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ENERGY CENTER SYSTEM AT THE STEEL MAKING PLANT

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1 INTRODUCTION

Steel making plant consume enormous quantity and sorts of energy as fuel, electricity, steam and air. Among these, energy to be purchased from outside (primary energy) are coal, petroleum-based fuel and electric power, and they are converted into byproduct energy (secondary energy) as gas, electric power, and steam in the production process at the steel making plant. The remarkable features of the energy consumption in the steel-making plants, unlike other sectors of industry, consists in producing various sorts of byproduct energy. What's more, of the energy consumped in the steel making plants themselves, about 40% are these byproduct energy. These energy have a complex interrelationship among them, and as they vary from one to another in a large scale, dexterity in managing energy will exert a great influence to the cost of the products, so that almost all steel making plants in Japan have established their own energy centers, though they many differ in their scale, aiming at effective energy administration.

The main purpose of the energy centers are:

(1) Stable supplies of various sorts of energy to production plants,
(2) Energy-saving through centralized control of energy by energy centers.
(3) Improvement in precision of record up-keeping of energy production and comsumption.
(4) Reduction of total energy cost.

In particular, the energy center systems projected recently take the total energy cost minimum as their main objective, connecting it directly to the production plan, and a new sort of systems that has adopted the optimum distribution calculation has come to be spotlighted.

In this trend as a background, Chiba Works of Kawasaki Steel Corporation has inaugurated its energy center system on October, 1984, aiming at effective reciprocal use of various energy by centralizing the enormous informations on demand and supply of energy produced and utilized at the steelmaking plant, such as electric power, fuel, steam and oxygen.

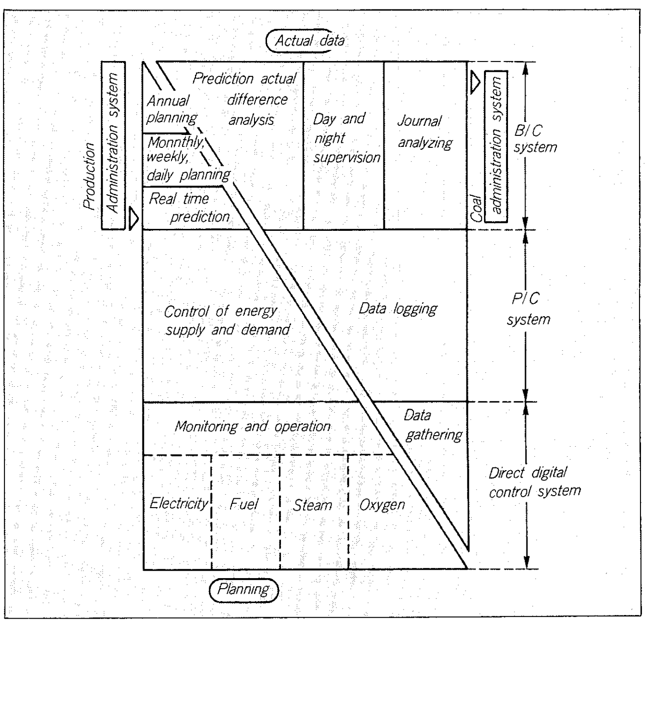
This system is constructed by three-stage construction, namely, Business Computer System (hereinafter referred to as B/C), Process Computer System (called P/C) and Direct Digital Control System, each one assuming their respective duty of project coordination, operation management and supervisory operation. The features of this system consist in that it carries out optimization of energy demand and supply on basis of production plan by taking in B/C production information.

This article reports as the main topics the functioning of the energy center computer system that takes up the charge of operation control in the energy installation as P/C for energy center system, as well as the electric power supervisory operating system that assumes the responsibility for power supervising operations.

2 FUNCTION AND CONSTRUCTION OF ENERGY CENTER SYSTEM

Fig. 1 shows functional construction of each system, and *Fig. 2*, its objective.

Fig. 1 Functional construction diagram of an Energy Center



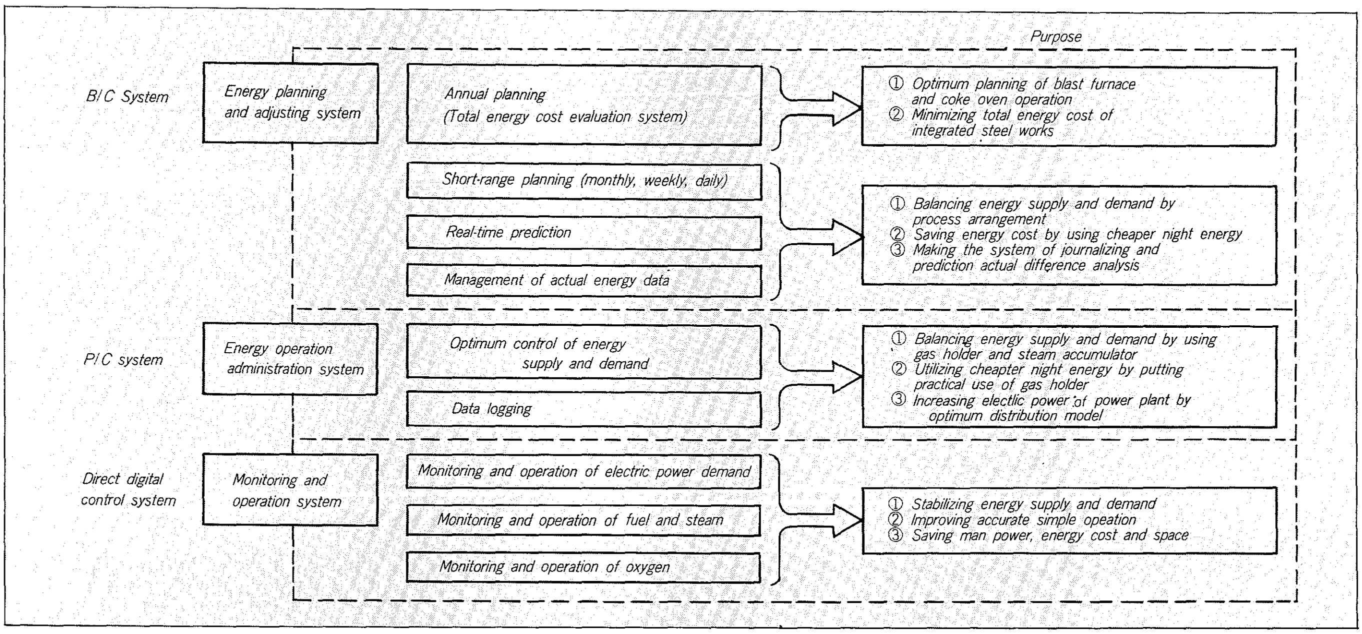


Fig. 2 Purpose of energy system

2.1 Function of each system

(1) B/C system takes up the position of supporting production control system of a steelmaking plant. Its main function is to predict in a precise way, based on the production and working plans, the energy demand and supply, to coordinate the working process in order to smoothen the unbalance that may exist in demand and supply, and to grasp and analyze the energy consumption record.
(2) P/C system (energy center computer system) is used for administrating energy supply and demand operation, whose main function being the optimization of supply and demand by efficiently using the power plant that is energy consumption installation and the gas holder that is buffer energy installation.
(3) Direct digital control system is a system that does the real job for energy supply and demand, whose main function is to monitor energy supply and demand and to control and operate the energy installations.

2.2 Interrelationship among each system

In B/C, energy supply and demand planning for yearly, monthly, weekly and daily basis are carried out. In P/C, on the basis of planning data elaborated by B/C and actual data informations received from direct digital control system, the optimum supply and demand operating guidance for up to several hours ahead will be made out, and a part of this data will be transmitted as a control set value to the direct digital control system. On the other hand, the actual data will be transmitted to digital control system → P/C system → B/C system, and will be used for original unit administration and prediction actual analysis data.

3 ENERGY CENTER COMPUTER SYSTEM

3.1 Hardware composition

Fig. 4 shows hardware composition diagram of Energy Center Computer System. It shows a system flexible and abundant in possibility for expansion in direct answer to the demand for expansion and wider coverage of the energy center administration region. The following points were particularly taken into consideration when the system composition was designed.

(1) The computer are of three-unit (U-1500 x 3) consturction, the first taking charge of the function related to fuel, power and steam, and coodinating whole system functions (energy center system), the second taking charge of the functions related to West power plant and oxygen, and the last taking charge of back-up and development. The main purpose of designing this

Fig. 3 Energy Center Operating Room

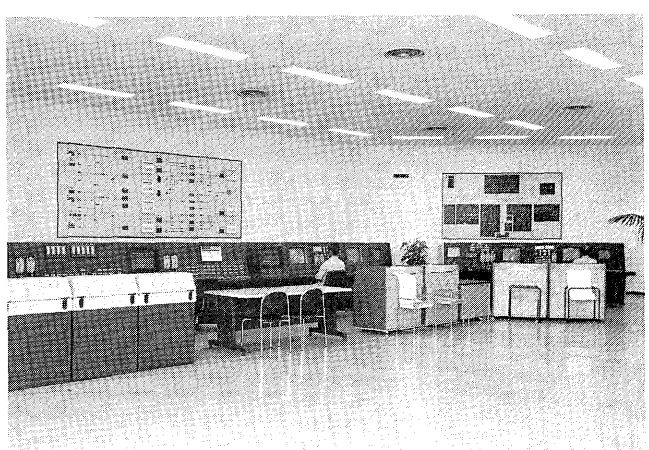


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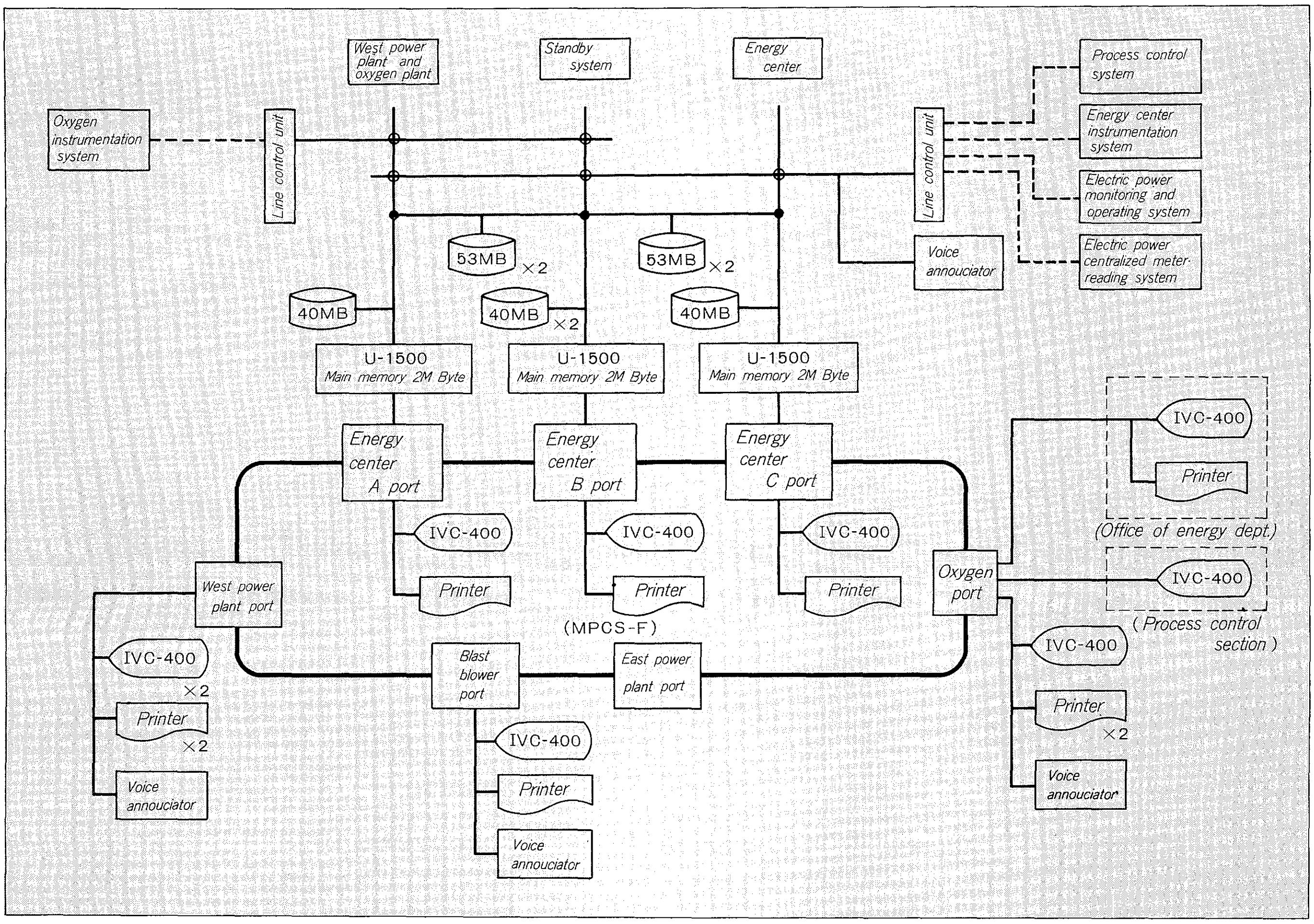
Fig. 4 Hardware Composition of Energy Center Computer System



composition was to improve the system reliability and flexibility for modifications of software.

purpose of designing this composition was to improve the system reliability and flexibility and flexibility for modifications of software.

(2) The auxiliary memory for data, in accordance with the policy of above-mentioned computer composition, is dualized and, at the same time, is of specification permitting cross calls.

(3) For data transmission between Energy center and each local facility, a light data way (MPCS-F) utilizing in-station light network, which is high-function and high reliability transmitting equipment is used. This data way has put the following functions into practical use:

(a) Data transmission between each computer

(b) Multiple access to PI/O, CRT and printer, etc. connected to port from plural computers.

Table 1 shows the main specifications of the data way.

(4) By adopting voice annouciator, Kanji (Chinese characters) printer and high-density CRT, improvement of man-to-machine interface functionality is devised.

3.2 Function Composition

On basis of energy prediction informations elaborated by B/C, Energy center computer system tries to:

- Reduce energy to be purchased (LPG) through balancing energy supply and demand by utilizing buffer facilities as gas holder, steam accumulator and CDQ.
- Utilize energy of lower cost nighttime rating through storage volume control on buffer facilities.
- Increase the quantity of electric power generated independently in due consideration of difference in generating efficiency of each unit of generating facilities through optimum distribution of load and gas.

Table 1 Data way specifications

Transmission path	GI type optical fiber cable
No. of bound ports	32 max./data way
Distance between ports	4 km, max.
Transmission system	Independent bucket type, Entirely dual communication
Exchange system	Accumulation exchange system
Transmission speed	12.6 M bits/sec.
Effective transmission speed	1,300 bytes/sec.
Error control	CRC check and frame check

Fig. 5 Function composition of energy center computer system

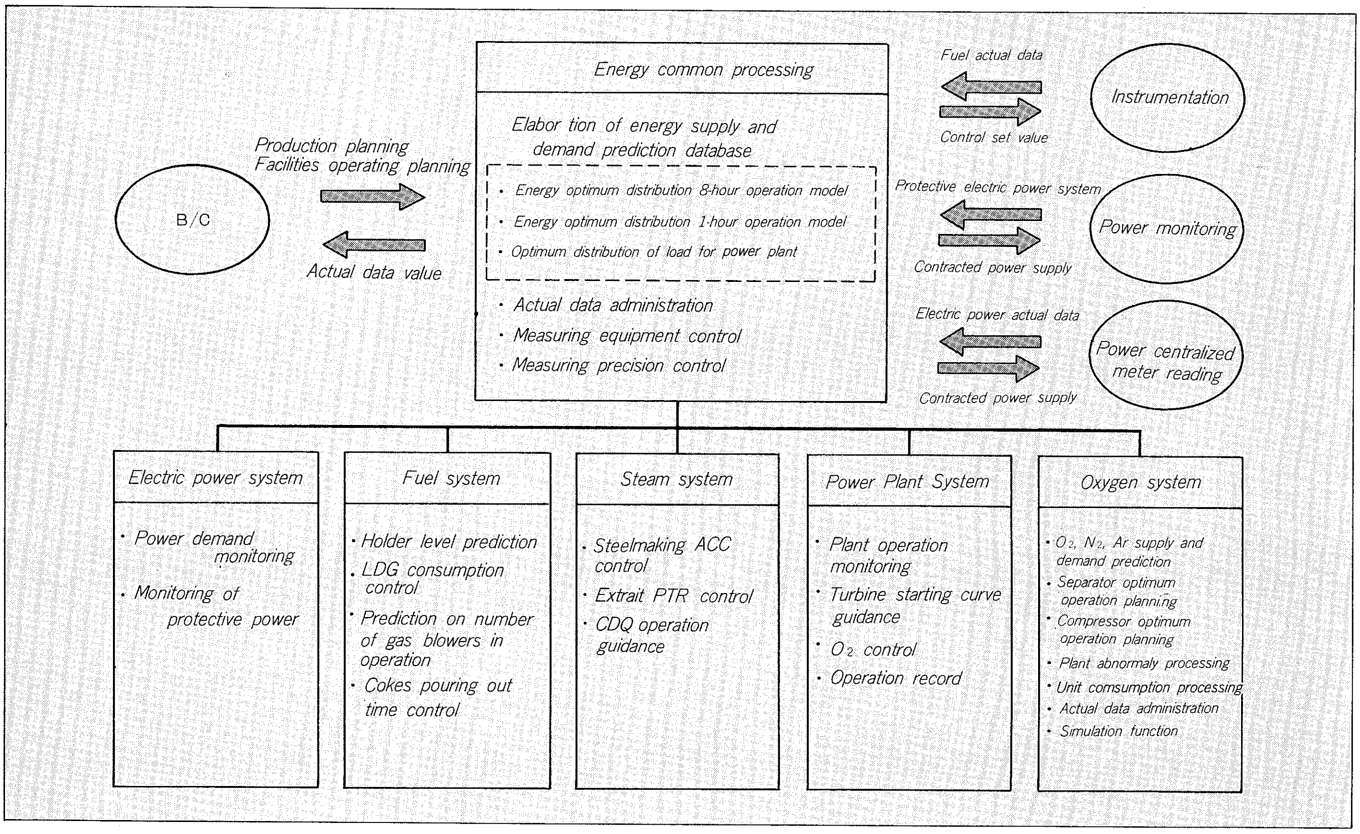


Fig. 5 shows the function composition of the system.

Seen from the point of view of function compositon, the system, with energy common processing as the central figure, is composed of electric power system, fuel system, steam system, power plant system and oxygen system, so that a particular consideration was given so that an effective energy admnistration can be attained through unified adminstration of electric power, fuel, steam and oxygen.

(1) Energy common processing

Central figure of the function is the energy optimum distribution processing, and by incorporating positive administration of buffer facilities into processing, an operating form within 8 hours, minimizing the cost of purchased energy,

(Quantity of purchased electric power x unit price + LPG consumption x LPG unit price)

will be determined.

(2) Electric power system

As for its function, two systems are available: bluk prediction on basis of production planning and facilities operating planning received from B/C, and another, prediction on basis of actual data received from digit control system. With these, a high efficiency in monitoring of received electric power and monitoring on protective power is obtained.

(3) Fuel system

Its function is characterized by incorporation of smoothening function that stabilizes as much as possible the pay out volume from holder for controling the consumption of LDG and thus, it minimizes the influence of blowing in the furnace.

(4) Steam system

As in case of LDG consumption control, it incorporates smoothening function for determining the blowing volume from the accumulator, so that it reduces the adverse effect of blowing and degassing to the steam piping system and improves the efficiency of optimum steam supply.

(5) Power plant system

Its function items include: boiler combustion control, operation, monitoring, elaboration of daily operation report and monthly operation report.

(6) Oxygen system

As its large function, there are monthly optimum distribution planning, and 8-hr. optimum operation planning. By adopting non-linear programming method, it contributes to prevention of oxygen diffusion and to improvement of electric power unit consumption.

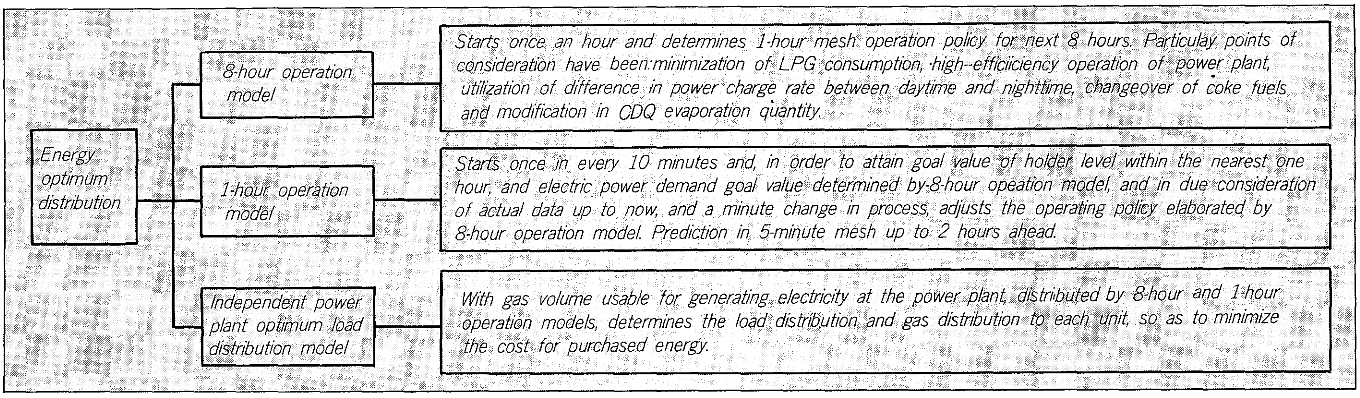
3.3 Details of Functions

In this section, a description is given in particular on the energy optimum distribution processing, that constitutes a principal function of this system.

(1) Composition and Features of Energy Optimum Distribution

Fig. 6 shows the composition of energy optimum distribution. For 8-hour operation model and 1-hour opera-

Fig. 6 Energy optimum distribution composition



tion model, a heuristic model that can cope flexibly with changes of energy supply and demand in conformity with operating datum of energy installation is adopted. For this, in the optimum load distribution model for power plant generation, a non-linear programming method with restriction is adopted as its solution, that is considered to be the optimum due to the character of the model.

(2) Package composition of 8-hour and 1-hour operation models

Fig. 7 shows the package composition of 8-hour and 1-hour operation models. It is composed of two common packages and two individual packages.

(a) Each hour mesh energy distribution pakage

This has a function of outputting coke furnace fuel change-over, LPG charging to hot strip mill area, and fuel and electric power consumption limiting in due consideration of switching over and restricting time.

(b) Holder transition decision package

By utilizing to full minimization of LPG consumption volume through storing by holder and by profitting the difference in power charge between daytime and nighttime and peak hour (strategic use of holders), generating quantity of plant and gas consumption of 1 hour mesh to 8 hours ahead will be determined.

(c) Energy administration final determination package

This is a package that carries out the principle function of 1-hour operation model. In due consideration of transition of actual data of gas holder level and quantity of electric power purchased up to the present, each gas consumption volume is determined by 5-minute mesh as well as the generating quantity of electric power at power plant that is made possible to approaching to the ideal administration that has been calculated by 8-hour operation model.

(d) Power plant optimum load distribution package. tribution package

This has a function of minimizing the cost of purchased energy through high-efficiency operation of power plant.

(3) Power plant optimum load distribution package.

Fig. 8 shows the composition of the power plant optimum load distribution package.

Fig. 7 Package composition of 8-hour and 1-hour operation models

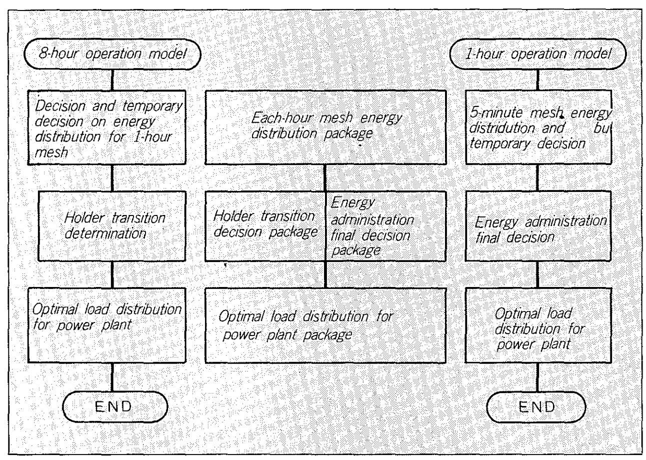
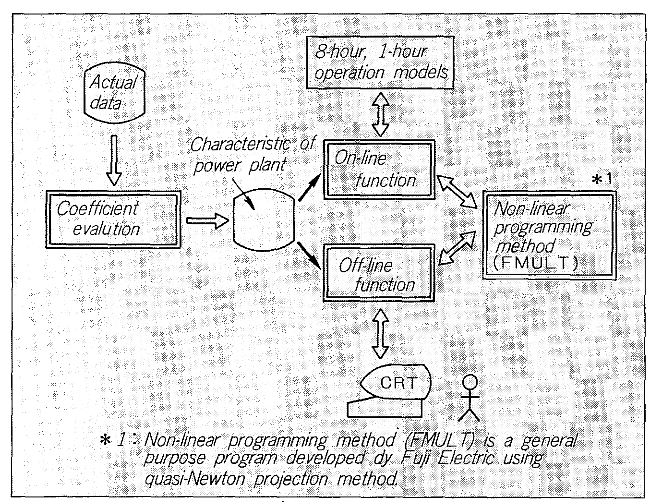


Fig. 8 Composition of optimal load distribution package for power plant



This is composed of on-line function, off-line function and coefficient inferring function of power plant characteristic formula.

(a) On-line function

This is a function that distributes the gas consumption volume and the minimum volume necessary for generating electricity determined by the 8-hour and 1-hour operation models, to each unit. This problem is the non-linear optimization problem by which the cost of purchased energy is desired to reduce to the minimum under the restriction of global load volume to be fulfilled for the upper and lower limits of energy distributed to each unit. The characteristic formula of each unit is:

$$P = ap^2 + bp + c$$

$$P = (dQ_1f_1 + eQ_2f_2 + gQ_3f_3) + h$$

whereas,

P : Quantity of generation p: intermediate variable

Qi : Calorific value of fuel i.

fi : Flow of fuel i.

a-h : Coefficient and constant

And this problem will be solved by using non-linear programming method. However, the non-linear programming method is not a global optimal solution, but it has a property of finding a local optimal solution that is near to the initial value, and the arithmetical speed until calculation up to optimal solution depends on the initial value, so that it constitutes a hindrance for operation under the real-time environment. Therefore, in this system, speeding up of the calculation to the order of several seconds was made possible by providing an initial value setting program in the stage preceeding to the non-linear programming method, and we have realized 10-minute periodical operation.

The initial value setting program uses efficiency order of each gas and efficiency order of each unit, and has a function of setting values sufficiently near to the global optimal solution in high speed.

(b) Off-line function

This is a function that carries out an optimal load distribution for power plant conversationally by using CRT. It has the following sub-functions:

- Function of optimalload distribution to each unit when the total gas volume and total generating quantity necessary are given.
  Function of calculating the necessary total quantity of remaining gas and, further, that of optimal distribution to each unit, when any gas total volume and necessary generating quantity are given.

Since this function permits instant comparison of optimal distribution under all and any operational conditions imaginable by operators with that computed by a computer, an administration abundant in flexibility can be determined.

(c) Coefficient evaluation function for power plant characteristic formula

In order to cope with ever changing characteristics of installations at power plant found at the time of periodical inspection and due to secular change, actual data on the operation of independent power plant are accumulated and analyzed when necessary, and used for tuning the coefficient of the characteristic formula.

4 POWER MONITORING AND OPERATING SYSTEM

This system is used for carrying out centralized monitoring operation by two CRTs and graphic panel on 30-odd electric power installations within the Iron Work, and attains save-labor force and save-space objectives.

4.1 Functions of the system

(1) Monitoring on operating conditions of the power system

It carries out monitoring on the operation of receiving and generating systems.

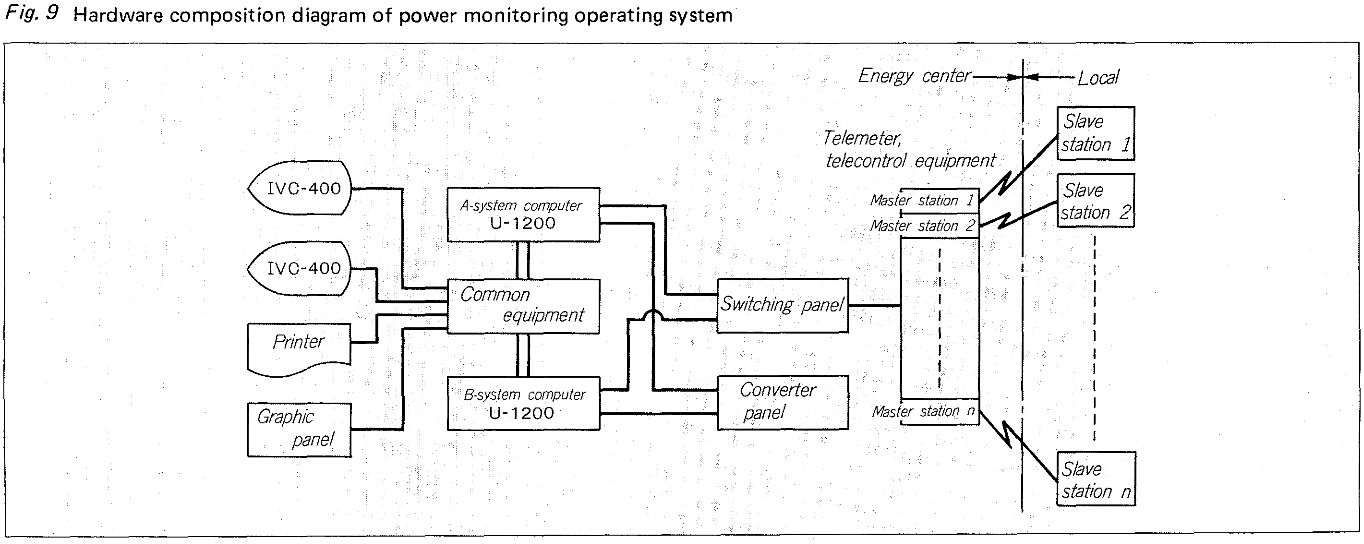
(2) Monitoring on power supply and demand states

It carries out monitoring on power reception, power generation and data on various types of currents.

(3) Operation of power system

With this, switching ON and OFF of CB, DS, etc, as well as raising and lowering of transformer tap will be carried out.

Fig. 9 Hardware composition diagram of power monitoring operating system



4.2 Hardware composition

Fig. 9 shows a diagram of hardware composition of the system. For composing this configuration, the points taken into consideration are the following:

(1) All monitoring operations are carried out through intervention of computers. So that in order to obtain higher reliability, computers are all available in two units: one is for normal operation and another for standby. With this system, further expansion can easily coped with.

(2) Monitoring operations are all possible by means of CRT with a light pen and several swithes, but for monitoring the main systems, a graphic panel with bus line lighting function is used at the same time.

(3) Signal transmission between each local installation and the energy center is carried out by the following two systems:
- Digital: Telemeter and telecontrol equipment
- Analog: Direct transmission

(4) The telemeter telecontrol equipment has the following composition in order to obtain full utilization of existing facilities, space saving, higher functionality and higher reliability.
   (a) Opposition system will be 1 : 1.
   (b) For existing stations, slave stations of other system will be used.
   (c) Master stations will have intelligence function, and their hardware will be of unit type (8 station/1 locker), and at the same time, interface equipment with the computer will be provided.

(5) It is made possible to swtich over from and to computers and each I/O (CRT, printer) and master stations, in a global way or by each equipment or station at the time of installation modification, reconditioning or testing.

5 EFFICIENCY

Merits that may be derived from the operation of energy center system are as follows:

(1) Reduction of contracted power consumption
(2) Increase in rate of usage of nighttime electric power
(3) Steam saving through steam pressure balancing.
(4) Energy saving through concentration by energy center
(5) Energy saving through systematization of data gathering.

6 CONCLUSION

We have described the function of Energy Center Computer System and Electric Power Monitoring Operating System established at Chiba Works of Kawasaki Steel Corporation. Both systems are the systems provided with the latest equipment and functions and, we are positive that this type of installation is the demonstration of not only steelmaking plant but of all sectors of industries of how to administrate energy in near future.