation of a steel plant. Stable operation and efficient maintenance are required of DCS.

3. Example of MICREX-NX Application to a Steel Plant

Fuji Electric has delivered many DCS, mainly to steel plants, and claims Japan's top market share in control systems for BOF processes at steel plants. Below, an example of MICREX-NX application to a BOF process is presented and Fuji Electric's latest control system technology is described.

3.1 Construction of a MICREX-NX-based BOF control system

The BOF process is configured from many sub-systems, including top blowing and OG (oxygen converter gas recovery) equipment, a bottom blowing equipment, a lance hoist, a sub-lance equipment, a ferro alloy charging equipment, a flux charging equipment, etc. Table 1 shows the relationship between operation of the BOF process and the equipment used.

Control systems for different sub-systems are often configured of DCS and PLC from many different manufacturers, and a BOF DCS must seamlessly connect to the control system for these sub-systems and provide integrated monitoring and control.

The MICREX-NX enables the configuration of a control system that horizontally integrates these sub-systems. The functions necessary to construct the control system are described below (with reference to Fig. 1).

(1) A DCS (MICREX-PⅢ/IX/AX) for an existing BOF can be connected via an operator station (OS) server to an existing control LAN (DPCS-F/FL-net compliant LAN). As a result, an existing DCS can also be monitored and operated from a new OS, thereby realizing the integration of both old and new DCS.

(2) By using P/PE-link and T-link link devices, existing devices such as a remote I/O device (FTU, FTK) and PLC (MICREX-F) can be connected directly to an automation system (AS).

(3) DCS made by other companies can be connected via the OS server to a JIS FL-net*1.

(4) PLC that has been delivered by other equipment manufacturers can be connected with an AS and a general-purpose LAN (Ethernet*2), or with a PRO FIBUS-DP.

(5) The process computer can be connected, via a process computer server on the terminal bus, to an Ethernet.
Connection can be made with a conventional socket communications interface protocol, or with OPC*3 transmission, which is a Windows*4 standard interface.

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*1: FL-net is a network developed by JEMA.
*2: Ethernet is a registered trademark of US-based Xerox Corp.
*3: OPC is a registered trademark of US-based Microsoft.
*4: Windows is a registered trademark of US-based Microsoft.

Table 1 BOF operating processes and main equipment used

Operating process	Control / function	Equipment used	Overall equipment
Standby	Preparation for charging at an early stage	Flux charging equipment	
	Weighing of specified quantity of main raw material	Hot metal and scrap weighing equipment	
Charging of main raw material (hot metal, scrap)	Change flow rate of bottom gas blowing	Bottom blowing equipment	
	Static model calculation	Process computer	
Blowing	Control of lance height, oxygen flow rate and bottom gas blowing flow rate according to blowing pattern	Lance hoist equipment, top blowing equipment, bottom blowing equipment	
	Inactive zone constituting control, exhaust gas recovery control	OG equipment	
	Charging of slag-making material, charging of coolant, charging of sloping-preventative material	Flux charging equipment	
	Measurement of molten steel temperature, free oxygen concentration in molten steel, and carbon content	Sub-lance equipment	
	Dynamic control, blowing stop control	Process computer	
Tapping (final product adjustment and discharging)	Charging of ferroalloy	Ferroalloy charging equipment	

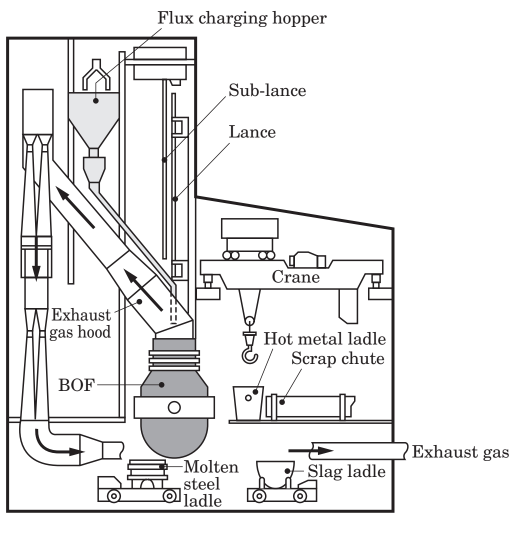
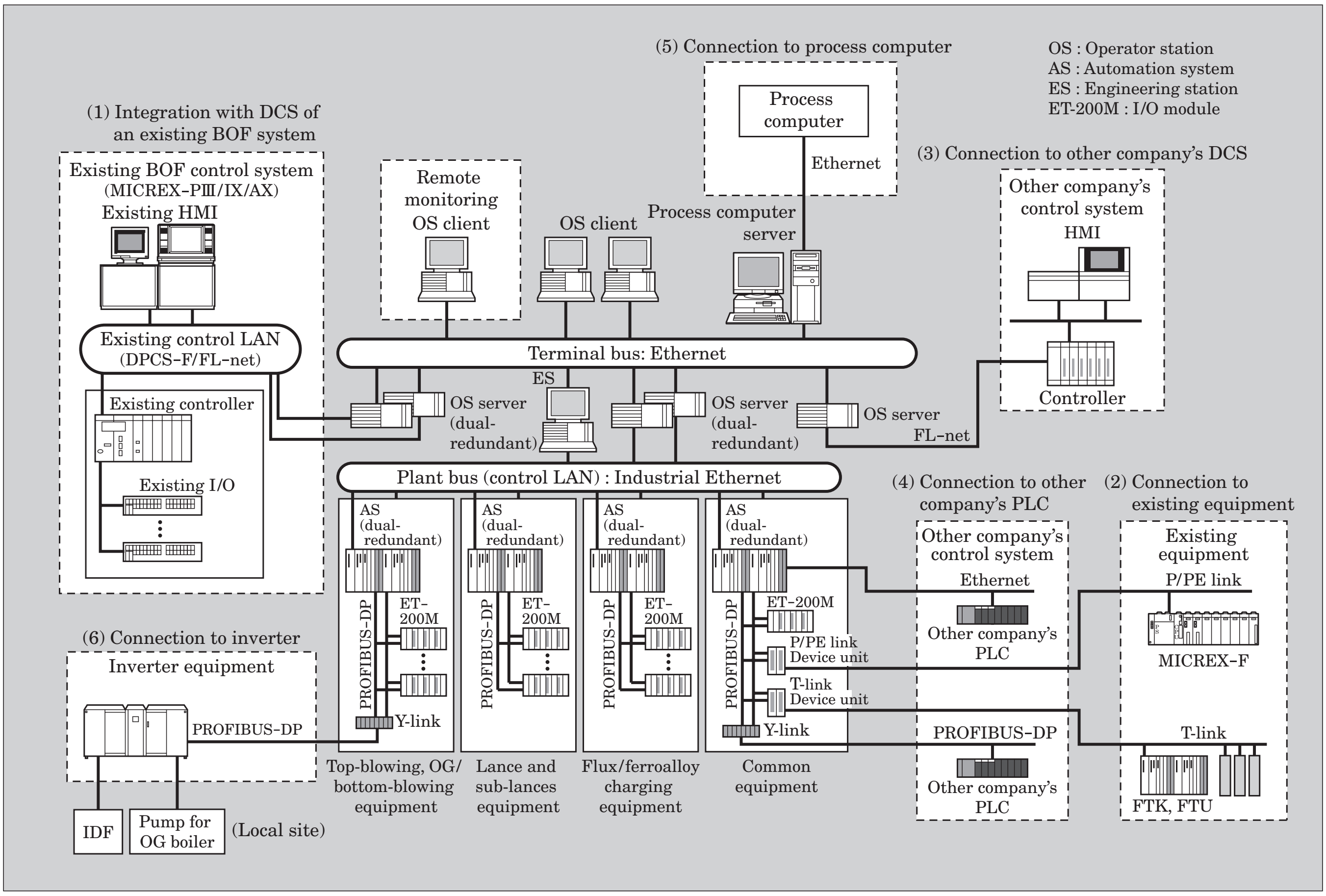


Fig.1 Example configuration of control system



(6) The inverter driving the IDF (induced draft fan) of a BOF and the pump associated with an OG boiler can be connected directly to a PROFIBUS-DP and controlled from an AS.

3.2 Ensuring high reliability and safety while maintaining stable operation

The BOF process encompasses multiple sub-systems, and the control system often becomes bulky in size. Stopping the operation of even one sub-system will lead to stoppage of the entire BOF process, and because the system is located upstream in steelworks, the impact on the entire steelworks will be large. Moreover, because large quantities of hot molten material and highly pressurized explosive gas are handled, a system malfunction can result in a major accident. For these reasons, high reliability and safety are required of the DCS of a BOF.

(1) Dual-redundancy of AS

Since the dual-redundant CPU switching time is short (30 ms) for an AS of the MICREX-NX, switching has no adverse effect on operation. Additionally, CPU modules can be replaced while online, without having to stop operation. After replacement, program and data information is automatically loaded from the driving system CPU to the replacement CPU in order to eliminate operational mistakes. The CPU, of course, is able to support dual redundancy by selecting only required elements, including I/O devices and the I/O bus, and thus dual redundancy can be constructed in a highly cost effective manner.

(2) Safety instrumentation system

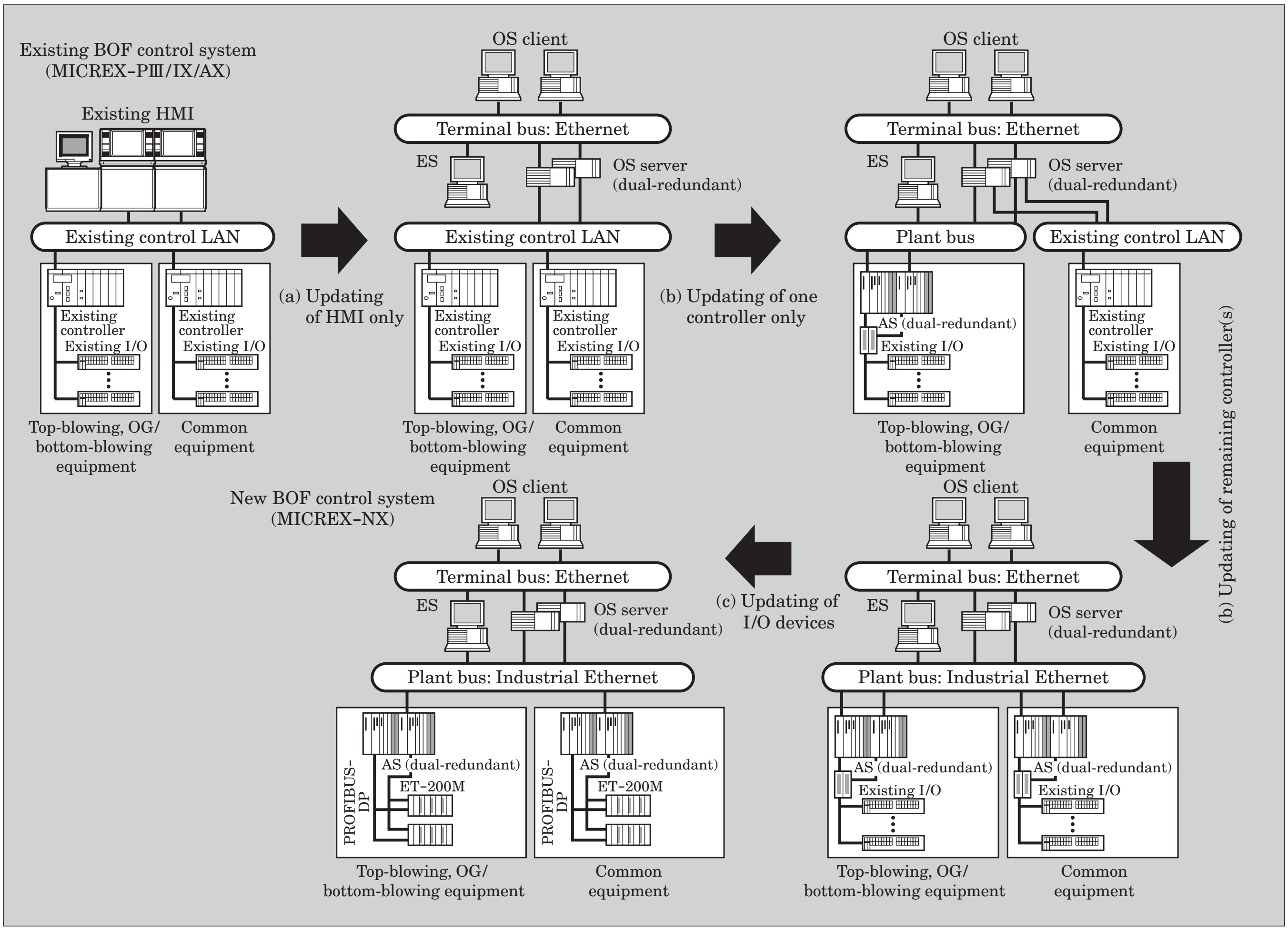
The MICREX-NX conforms to the IEC 61508 international standard, and provides a safety instrumentation system that is compliant with SIL3 (safety integrity level 3), and should an error occur, is capable of running the processes in a safe state.

The top blower and OG equipment that operate under hazardous conditions because they handle explosive gas have previously been configured with an emergency shut-off outlet jig at the hardwired circuit for relay board backup, but with the MICREX-NX, a safety mechanism, should an error occur, can be configured with AS and I/O devices only.

With the MICREX-NX safety instrumentation system, a standard control program and a safety control program can co-exist within the same AS, and can be programmed with the same engineering language as used with a standard controller. Also, dedicated I/O modules for the safety instrumentation can run on the same PROFIBUS-DP as standard I/O modules, and both the AS and I/O can be constructed with a dual-redundant configuration.

By combining the safety instrumentation system

Fig.2 Example method for updating existing DCS



with a dual-redundant configuration, the BOF DCS is able to ensure safe operation of the plant and high reliability.

3.3 Method of updating DCS of an existing BOF

(1) Partial updating of the DCS

The MICREX-NX provides a mechanism for maximizing effectiveness of a user's existing DCS, while also enabling partial updating of that DCS. Figure 2 shows an example of the updating method.

(a) Updating of HMI (human machine interface) only

(b) Updating of controller (continued use of existing I/O devices)

One controller can be updated, and a combination of new and old controllers can be used simultaneously. At such a time, the continued use of existing I/O devices is permitted.

(c) Updating of I/O devices

(2) Method of updating controller within a short amount of time

The BOF process normally encompasses two or three BOFs, and the equipment shared among these furnaces. Each BOF stops for approximately 1 to 2 months for refractory maintenance, but the shared equipment only stops for approximately 1 day, and therefore the controller updating must be implemented quickly, within a short amount of time.

The use of an existing external signal cable and connector terminal to perform onsite updating work quickly is described below with the example shown in Fig. 3.

(a) Advance preparation

During construction of a new AS locker, a connector converter plate is attached to connect the connector terminals of existing external signal cables to the new I/O devices, and a cable for trial run is prepared to connect the connector terminals of the existing external signal cable to the new connector converter plate.

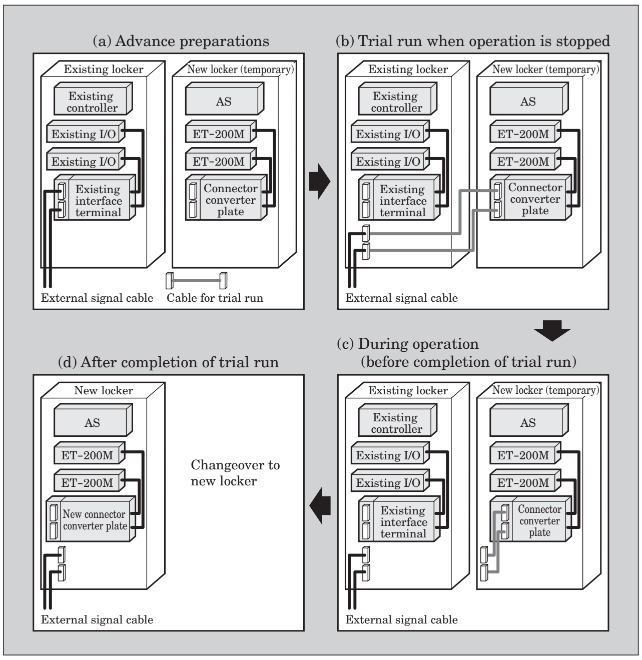
Additionally, new temporary lockers are constructed for the AS and I/O devices. If there is no available space for the temporary structures, an easily moveable rack may be used.

(b) Trial run when operation is stopped

With the cable for trial run and the connector converter plate, the new I/O devices capture existing external signals, and trial runs that can be completed within the stoppage time are implemented.

(c) During operation (before completion of trial run)

Fig.3 Example method for updating existing equipment controller



After completion of a trial run, the trial run cable is removed from the existing locker, the original state is restored and operation implemented with the existing DCS.

The operations in (b) and (c) are repeated until all trial runs are completed.

(d) After completion of trial run

After all AS trial runs are completed, the locker is switched over and the connector terminal of the existing external signal cable is connected to the new locker connecter terminal.

By modifying and attaching existing lockers for the new AS and I/O devices, the work involved in constructing and installing new lockers can be eliminated. The decision of whether to replace a locker or to modify an existing locker is made by verifying the installation status of existing lockers and the status of attached existing controllers and I/O devices, and then choosing the method that saves the most time and cost.

(3) Updating of application software

In order to effectively utilize a user's existing assets, application software is converted and a library of individual control functions is created for OS software and AS software so as to enable software to be created more efficiently and with higher quality.

3.4 Efficient maintenance that maintains stable operation

(1) In the control of a BOF comprised of multiple sub-systems, when a process malfunction occurs, it is necessary to have the ability to identify quickly the cause of the malfunction from among a large quantity of sub-system information.
The MICREX-NX is able to synchronize timings across the entire DCS, and applies a time stamp with 10 ms precision to various events and I/O signals, thus helping with the rapid analysis of a root cause when a malfunction occurs.

(2) Because the AS is capable of implementing electronic control, for which rapid response is required, simultaneously with process control, all equipment controllers can be standardized to the same model. Thus, fewer different types of parts are needed for maintenance and the maintenance work becomes more efficient.

(3) DCS printed circuit boards, depending on their installed location, are affected by dust and corrosive gas, and may age prematurely. With the MICREX-NX, the printed circuit boards are coated in accordance with the environment in which they used, thereby extending the useful service life of components.

(4) Maintenance procedures for the MICREX-NX can be provided as a combination of DCS-appropriate menus, selected from a wide range of service menus (such as present state diagnostics, preventative maintenance, corrective maintenance, etc.)

4. Conclusion

The MICREX-NX was developed as the foundation for a control system having a successful track record of more than 4,000 delivered systems. In Japan, DCS that conforms to various international and overseas standards is able to realize highly reliable operation.

Responding to user needs, Fuji Electric intends to continue to provide DCS that utilizes the improving operational safety and efficiency of steel plants.