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LATEST INSTRUMENTATION SYSTEMS IN IRON AND STEEL INDUSTRY

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1. FOREWORD

Reguarding control system is the iron and steel industry, the trend toward integration of electromachinery (E), instruments (I), and computer (C) is quickening to purse economy. The application of control systems based on the latest control techniques and artificial intelligence advanced control is also advancing positively.

EIC integration system and advanced control are introduced here from among the many facilities we have delivered.

2. TREND

Stable operation is strongly demanded of the blast furnace as the source department and the mainstay of energy supply in an iron and steel plant. Within these, an expert system is introduced to secure a stable production quantity, stabilize the furnace conditions regardless of changes in the operating conditions, and to secure pig iron quality (pig iron temperature, Si component) according to the steel plant production plan.

For a steel making plant, investment is not made in new facilities, but is made continuously in the hot metal treatment facility and degassing system (RH, VOD, AOD) to produce high grade steel.

Many facilities are 15 to 20 years old and are actively replaced as they age. The objectives of this are:

(1) Measurement and control facilities realized by the analog instruments cannot cope with the automation of blowing described later.
(2) Securing of control room and electric room space by strengthening of functions.
(3) Difficulty of parts procurement.

Domestically, the ratio of continuous casting has already reached 94.1%. Therefore, very few new continuous casting facilities are being built and the aging of facilities is accompanied by a period of continuous caster modernizing.

In recent years, the trend has been toward product diversification, advanced functions, improvement of casting quality, and direct rolling. On the other hand, compact and high cost-performance systems are demanded of electric furnace manufacturers.

The continuous annealing and pickling line, continuous annealing and coating line, and continuous aluminizing and galvanizing line are being actively introduced on the processing line to produce high quality products, cut costs, and save labor.

3. EIC INTEGRATED SYSTEM

The pursuit of economy is the biggest background behind EIC integration.

The merits of EIC integration are shown in *Fig. 1*.

The features of the distributed total system MICREX SYSTEM are described here.

(1) EIC control and monitoring data base
The data of each controller is collectively managed by using a data base station (DBS-1500).
(2) Common MMI for EIC
The MMI (Man Machine Interface) can offer an integrated operating environment (single window) that does not depend on EIC differences by means of an operator station (OCS-1500). The integrated data management system (FSINET) is one of these element technologies. The functions and construction of FSINET are shown in *Fig. 2.*
(3) Integration of system engineering
An engineering station (EWS) is installed as the software development environment and EI software can be accessed independently by using multiple EWS.
(4) High speed and advanced functions networking
Total systemization as a network with a main private LAN DPCS-F, with a P link between DCS controllers and a T link between PIO controllers is possible.
The system of a steel making plant is introduced as an example of an iron and steel EIC integrated system.
An example of the configuration of an EIC integrated steel making plant control system is shown in *Fig. 3.*

4. ADVANCED CONTROL

Advanced control improves the functions and reliability and lowers the price of a digital control system. Practi-

Fig. 1 Merits of EIC integration

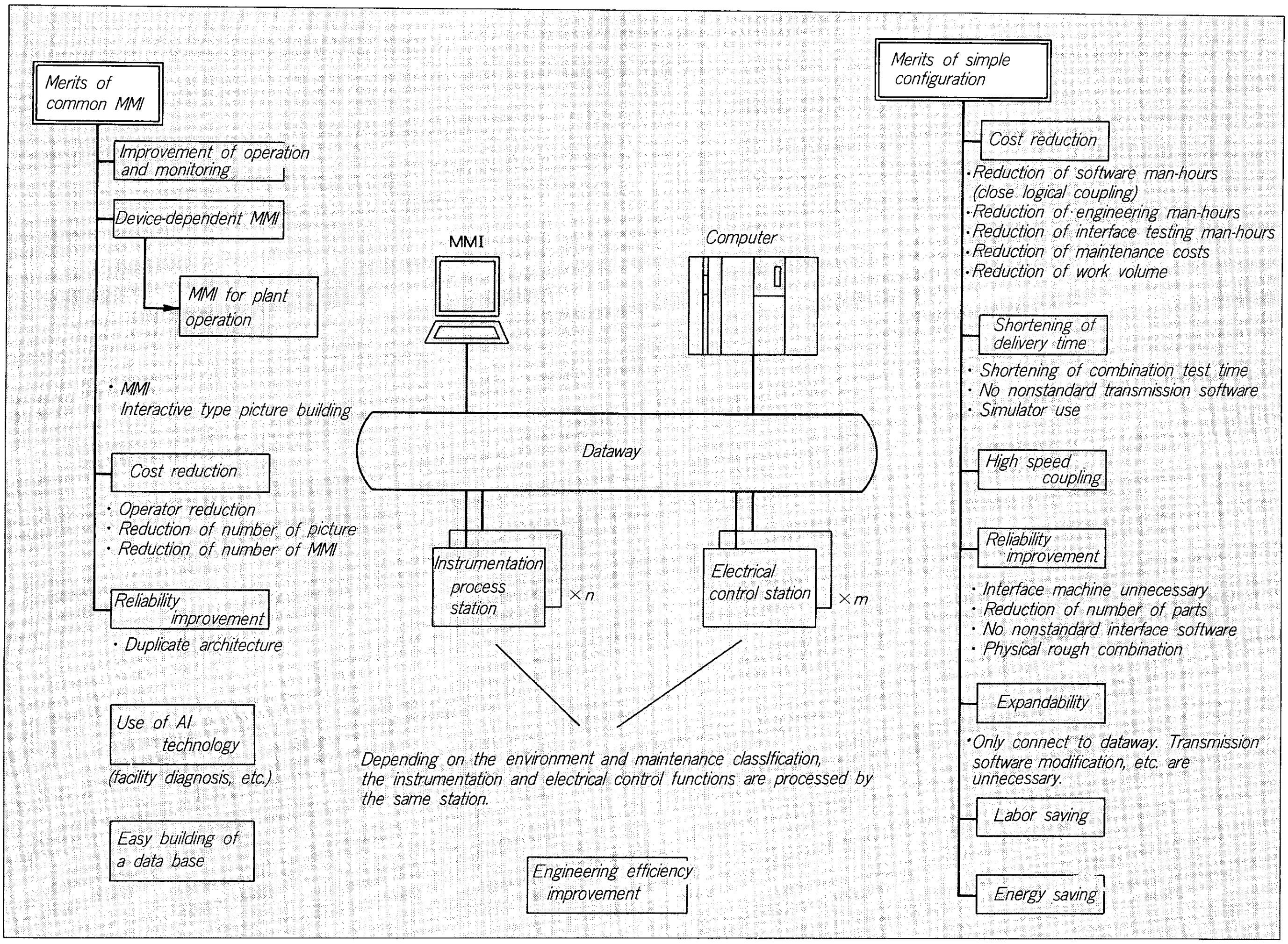
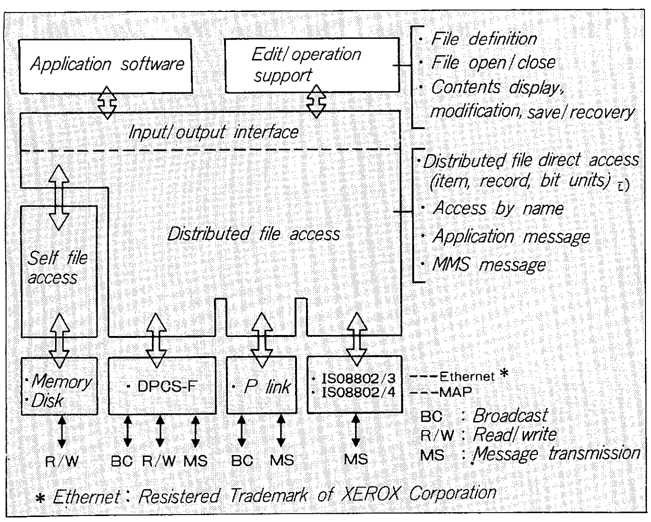


Fig. 2 Functions and construction of integrated data management (FSINET)



calization of advanced control with ordinary analog control systems impossible to realize in the past is advancing.

In the increase of application examples in following:

(1) Coping with the advanced information society

(2) Coping with the change from analog control system to digital control system

(3) Coping with labor saving and resource conservation

(4) Coping with the growth of the latest control techniques and the advance of modeling technology

An example of application of advanced control to the steel process is shown in *Table 1*.

4.1 Blast furnace expert system

Blast furnace operation relies on the intuition and experience of a skilled operator. This depends on the following blast furnace characteristics:

(1) The interior temperature is high and it is difficult to measure its state directly.

(2) The time lag from charging of the ore and coke to tapping is long and it takes time to obtain the action result.

(3) The interior of the furnace is a continuous process with mutual interference between gas, liquid, and solid, and theoretical analysis is difficult.

For the instrumentation control system aimed at solving these problems, physical models and statistical processing or various sensors were developed at the limited parts, and because theoretical analysis is difficult, experience rules

Fig. 3 Steel making plant control system block diagram

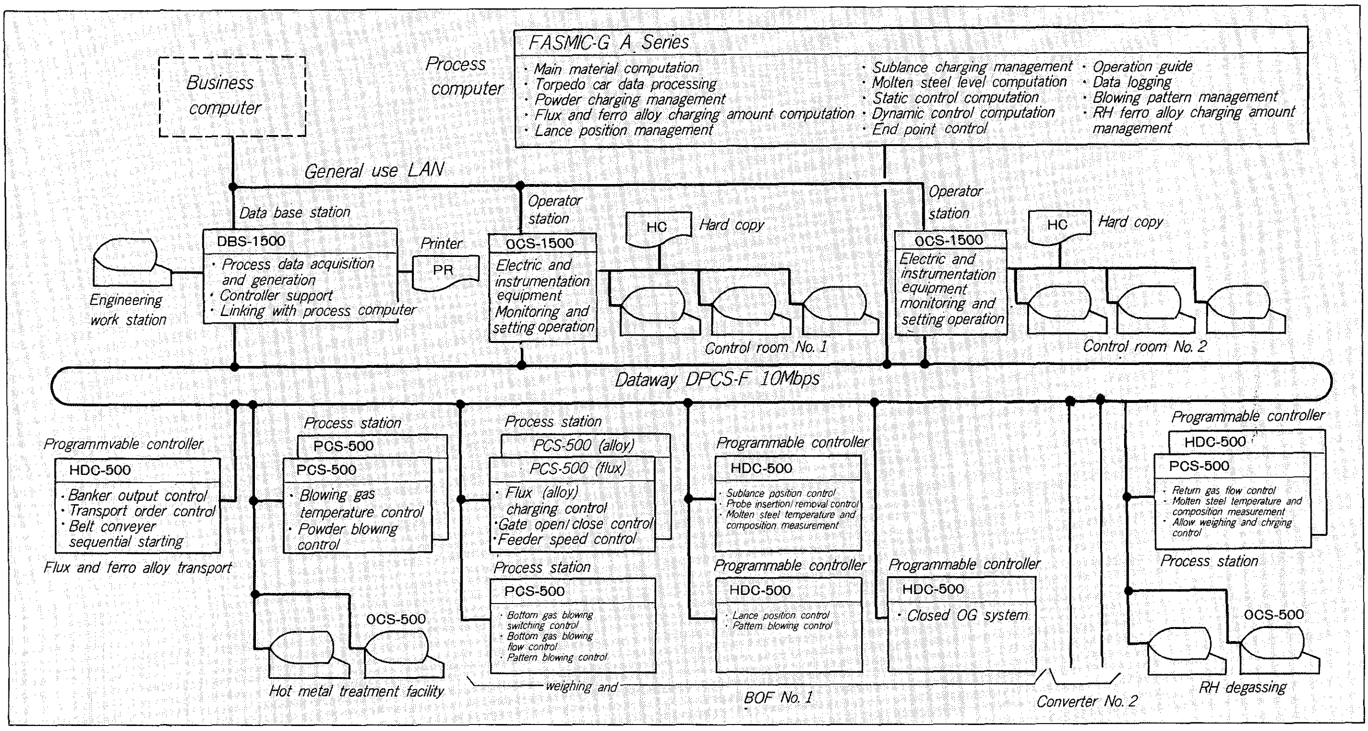


Table 1 Application examples of advanced control at an iron and steel process

Application example	Blast furnace process control	Converter process control	Closed converter waste gas recovery facility furnace pressure control	Continuous casting secondary cooling water control	Continuous casting mold internal molten steel level control	Continuous stripe temperature control
Process features and control objective	Chemical reaction Material transport Stability of plant operation Abnormal state detection	Chemical reaction, Stirring Molten steel temperature Improvement of composition hit ratio	Pressure propagation Improvement of gas recovery ratio	Solidification, Cooling Realization of uniform cooling	Liquid level system process Molten steel temperature level stabilization Automation	Heat process Operation stability
Process model and, important process variables	Physical model Hot-metal Si density Temperature	Auto-regression model/ identification Optimal regulator control Hot-metal temperature Carbon	Transmission function Pressure	Physical model Surface temperature Solidification thickness	Transmission function Molten steel level	Temperature, Gas flow Line speed Heat conductivity model
Advanced control system	Guide by simplified physical model and experience	Auto-regression model	Discrete optimal control	Simplification of physical model Kalmann filter	Nonlinear type PID	Variable gain Feed forward control wasted time compensation
Conventional control system and its problem points	Manual operation Operation delay Frequent facility trouble	Manual operation Increase of number of reblowings	PI control Closed operation impossible Improvement of gas recovery ratio	Ratio control Generation of cracks and segregation	PID control Generating of hunting	PID control Gain change at conditions switching
Advanced control system technology and features	Estimation of blast furnace state Integration of process data	On-line Optimal gain computation	Combination with prediction control Logic type adaptive control	Partial differential equation approximation solution method	Cascade control Backlash compensation	Combination with prediction control Combination with logic type control
Data analysis item	Physical model verification	precision verfication	On-Line Estimation of outside disturbance frequency	Physical model verifications	Estimation of nonlinear elements	Physical model constants decision
Simulation analysis items	Comparison with operation by an expert	Weighting matrix decision	Sensitivity analysis	Approximation solution method precision verification	Control parameters	Effect of variable gain Smith method feed forward method
Control cycle	1 hour	1 second	0.2 second	10 seconds	0.2 second	0.2 second
Application points and problems	Work pattern classification Physical model computation Judgment threshold decision	variable parameters specification Limited to 1 input 1 output	Logic type adaptive control parameter regulation Coping with sudden process characteristic changes	Test expression decision Computation time is long	Reduction of number of operations of actuator	Adaptive control parameter regulation Method of finding model constants
Backup system	Manual	Constant value control	PI control	Ratio control	Non	PI control
Controllability and operation improvement effect	Improvement of stability Stabilization of operation Early detection of abnormalities	Improvement end point control Improvement of yield	Reduction of control deviation Improvement of energy recovery Improvement of yield	Improvement of response Reduction of defects	Improvement of stability Improvement of actuator life Realization of complete automation	Improvement of stability Improvement of quality Improvement of yield
Future technology	Introduction of knowledge engineering Sensor development	Automation by AI	Generalization of logic type adaptive control	Distributed constant value system control Detection ore development		Model simplification Learning control

Fig. 4 EIXAX system block diagram

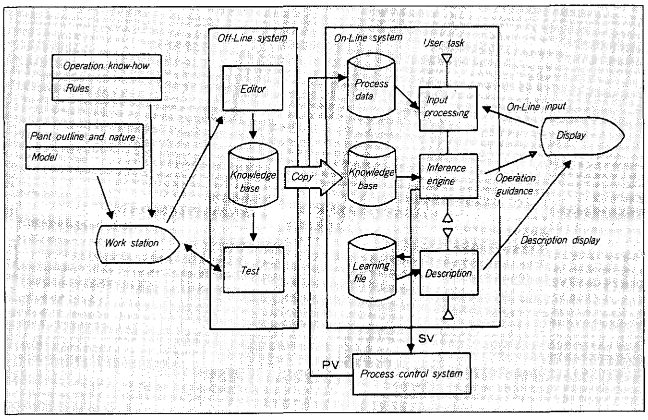
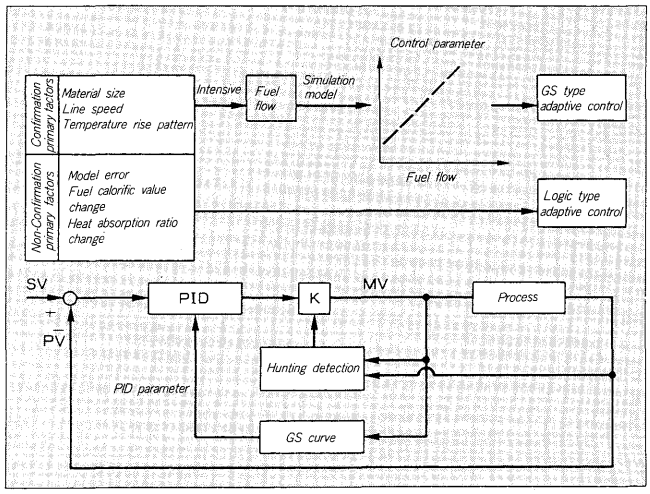


Fig. 5 Block diagram of adaptive control at furnace temperature control



were used and an expert system focused on the know-how and knowledge of epxerienced operators was practicalized.

Because there are many parts intertwined with know-how in realizing an expert system, the manufacturer offers AI tools and the user performs knowledge engineering.

Fuji Electric focuses its attention on the solving of control system problems, and offers the AI tool EIXAX which builds experienced operator know-how with rules and models. As shown in *Fig. 4*, EIXAX has the following features:

(1) Expert system configuration support (off-line) and execution (on-line) are separate and independent on the same computer.
(2) Multiple knowledge base reasoning can be executed with one inference engine.
(3) Abundant support functions (test, simulation, and learning functions)
(4) High speed execution
(5) Coordination with on-line system process data base
(6) Numerous problem solving packages

4.2 Steel making advanced control

The closed OG system and it's controller which is called NCPo (new Po control) system makes a large contribution to automatic blowing as advanced control applied to a steel making plant.

4.3 Continuous caster advanced control system

(1) Mold level control

From the standpoint of quality, this control is the most important control in continuous casting. Because the effect of various outside disturbances on control precision is large, good control precision can be maintained by providing compensation circuits corresponding to the various outside disturbances.

(2) Secondary cooling water flow control

The solidification state doesn't change so much even when the continuous caster withdrawal speed is changed suddenly. For ordinary specific water coefficient control, only the cooling state changes suddenly and, therefore, cooling becomes uneven and product quality defects are produced. On the other hand, cooling process control also developes a control model which performs control with perfect solidification thickness as the target position and good results are obtained.

4.4 Continuous annealing and processing line advanced control system

(1) Strip control

For strip temperature control, initial setting, feedback control, feed forward control, line speed control, and furnace temperature control are done based on an annealing furnace model. Since the process characteristic at a normal furnace temperature control system change considerably with the plate passing conditions, adaptive control is necessary. Since the plate passing conditions are line speed, steel plate size, and set temperature, finding the process gain as a function of these is complex. Therefore, if the process characteristics are found from the step input response versus fuel flow by using a simulation model and gain scheduling type adaptive control with the fuel flow as the adaption index is performed, good control is possible. The adaptive confrol configuration is shown in *Fig. 5*.

(2) Real-time fuzzy control system

Fuji Electric has developed fuzzy control system which can be mounted in a distributed system PCS-500 shelf. This fuzzy control system has 128 rules and a high speed of 500 ms/output. Amply satisfactory control can be expected in CGL (Continuous Aluminizing and Galvanizing Line) control, pickling line density control, etc. by this development.