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COMPUTER CONTROL IN ENERGY CENTER

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I. INTRODUCTION

Fuji Electric has made many commercial installations of energy center facilities in iron and steel works. Several sets of facilities recently installed are designed to utilize computers for improvement of efficiency of energy control.

The following describes the functions of the computer and related peripherals and the fundamental concept of the energy center.

II. FUNCTIONS OF ENERGY CENTER

The iron and steel works utilize various kinds of energy resources such as electric power, crude oil, tar, coal, B-gas, C-gas, LD-gas, steam, water, oxygen, compressed air, etc., which are closely interrelated. The energy center is installed for integrated control of these energies, improvement of operation efficiency, and reduction of costs related to the energies. (*Fig. 1.*)

1. Requirements for Improvement of Operational Efficiency in Factories

1) A suitable quantity of energy necessary as a buffer should be prepared in view of the factory operating conditions in the future.

2) Dangerous conditions (which may discontinue the scheduled operation) should be detected in advance and countermeasures should be taken, and the equipment should be controlled.

3) If change in the operation schedule is inevitable due to an unexpected trouble such as a breakdown of equipment, a countermeasure to minimize the influence of such trouble should be determined and the equipment should be controlled.

2. Requirements for Reduction of Costs Related to the Energies

1) The supply of energies should be balanced with the demand for them in the cases of either of

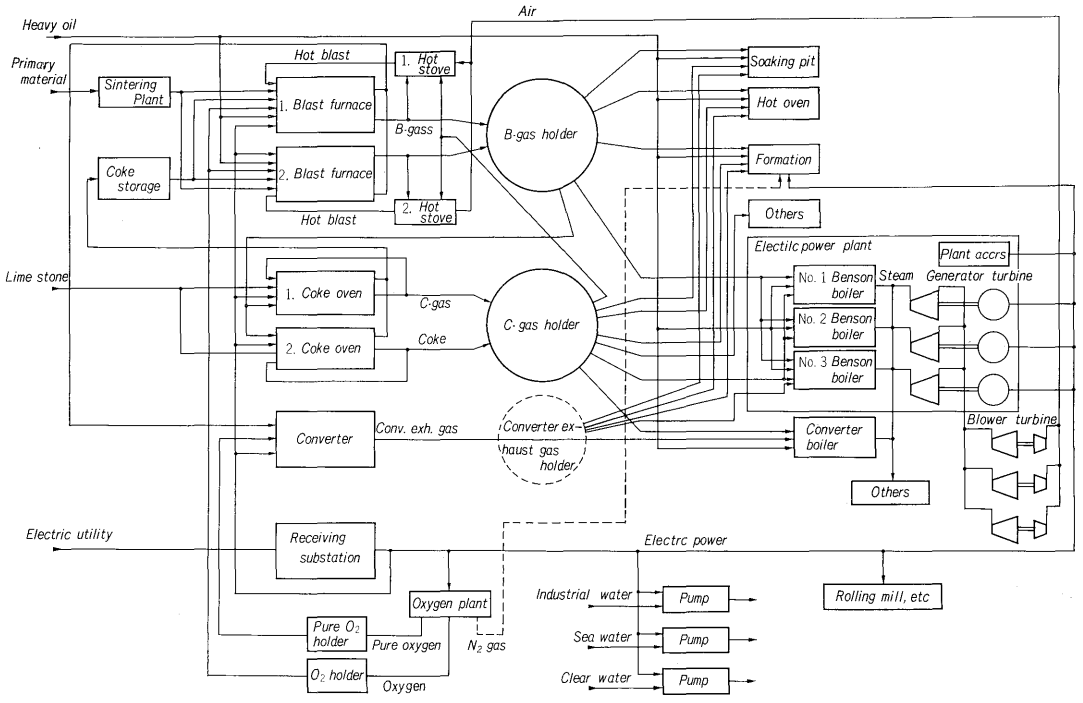

Fig. 1 Energy flow diagram in iron and steel plant

the workshops and of the entire iron and steel works.

2) If plural boilers, turbines, generators, etc. with different capacities and efficiencies are installed, allocation of the output of these devices should be determined for economy and the frequency of operation should be minimized.

3) Optimum combination of energy sources should be determined for the workshops in which substitute energy sources can be used such as, for example, boilers, soaking pits, reheating furnaces, sintering plants, lime stone plants, etc. in view of the different efficiencies due to the kinds of energy sources and balance between the demand and supply.

4) Reduction of labor cost owing to automation and speed up of operation

III. FUNCTIONS OF COMPUTER EMPLOYED FOR THE ENERGY CENTER

It is desirable to automatically control the functions described in section II through the computer and related peripherals. Direct control of all related information which is automatically fed into the computer is extremely difficult for iron and steel works since a large number of processes are involved. Since the function of the energy center is emphasized on the integrated energy control, not on the automatic control, human determinations in accordance with external conditions should be performed in many cases. Taking the troulbles of the computer into consideration, the minimum number of back-up units and operators are required. Accordingly, it is important for the energy center system to elaborate data transfer between the the operator and the computer, types of information, frequency of data transfer, information, quality, setting method, etc. The cathode-ray tube indicator with the hard copy function is a very useful data communication means and it will be indispensable for energy center systems in the future.

However, the cathode-ray tube indicator is disadvantageous because an operator should be skilled in operation to some extent and it is not sufficient for high-speed frequent setting of the data into the computer. Therefore, the operation desk and indicator which are manufactured for the respective systems are available.

Fig. 2 shows the data flow in the energy center of the iron and steel works. In this case, the data flow relating to the computer is mainly discussed and the description of the peripheral units (graphic panel, telemeter-telecontrol unit, wireless unit, etc.) is omitted.[1]

The functions of the computer for the energy center can be primarily classified into the following applications

1) Forecast of energy and calculation of most economical distribution of energy under consideration of day interval

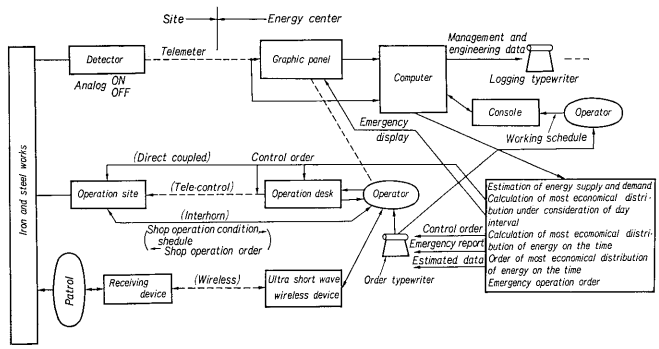

Fig. 2 Information route

This application is necessary to stabilize the supply of energy and to provide the standard for most economical distribution of energy under consideration of day interval. The input data for computation is the operation schedule for each workshop (hourly schedule) which is given by an operator and the results of operation in the past, and the output data is operation commands for gas holders, output values of the boiler and generator, etc., which will be typewritten out hour by hour as data. The above data is usually computed on every preceding day and can be repeated many times.

The results of computation are directly utilized for calculation of most economical distribution of energy on the time on every following day or are applied as the instructive information merely for the operator. In case the results are directly utilized for the application of the following day, the forecast data should be corrected if difference between the forecast data and actual data is found; therefore this computation should be repeatable at any time.

2) Most economical distribution of energy on the time

This application is intended to calculate the optimum operating condition of the processes from the current point to the next calculation point and to obtain the results of computation as the output data. It contains the following two steps.

(1) Correction or preparation of forecast data
(2) Calculation of most economical distribution of energy on the time

The values obtained from forecasting and calculation of most economical distribution of energy under consideration of day interval should be corrected using the actual data, with respect to the items to which the values shown above can not be applied, the data for the next period of time should be forecast using the digital filtering according to the characteristic of a variable.

Since the iron and steel works include the plant with the converter and the hot stove which the operating conditions periodically vary suddenly even in the usual operations and the plant with the blast furnace and boiler which the operating conditions abruptly vary greatly, the most important problem is how to apply the operating conditional data of

those plants to the forecasting model. Since the signals automatically obtained from the plants cannot be efficient information necessary for computation. The information such as that the operation other than the standard is being performed, should fed into the computor through the operator desk.

The forecast data is generally prepared according to the kind of energy with respect to the blast furnace, C-gas, LD-gas, steam, electric power, air volume and water.

In the calculation of most economical distribution of energy on the time, effective distribution of gas and steam to the generator or blower is determined. The input data of calculation is the forecast data (the average values) obtained from the current calculation point to the next point and the output is displayed on the special indicators and the cathod-ray tubes at the workshops.

The operation cycle relating to the most economical distribution of energy on the time is the delay of control usually several minutes approximately 15 to 20 minutes including.

3) Monitoring the processes, detecting the abnormalily and controlling the abnormality and the recovery from abnormality

The data of the structural upper and lower limits of the process as well as the upper and lower limit data which are necessarily determined according to the forecast data and the commands for most economical distribution of energy on the time should be monitored at all times. Through this monitoring, early detection of abnormality and early action against abnormality are possible. The control when abnormality occurs and the plants are restored from abnormality, is performed according to the given sequence. The processes except a limited number of processes generally include many factors for determining the sequence and those factors are generally unnecessary on the normal operation. It is difficult to expect that the determinative factors are correctly given to the computer. Accordingly, the processes when abnormality occurs cannot help being dependent on the operating guide system. The practical operating guide system differs with the scale of the iron and steel works and the control system, and the conversation method between the operator and the computer through the cathod-ray tube is generally employed.

4) Automotic control

The energy center is intended to determine the control system of the entire energies, and in most cases, individual controls are performed at each workshop. Urgent control which affect the entire system, partial sequence control and automatic control are automatically performed through the computer of the energy center. The range of control depends on the energy control system of the iron and steel works and the extent of automation of the equipment. Along with progress of automation, the range of direct control by means of the computer will be expanded.

The following shows the items which have been actually controlled by the energy center system in the past.

(1) Opening and closing of the emergency shut-off valve when the gas holder level reaches the upper or lower limit upon power failure.
(2) Automatic operation of the crude oil service tank (operation of the pump and valves)
(3) Selective interruption of a load when it is switched over from parallel running of electric utility and own power station to own power station system only.
(4) Interlock of operation of the circuit breaker
(5) Control of the gas expansion valve
(6) Control of gas flow for the boiler and commercial supply with compensation of pressure, temperature, humidity and calorie (Setting for the loop station)

5) Preparation of control data

The data log (daily report) in which the status of the process is recorded with fixed intervals, data for transactions, data for inter-office cost control and data for budgeting are prepared in this application.

6) Others

Various technical computations, determination of the standard operation systems are performed in accodance with the existing process and the status of the process externally given are calculated. The functions for these operations are provided according to the energy center system.

IV. SYSTEM CONFIGURATION (HARDWARE)

The following briefly describes the equipment necessary to satisfy the functions of the computer in the energy center system which is set forth in section III. However, the function set forth in section III are not always necessary depending on the type of the iron and steel works. It is natural that the system configuration with the same functions varies with the scale of the iron and steel works (number of blast furnaces and equipment configuration in the workshops of the plant). It should be noted that the following description is based on the scale of the average iron and steel works in Japan.

1. Graphic Panel

The graphic panel is respectively installed for the electric power system and the gas system. The important system which should be always monitored is graphically displayed on the graphic panel. The operating condition and abnormality are indicated with the lamps and indicators. The computer monitors the dynamic condition of the system and indicates the abnormality and cause of abnormality before the equipment falls in physical danger. The status of the system which is not so important is displayed on the cathode-ray tube when the operator

requests or the abnormality occurs.

2. Operator Desk

The operator desk consists of the indicator lamps, operation switches, data setting switches, cathode-ray tube, keyboard for the cathode-ray tube and interphone for communication. Usually, one operator desk is installed for one operator, 3 or 4 units in total.

Data transfer between the operator and the computer is performed through the operator desk. If the correct information (such as the working schedule for the converter) is unavailable in the energy center, the operator desks at the workshop are connected to the computer at the energy center.

The energy center handles a great deal of data which is transferred between the operator and the computer. The general-purpose input and output units such as the cathode-ray tube are employed and the special setting switches are provided for the data which requires frequent settings.

3. Communication Unit and Data Transfer Unit

In the iron and steel works, the average distance from the energy center to each workshop is 1 to 2 km. Some workshops need the operators and some workshops (control station) do not need the operators. Communication to the control station where the operator is working is done through the interphone, that to the control station where the operator is not working is done through the mobile wireless unit and the data communication between the operators of the energy center and the workshops are thus performed. The data (working schedule which is not automatically given from the input unit to the computer is informed to the computer through the operators of the energy center.

If the number of factors per workshop about which the data transfer is automatically performed, between the energy center and workshops is large, the analog or digital telemeter, tele-control unit, etc. are employed; however, according to the results in the past, the direct transfer method are used. Recently, many workshop of the iron and steel works employ the computers for control. The data transfer between the energy center and these computers is generally performed on the real-time system.

In the energy center system which has been examined, the quantity of information is few and the distance between the energy center and the plants is less than 2 km. The parallel DC transfer system which uses approximately sixteen special transmission lines and is based on the byte unit is employed.

4. Typewriter

The conventional systems have employed the special typewriter for preparation of the daily reports. In this case, approximately 3 to 10 tpyewriters are required. The energy center systems recently established employ the line printer instead of the special typewriter. In some cases, the typewriter is used to provide the commands to the operators. Its slow motion is a great fault. It is general to provide the commands and to record the results of commands with the hard copy function (copying on the line printer by the software is economical) between the cathode-ray tubes. The required number of the cathode-ray tubes is equal to the number of the operator desks.

5. Central Processing Unit and Memory

FACOM 270–20	1 set
Main memory (magnetic cores)	16 kwords

For the large-scale iron and steel works, it is desirable that the computer is provided with the floating-point arithmetic function.

6. Cargo Capacity Storage

Magnetic drum	128–255 kwords

7. Real-time Control Unit

Analog input	256 points
Pulse input	128 points
Digital input	284 bits
Interrupt input	48 points
Analog output	Several
Digital output	256 bits

V. SYSTEM CONFIGURATION (SOFTWARE)

The outstanding feature of the energy center is that the supplementation of the facilities and modification of their functions are always performed because the object of control is the large-scale iron and steel works. Accordingly, the software should be modified to meet expansion of the facilities and capacity. For this reason, the data file, logging sheet, printing format for the cathode-ray tube, etc. are designed in accordance with the table system so that these factors can be changed by the on-line system. For the outline of the software, refer to a separate volume of this collection of papers.[2]

VI. CONCLUSION

The above outline the computerized control system of the energy center. Since the functions of the energy center greatly differ with the type of the iron and steel works and are variable, the description is rather abstractive. We hope this will be helpful and useful to readers.

References:

(1) Yashima, Wada: Energy center equipment for Sakai Works, Yawata Iron & Steel Co., Fuji Journal 38, No. 10 (1965)

(2) Arakawa, Shirae: Energy center equipment for Yawata Works, Yawata Iron & Steel Co., Fuji Journal 41, No. 12 (1968)