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Development of Energy System

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1 Introduction

Since the 1973 oil crisis, Chiba Works has been promoting various measures for saving on energy spending in production facilities, such as a continuation of two or more manufacturing processes and a recovery of exhaust energy. Along with these energysaving measures, it has become increasingly necessary to reduce energy costs through such steps as a thorough analysis of total energy balance of supply and demand at the Works level, and effective recycling of fuel gases and steams, and an economization of purchased electric power. Against such backdrops, an energy system has been developed aiming at an effective recycling and conversion of various types of energy resources by centralizing a large volume of supply and demand information on energy such as electric power, fuel, steam, oxygen, etc. in use or generation in the entire steelworks compound.

Linked closely with the Works' production administration system, the present energy system regulates energy supply and demand in a way best fit to production activities. A fast and reliable energy administration has been realized by on-line realtime information transmission made available by use of up-to-date electronics and computer techniques.

The operation of this energy system has contributed to the drastic reduction in energy costs and the rationalization of workforce requirements.

This paper describes the organization, functions, and features of the energy system.

2 Configurations and Functions of Energy System

2.1 Overall Configulations

The energy system is comprised of a three hierarchical structure of a business computer (B/C) system, process computer (P/C) system, and direct digital control (DDC) system (refer to **Fig. 1**).

The equipment structure of the energy system is shown in **Fig. 2**. Operators view a color-graphic CRT, while a voice annunciator is used as an alarm, ensuring

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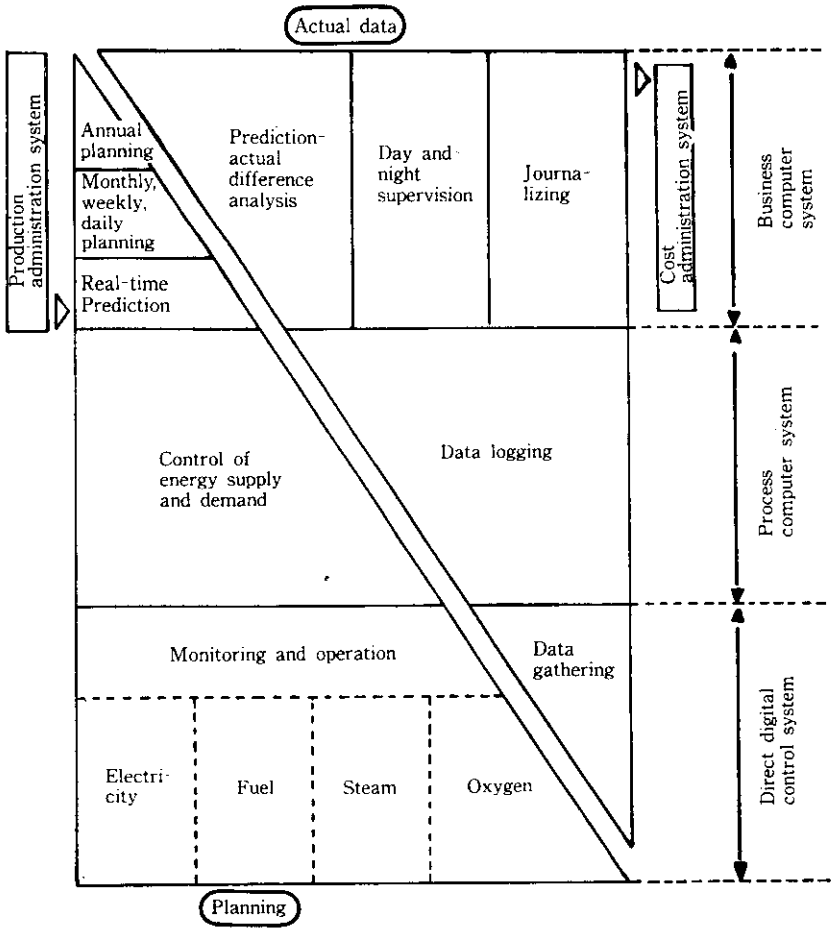

Fig. 1 Energy system function organization

errorfree operation judgement. Information is transmitted real-time using an optical fiber network covering the entire compound of the steelworks. The production process, power plants, such as the power station and oxygen generating plant, and the energy center are all included in a unified energy supply and demand operations.

A flow chart of subsystems classified by function is shown in **Fig. 3**. The B/C system produces yearly, monthly, weekly, and daily energy supply and demand plans, and performs real-time energy predictions. In the P/C system, an optimum supply and demand position guidance up to several hours in advance is projected and partially communicated to the direct digital control system (DDC) as set-up values. The DDC system monitors energy supply and demand conditions and controls the operation of energy-using facilities.

Functions and aims of each hierarchy of the energy system are shown in **Fig. 4**. The B/C system is positioned to support the Works' production administration system. Its main functions are to predict energy supply and demand accurately in accordance with production and operation plans, to adjust processes to reduce imbalances in energy supply and demand and to collect energy data, for analysis and evaluation.

The P/C system controls the energy supply and demand operation. It main function is optimization of energy conditions through effective use of the gas holder and power station. These units have a buffer function for the optimization of the energy supply and demand.

The DDC system is a principal tool of the energy supply and demand operation. Its main functions are monitoring the conditions of energy supply and demand, and controlling the operation of energy-using facilities.

2.2 Configulations and Functions of B/C System

2.2.1 Intermediate- and long-term plans (total energy cost evaluations system)

The intermediate- and long-term planning system is an energy strategy system that simulates the operations of the blast furnace and coke oven units, which

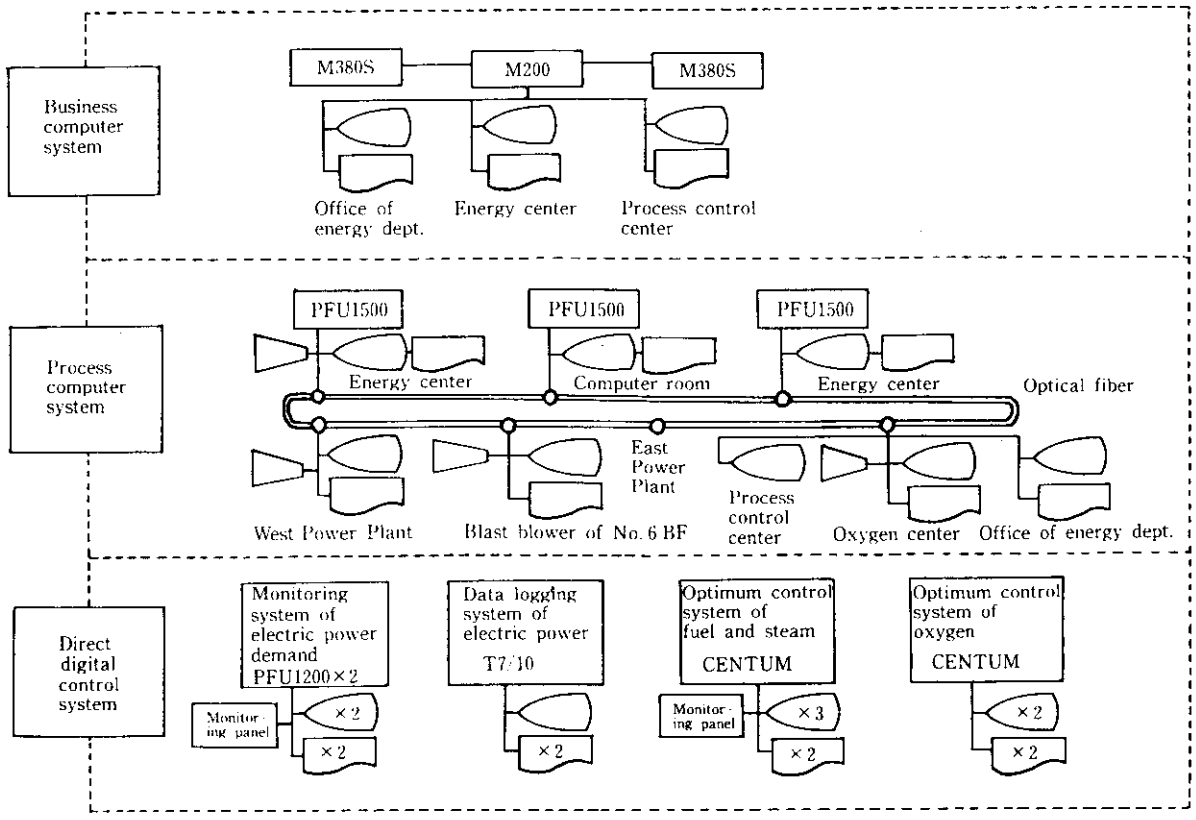

Fig. 2 Energy system equipment organization

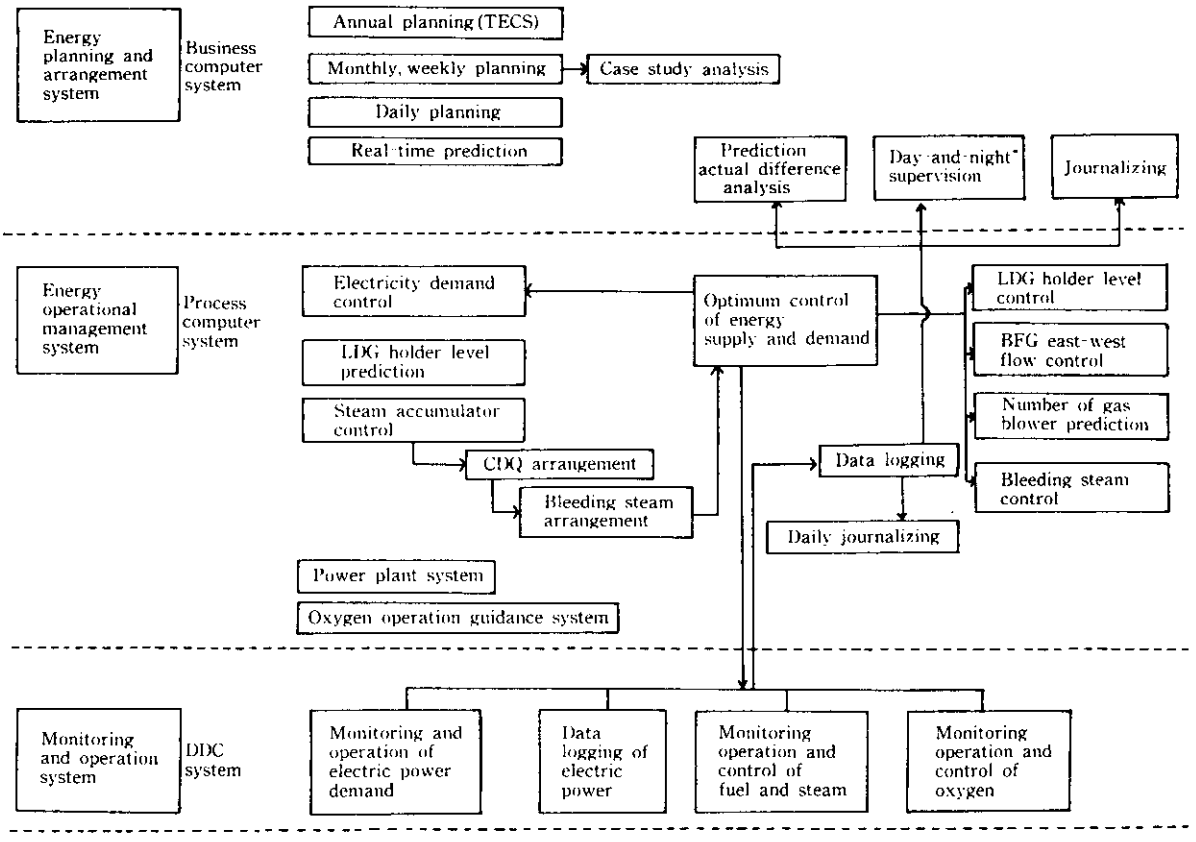

Fig. 3 Energy system subsystem flow

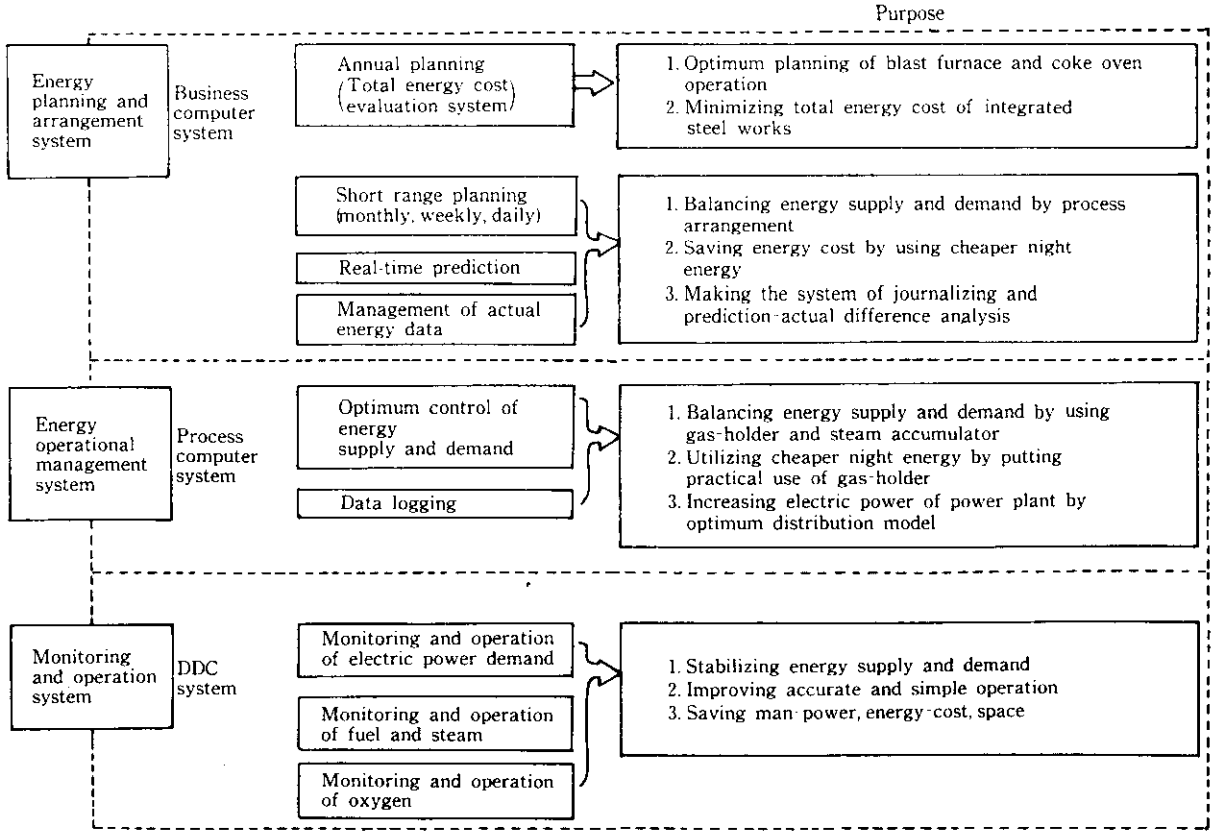

Fig. 4 Aims of energy system

greatly affect the Works' overall energy balance. On the basis of its simulations, the system formulates energy supply and demand plans which will minimize the energy costs of the entire steelworks.

2.2.2 Monthly and weekly plans

When production and operating plans of various lines at the steelworks are inputted by interactive processing, the B/C system compiles a time-series energy supply and demand balance. The predicted supply and demand balance transition is displayed as a graph to permit study of possible problems such as gas release, use of auxiliary fuel (LPG), or power consumption in excess of that contracted with the outside electric supplier. If any problem exists, the B/C system is again called on, after adjustments of the operation plan, to revise and finalize the energy plan. The daily amount of outside-contracted electric power is adjusted according to this revised monthly supply and demand plan. An example of the monthly electric power balance is shown in **Photo 1**.

2.2.3 Daily plan

At 6:30 every morning, the B/C system automatically produces a one-day time-series energy supply and demand plan for that date, on the basis of the latest operation prediction information for each line. At the same hour, the system also offers a comparison of the energy supply and demand plan and the actual value for the preceding day as a reference material of supply and demand control.

2.2.4 Real-time prediction

Constantly changing conditions of the operation of each line are obtained from information given by the Works' production administration system, and are used

Photo 1 Monthly planning display

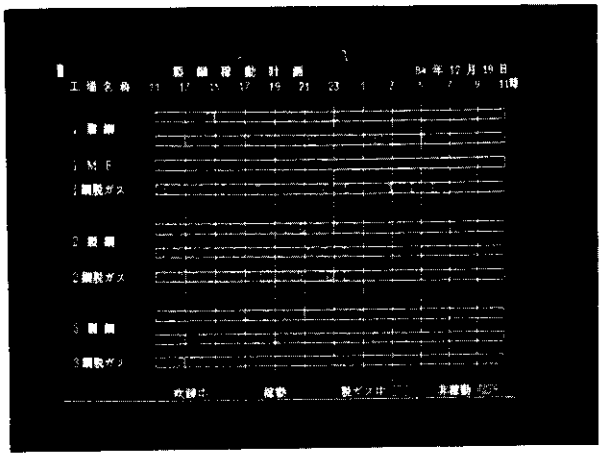

Photo 2 Real-time prediction display

for predicting subsequent line operations and also utility consumption. An example of a real-time prediction of the energy supply and demand at the steelmaking plant is shown in **Photo 2.**

2.2.5 Measured value administration

Receiving hourly measured values of utility consumption from the DDC system via the P/C system, the B/C system accumulates and tabulates data on a monthly basis. These accumulated values are journalized by facility, for use by the cost administration system in cost accounting. These accumulated values are also categorized and summarized by day and night shifts, forming reference materials for control of day and night shifts. The B/C system collates the cumulative utility actual consumption data and actual operation values at each production line as received from the quality control system, and calculates the actual values of unit energy consumption. Through interactive processing using a graphic display, the B/C system performs unit consumption analysis for various conditions. As these analysis results are then reflected in the prediction formula for energy generation and consumption, prediction accuracy is enhanced.

2.2.6 Spot analysis

On the basis of information concerning the monthly and weekly plans used in the commercial production, the B/C system revises changes to be made in the energy environment and in the supply and demand conditions. It also executes case studies of the energy supply and demand balance, using interactive processing.

2.3 Organization Functions of P/C System

2.3.1 Optimum energy distribution plan

On the basis of up-to-date predictions of energy generation and use, the P/C system effectively utilizes energy buffer facilities, and compiles an optimum supply and demand plan. Aimed functions in compiling the optimum supply and demand plan are as follows:

(1) Operation of the gas holder by taking into account the difference in rates for purchased electric power between day- and night-time and also a measure leading to a reduction in the purchase of LPG.
(2) Optimum distribution of fuel and energy output by using a power generation plant model utilizing the non-linear efficiency characteristics of the in-house power generation facilities.

2.3.2 Electricity demand control

The P/C system predicts hourly and daily power amounts of electricity to be received from the electric power company, on the basis of electric power requirements and the predicted values for in-house power generation. These predictions reflect the calculations of optimum distribution of generated power, by the P/C system. Amounts to be received are monitored to avoid exceeding contracted amounts. The electricity demand control display screen is shown in **Photo 3.**

2.3.3 LD gas holder level control

The P/C system calculates the optimum quantity of gas to be drawn from the gas holder on the basis of steelmaking blowing schedules. At this time, the system tries best to balance gas use patterns. Since LD gas is supplied to the power plant, the P/C system operates the gas holder in consideration of differences in day and night electric rates.

2.3.4 Steam accumulator control

The P/C system calculates amount of steam generation by the converter waste heat boiler on the basis of the steelmaking converter blowing schedule and the

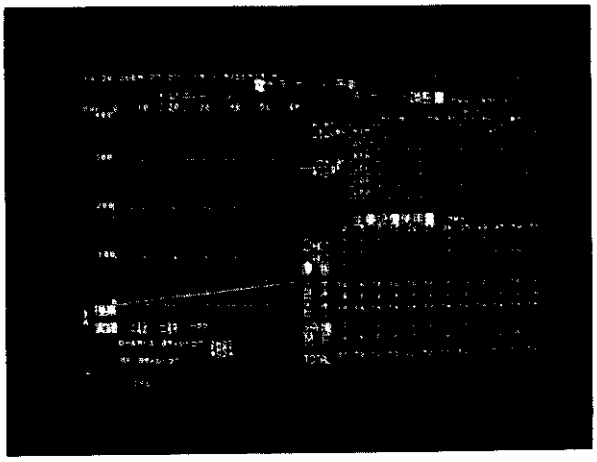

Photo 3 Electricity demand control display

amount of steam consumption at the vacuum degassing facility on the basis of the degassing schedule. The degassing facility at the same steelmaking plant is given priority in the resulting steam supply plan; excess steam is assigned to the main steam pipe system. The P/C system effectively uses the steam storage facility (accumulator) installed at the LD boiler outlet to balance supply of steam to the main pipe system and suppress pressure fluctuations at the system, thereby conserving steam.

2.3.5 Bleeding steam arrangement of power plant turbine

Because only steam produced by the exhaust heat recovery boiler is used, steam shortages may occur. In such cases, steam is bled from the power plant turbine or from the multipurpose turbine. The P/C system calculates the amount of steam to be bled from respective facility.

2.3.6 Power plant operation system

This system controls operation of the power plant and has the functions of monitoring power generation plant operation, turbine starting curve guidance, O_2 control, and compilation of operation records. An example of the system display is shown in **Photo 4**.

2.3.7 Oxygen plant optimum operation system[1)]

This system compiles the optimum operation plan of the oxygen plant in monthly and 8-hour plans.

(1) Monthly Operation Plan
From the operating plans of major oxygen users, such as the steelmaking plant, optimum operation plans for the oxygen separation facilities, air compressors, and oxygen compressors are compiled.

(2) 8-Hour Operation Plan
On the basis of the real-time blowing schedule, an oxygen plant operation schedule is compiled, giving consideration to optimum use of the oxygen gas holder.

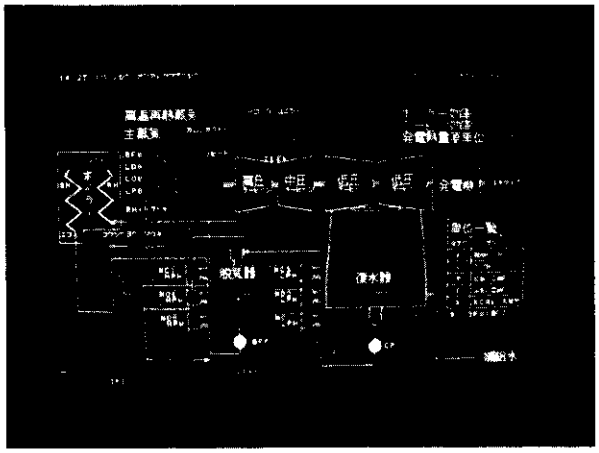

Photo 4 Power plant system display

2.4 Function and Structure of DDC System

2.4.1 Fuel and steam monitoring system

Main functions of the fuel and steam monitoring system are shown in **Table 1** and are summarized below.

Table 1 Function of fuel and steam optimum system

Energy plant	Function
Gas holder	a) Gas holder level, pressure and piston speed monitoring b) Inlet and outlet interception valve interlock sequence c) Oil flow monitoring sequence
Flarestack	a) Flarestack control by monitoring holder level and gas pressure b) Flarestack automatic sequence
Fuel gas and steam supply, and demand instrumentation	a) Gas volume correcting by temperature, pressure, moisture and density
Gas blower	a) Start and stop operation sequence of gas blower b) Suction and delivery pressure control c) Surging protection control d) Temperature monitoring of blower
LPG reception facility	a) Pump operation sequence b) Gas leak detecting
Steam pressure and temperature reducer	a) Feed water control
Steam accumulator	a) Steam feed control b) Pressure monitoring of accumulator
Gas calorie controller	a) M-gas calorie feed-back control

(1) Ensuring stabilized supply, efficient operation, and quality assurance for fuel and steam supplies.
(2) Guaranteeing of measuring accuracy of utilities.

The monitoring panel is shown in **Photo 5**.

2.4.2 Electric Power Monitoring System

This system, using a display panel (**Photo 6**) and a color graphic CRT (**Photo 7**), monitors the following operating conditions:

(1) Electric power system operating conditions
(2) Electric power supply and demand conditions
(3) Electric power system operation

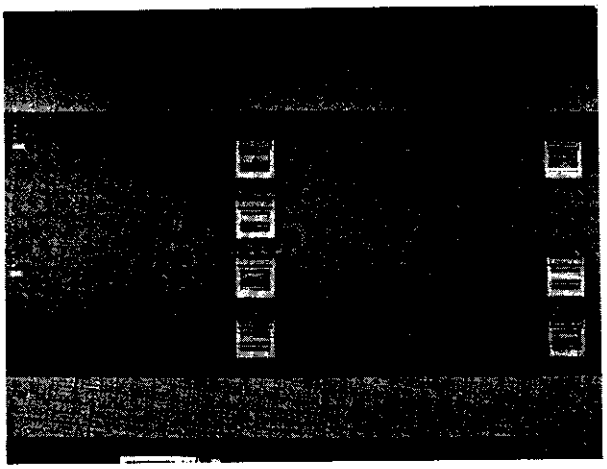

Photo 5 Display panel of optimum control system for fuel and steam

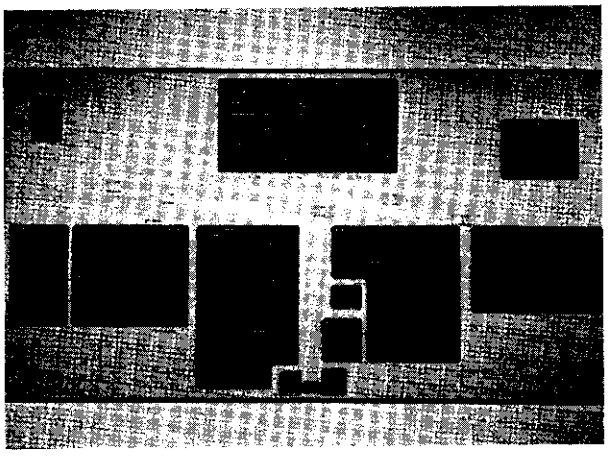

Photo 6 Display panel of monitoring system for electric power demand

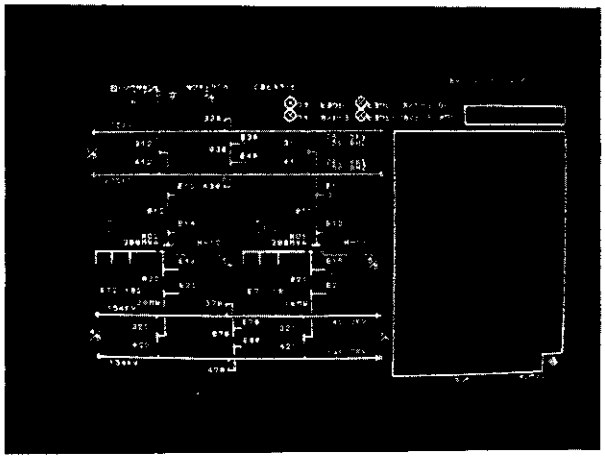

Photo 7 Display of monitoring system for electric power demand

3 System Feature

3.1 Optimization of Supply and Demand in Unification with Production Activities

Energy supply and demand at the steelworks are closely related to production activities. Taking this into account, the energy system is collecting information concerning operating schedules of production facilities from the Works' production administration system, which issues instructions to production lines, and working to conduct economical operations in the areas of energy supply and demand.[2, 3]

The energy system is connected, on a real-time basis, with the production administration system. Control of the energy system is centralized in the B/C system, which constantly receives updated production information. Accuracy has been particularly enhanced by correcting scheduled operation times to reflect actual operation time information for every blowing charge and for rolling of each slab. The energy prediction formula is constantly revised using actual unit-time energy values, also contributing to prediction accuracy. Such accurate demand and supply predictions permit the smooth efficient supply of energy to production divisions, as well as savings in purchased electric power.

3.2 Efficient Energy Conversion Operation through Unified Control

When all types of energy including electric power, fuel, steam, and oxygen, are subjected to a centralized, unified control, an efficient energy conversion plan is formulated and realized. Thus the No. 3 generating plant at the West Power Plant, which started operation in 1984, and the 200 000 m^3 C gas holder, completed this year, are now operating efficiently. The energy center control room is shown in **Photo 8**.

Photo 8 Energy center

3.3 Night Shifting Control of Day and Night Energy Use

Power consumption turns beneficial to the power company concerned and the user both, if minimized in daytime and increased in nighttime. Because of the inter-convertible characteristics of energy in various types, it proves rewarding to shift from daytime to nighttime the consumption of energy such as fuel, steam, and oxygen, not only electric power. The completion of the energy center has made it possible to determine the consumption of energy other than electric power during any time zone, and this further has led to effecting an economically optimum 24-hour energy use control.

3.4 System Construction by Hierarchical Structure

The energy system is constructed in a three hierarchical structure of the B/C, P/C and DDC systems, with each system sharing function by demonstrating its features in respective field of planning adjustment, operation control, and monitoring operation.

4 Effects of Energy System

The present energy system accurately predicts energy demand and supply position on the basis of the production schedule of the steelmaking process, and adjusts steel production to maintain the energy balance. It also carries out optimum operation of energy-generating facilities, such as the in-house power plant and gas holder, thereby realizing the following advantages:

(1) Rationalization of electric power contracts
(2) Effective use of night-rate electric power, taking advantage of the difference between day and night power rates
(3) Prevention of energy loss by balancing energy demand and supply
(4) Energy savings by the centralized regulation of energy demand and supply position
(5) Rationalization of accounting work by systemization of utility record-keeping

5 Conclusion

With energy control in the steel-works growing increasingly important, Chiba Works has developed an overall energy system which is directly linked to the Works' prodution administration system, thereby achieving major reductions in energy costs and making possible rationalization of workforce.

The environment surrounding energy is full of drastic changes as evidenced by recent trends in oil prices. In the steelworks, as well, the pace of change in energy-related facilities is rapid, calling for energy control that will meet it flexibly. Against this background, the authors intend to upgrade the level of the present energy system to meet the ever increasing requirements of the future.

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