“Steel EMS Package” Optimizing Energy Management at Steelworks

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ABSTRACT

With the installation of an “energy center” and the central management of various types of large quantities of energy at a steelworks, a comprehensive approach to energy savings, increased operational efficiency of labor saving and motive power equipment, and environmental management is being promoted.

Focusing on supply-demand forecasting and optimization, which is a basic function of an energy center, Fuji Electric has developed a “Steel EMS Package” for improving energy management and operational efficiency, which are complexly intertwined within a steelworks. This package forecasts the energy fluctuation for several hours in advance or makes daily or monthly forecasts, and optimally operates the energy production equipment so as to contribute to energy saving throughout the steelworks.

1. Introduction

In the steel industry, which accounts for 10% or more of the aggregate energy amount consumed in Japan, “energy saving measures” is regarded as the most important issue for resolving energy and environmental problems.

In steelworks, it is essential “to operate in the most efficient way to reduce total cost of the utilizing energy in order to work stably 24 hours a day, 365 days a year,” and “to monitor and control energy appropriately.” An “energy center” was established for the purpose of performing integrated management of various types and large amounts of energy and comprehensively controlling energy saving, labor-saving, rationalization, environmental management, etc.

In this energy center, which Fuji Electric has been building ahead of the world together with customers, “Steel EMS Package” that optimizes energy management was developed.

2. Energy Center

2.1 Purpose of energy center

The energy center has the following four purposes.

(1) Stable supply of energy

The energy required for production fluctuates greatly depending on the production state. As a result, it is necessary to constantly monitor fluctuating energy demand and control it appropriately.

(2) Energy saving

The important role is to keep a balance between supply and demand in the purchased energy (gas, oxygen, electric power etc.) and by-product energy (by-product gas, steam, electric power etc.), which are intertwined in a complicated way, reducing unnecessary energy through the most effective operation.

(3) Labor saving and rationalization

Integrated management of monitoring and operating energy facility and automated operation of energy systems are required.

(4) Environmental management

Recently, environmental problems have been becoming more serious and it is necessary for steelworks, where a large amount of energy is consumed, to address CO_2 reduction positively in ways such as introducing environmentally friendly facilities.

2.2 Basic function of energy center

Rotating the PDCA cycle of five functions (production and operation plan, results and facility monitoring, analysis and diagnosis, supply and demand forecast, and optimization) greatly helps the Energy Center to achieve its purposes as shown in Fig. 1.

(1) Production and operation plan

Draw up an energy allocation scheme that brings the best energy saving plan based on the production plan and operation plan of the facilities, while supplying energy stably.

(2) Results and facility monitoring

Operators check the operational condition and review energy allocation based on the differences between the production plan and results, and operation plan of the facility and results.

(3) Analysis and diagnosis

Grasp energy usage and generation amount per factory and product and review energy-saving further.

(4) Supply and demand forecast

Automatically judge the differences from the production plan and operation plan of the facilities based

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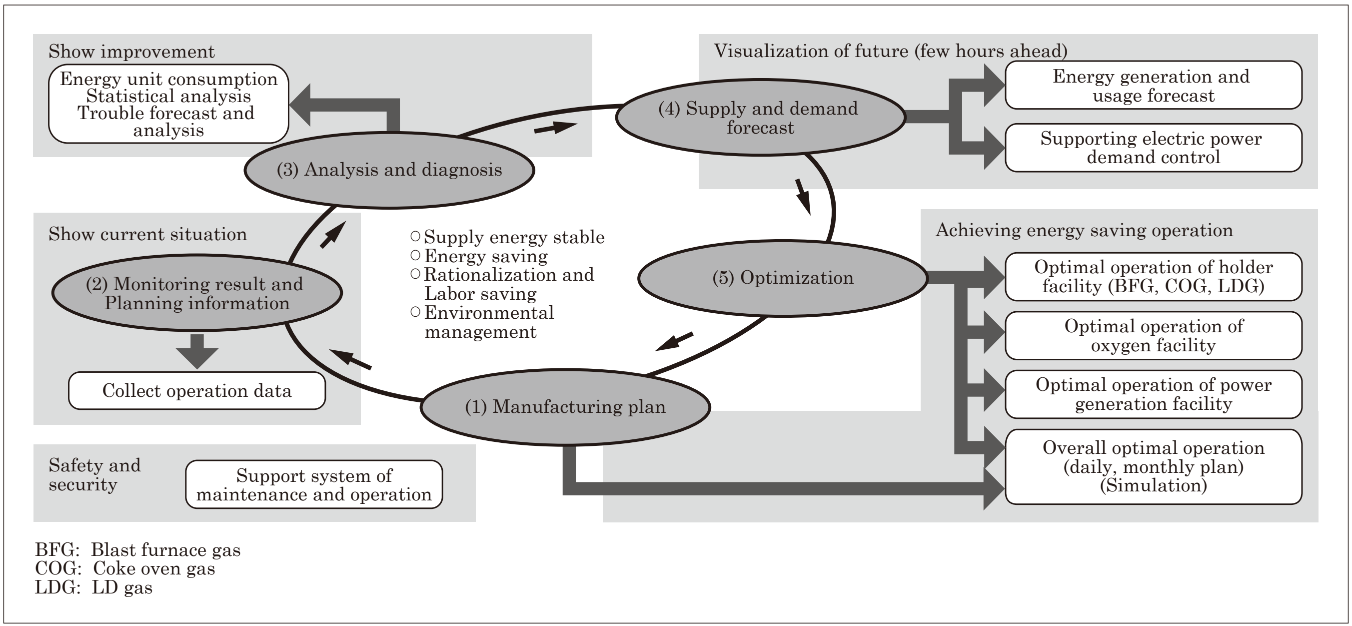

Fig.1 Basic function of Energy Center

on the results information, and forecast energy fluctuation daily, monthly, or several hours in advance by using the results of energy usage and generation amount per factory and product.

(5) Optimization

Draw up the optimal operation plan for energy production facilities based on forecast data of energy.

3. Steel EMS Package

The Energy Center has been built with a method that connects its basic functions one by one to meet customers' needs. However, the iron and Steel EMS Package strengthens further the function of "Supply and demand forecast" and "Optimization (Holder facility, oxygen facility, and power generation facility and whole plant)," which are the most important functions, and operates each function on the integrated EMS platform[1]. It is possible to build a system according to the customers' needs by installing only the required packages. It allows installing each function in an easier way than before and providing a more flexible and appropriate system (see Fig. 2).

The Steel EMS Package can further improve operational efficiency of the energy that is used in the intricately intertwined steelworks and reduce total energy cost to the utmost extent.

The integrated EMS platform was developed to focus on the energy supply chain of each field such as electric power, industry and retail distribution, not only iron and steel, to provide EMS functions that meet various needs on site promptly and at low price.

4. Visualization of Future via Supply and Demand Forecast

A supply and demand forecast is one of the important basic functions in the steel EMS. Energy fluctuation (by-product gas generation rate, load amount, electric power load, steam load etc.) is estimated based on the results data from the distributed control system (DCS) and production and operation plan data from the manufacturing execution system (MES).

Visualization of energy fluctuation enables operators to operate a system with appropriately anticipated behavior and in energy-saving manner.

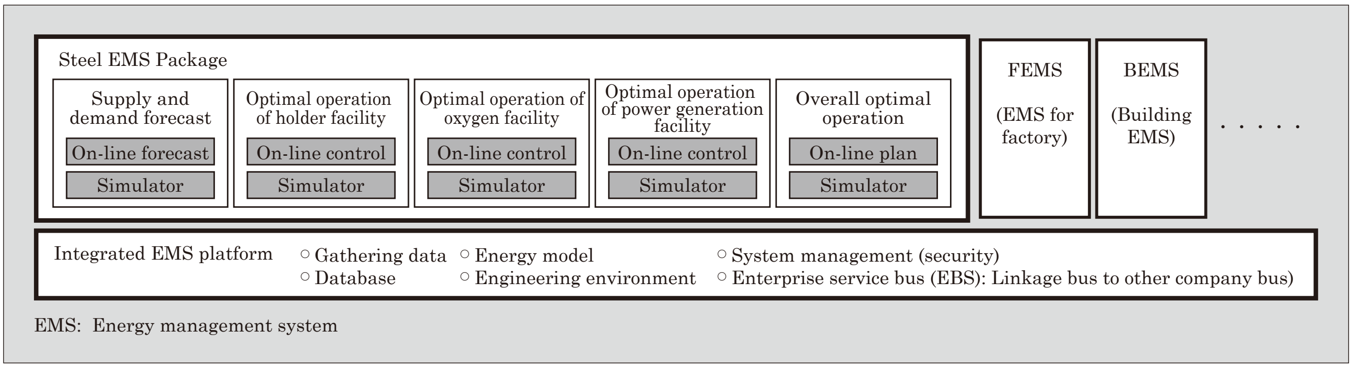

Fig.2 "Steel EMS package"

4.1 Forecast function

(1) Energy generation and usage forecast function

(a) Energy forecast from production and operation plan

When there is a difference between the operation state on site and production and operation plan, it is possible to obtain a highly accurate energy forecast value by correcting the plan automatically.

(b) Creation of energy consumption rate*[1]

Automatically create an energy consumption rate required for the forecast from results data.

(2) Electric power demand management support function

Operators monitor electrical power consumption of each factory within the steelworks, output an alarm if the value is about to exceed the contract value, and request each factory for production adjustment.

In addition, operators monitor the amount of received electricity from a power company and provide guidance for production adjustment of the factory according to the output adjustment and priority of the power generation facility. Operators make a request for production adjustment to the relevant factory according to the guidance.

4.2 Forecast method

(1) Forecast method based on operation plan

An energy supply and demand forecast per factory and type of energy is performed based on the operation plan of MES and energy consumption rate. In addition, the operation state of the site is compared with operation plan of MES, and a correction to the operation plan is made according to the difference.

(2) Forecast method based on production plan

Energy supply and demand forecast per product is performed based on the production plan of MES and energy consumption rate. In addition, the operation state of the site is compared with operation plan of MES, and a correction to the production plan is made according to the difference.

5. Achieving Energy Saving Operation via Optimization

Optimization is the most important basic function in the iron and Steel EMS Package. By applying optimization to steelworks, energy saving operation is realized. Energy cost of steelworks is minimized by using the particle swarm optimization (PSO) method[(2)], which is the latest metaheuristic optimization technology, based on the forecast data (data per factory and energy) obtained from supply and demand forecast.

The targets of optimal operation are holder facility, oxygen facility and power generation facility, which have particularly large energy saving effect in the steelworks, and in addition to these, optimal operation of the entire steelworks (daily, monthly plan) (see Fig. 3).

It is possible to automatically extract optimum operation patterns in operation facility using the PSO method and obtain the optimum solution when there is change in the operation method or when operation outside the scope of design, which is not feasible if created with logic, is conducted. The operation outside the scope of design is adopted when mathematical expressions are not available, when the formula becomes complicated, when the numerical formula changes depending on the conditions, and when verification is not yet performed.

5.1 Optimal operation of holder facility

In steelworks, by-product gas, which is generated in large quantities, is stored and used as energy source. Among by-product gas, blast furnace gas (BFG) that is generated from a blast furnace and coke over gas (COG) that is generated from a coke oven is used as fuel for power generation; and LD gas (LDG), which is generated from a LD is used as fuel for hot-blast stove and sintering furnace. Optimal operation improves gas recovery efficiency by specifying usage destination of each by-product gas and minimizing gas dissipation rate.

It is possible to achieve further energy saving because purchase fuel of a power plant can be reduced depending on the portion of increased gas recovery. From the effect trial calculation, a 90% reduction of the dissipation amount is expected.

(1) Optimal operation of COG, BFG holder

Making the optimal operation plan based on the occurrence forecast and usage forecast of COG or BFG, which is obtained from the forecast method based on the operation plan as described in Section 4.2 (1), the delivery amount is determined so that the dissipation amount is minimized.

It is possible to predict up to three hours ahead of the time at intervals of five minutes.

(2) Optimal operation of LDG holder

Making the optimal operation plan based on the LDG generation forecast and usage forecast, which is obtained from the forecast method based on the production plan as described in Section 4.2 (2), the delivery amount is determined so that fluctuation in dissipation amount and delivery amount is minimized. It is possible to predict up to three hours ahead of the time at intervals of one minute. Figure 4 shows a screen example of optimal operation for holder facilities.

5.2 Optimal operation of oxygen facility

In the oxygen facility, oxygen is taken out from

*1: Energy consumption rate: This value indicates energy efficiency. This represents the amount of energy, such as electricity and heat (fuel), required for unit production of the product (steel). It is generally used as an index to show the energy-saving state.

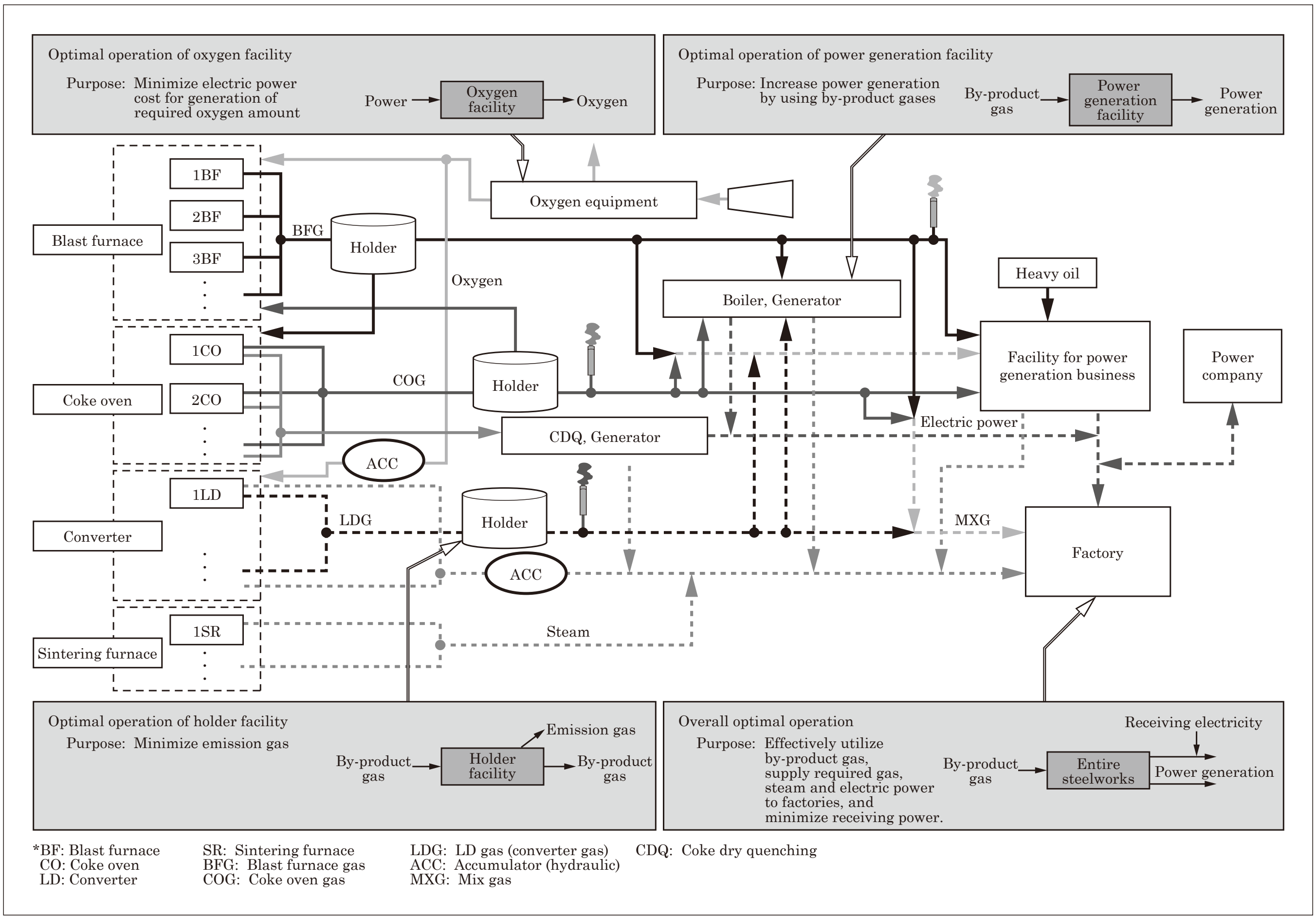

Fig.3 Energy saving optimal operation of steelworks

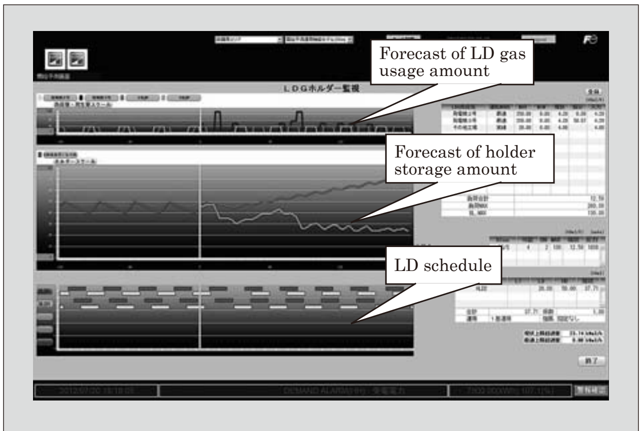

Fig.4 Screen example of optimal operation for holder facility

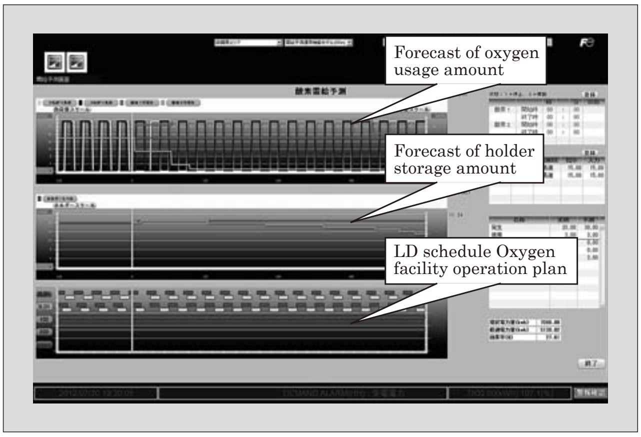

Fig.5 Screen example of optimal operation for oxygen facility

air, stored in the oxygen holder and then is sent to inside the steelworks as necessary. Optimal operation achieves energy saving by minimizing consumption power from the forecasted necessary oxygen amount. It is possible to predict up to eight hours ahead of the time at intervals of five minutes. Figure 5 shows screen example of optimal operation for oxygen facility

From a trial calculation of effect, 2.8% reduction (year) in energy consumption of oxygen facility is expected.

5.3 Optimal operation of power generation facility

In order to operate each unit of facility in steelworks, electric power is indispensable. Electric power is purchased from a power company; however, there are steelworks, where electric power is supplied from power generation facility using by-product gas in steelworks. With optimal operation, difference in efficiency of multiple units of power facilities is perceived, fuel for boiler and steam for turbine are distributed to ob-

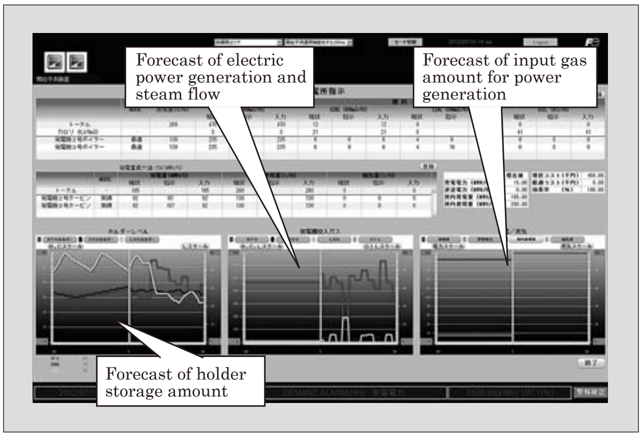

Fig.6 Screen example of optimal operation for power generation facility

tain the maximum electric power generation from by-product gas, achieving energy saving by minimizing the purchase of electric power. It is possible to predict up to three hours ahead of the time at intervals of five minutes. Figure 6 shows a screen example of optimal operation for power generation facility.

From a trial calculation of effect, a 2.0% (year) increase in electric power generation is expected, which leads to a reduction in the purchase of electric power generation.

5.4 Overall optimal operation (daily, monthly plan)

With optimal operation, energy saving is realized by minimizing daily running cost. Based on a generation and usage forecast of each type of energy, while meeting the energy demand required in the steelworks, the optimum allocation for three types of by-product gas, electricity, and steam for one day is drawn up in 30-minute intervals. In the same manner, by drawing up optimum allocation plan for one month, minimization of the monthly running cost is achieved. Optimization of operational balance of each unit of energy facility is also performed in order to minimize the emission amount of greenhouse gases.

In addition, a simulation environment for a case study of energy facility operation is implemented and it is possible to compare operation results when the current operation is continued with operation results based on forecast after optimization. The screen example in Fig. 7 shows the simulation result of optimum allocation from forecast of generation and usage of each type of energy in steelworks and gas input plan for power generation. From a trial calculation of effect, a 3.5% reduction (year) in electric power purchase cost is expected.

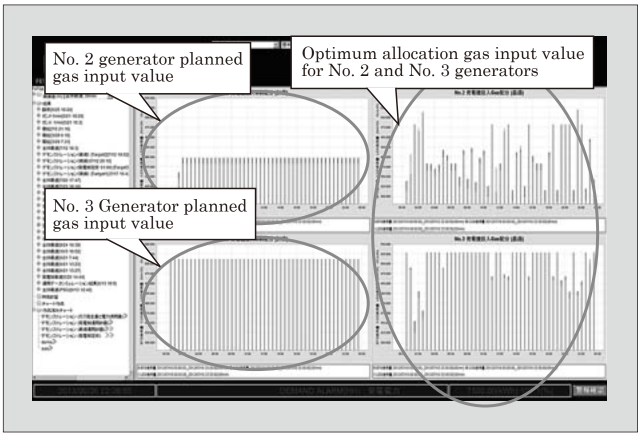

Fig.7 Example of simulation screen

6. Postscript

This paper described the "Steel EMS Package" to optimize energy management in steelworks. EMS makes it possible to achieve energy saving through optimization utilizing the long experience in operation of the Energy Center, state-of-the-art control technology and software technology. Fuji Electric will meet customers' expectation by forecasting the energy consumption amount, performing efficient energy operation without waste, and reducing energy cost and ultimately production cost.

Reference

(1) Horiguchi, H., et al. Integrated Energy Management System Platform. FUJI ELECTRIC REVIEW. 2011, vol.57, no4, p.146-151.

(2) Kennedy, J. and Eberhart, R. Particle Swarm Optimization, Proceedings of IEEE International Conference on Neural Networks, 1995, vol. IV, p.1942-1948.

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