The Development of Integrated Production Control System for Electric Arc Furnace Process

by

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Synopsis

In Osaka Steel Works, steel making processes located in two areas were integrated from the view point of the reduction in labor and intensive process operation. The characteristics of this new production control system are as follows.

1. The realization of full production control from manufacturing request to product shipping, administration of logistics, administration of records.
2. The introduction of open systems based on EWS and PC platforms considering future “end user computing”. Some new functions are also incorporated in this system. One is a production planning simulation system which applies the technique of mathematical programming and the other one is a raw materials combination system.

This total system has been operating normally since November 1995.

1. Introduction

The KANSAI STEEL DIVISION of SUMITOMO Metal Industries produces seamless steel tubes for drilling oil, power plants and heavy forgings. Raw materials used in the manufacturing plants are made in an electric arc furnace and supplied to the plants.

Recently we carried out a reform of the steel making process by installing new plants such as a 40-ton twin electric furnace.

In this report, we mainly introduce the process control system installed at the same time.

2. Reforming the Steel Making Plant

In the steel making process, the raw materials such as scrap iron are first mixed and then melted in an electric arc furnace. Secondly, each chemical element included in them is regulated in the refining section and sent to the casting section. Then, finally the steel material is produced.

This time, we succeeded in integrating processes located in two areas by introducing a 40-ton twin electric arc furnace and refining equipment.

The new process is shown in Fig. 1, and Table 1 shows the specification of the main equipment.
3. The System Configuration

Figure 2 shows the system configuration of this process computer system. We adopted the distribution system for the following two reasons.

One is that the steel making process is independent from other processes and the other is the reliability of the distribution system. We aimed for an open system architecture by mainly using EWS and the PC platforms considering the EUC (End User Computing) for the future.

This process control system realized the following five functions.

(1) to transfer the production planning information from the host computer
(2) the material tracking in the factory
(3) the process control
(4) gathering the production data
(5) the real time display of the results of analyzing the chemical elements
4. The Developed Technique

Table 2 shows the unique techniques developed and introduced in the computer system for this process.

4.1 Conveying Simulation System

Figure 3 shows the facility layout in the factory. There exist a large number of movement courses which convey melted steel according to the quality of the materials or the product shape. So competition for the carriage cranes or other facilities may occur, and there is the possibility that production efficiency will be reduced as a result.

<Example>

When melted steel is moved from the AOD facility to the ingot casting facility and another is moved from the LFV facility to the ingot casting facility, there is a simultaneous need for the No.1 crane and the ingot casting facility, so competition occurs. This situation creates the possibility that the total efficiency may decrease.

In order to solve this problem, we have developed and introduced a conveying simulation system. By means of this system, we can simulate the operation

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<td>The simulation method to check whether the production planning is adequate or not and to decide the final planning</td>
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<td>The installing calculation</td>
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<td>The regulation of element by using Artificial Intelligence</td>
<td>Automatically calculate the quantity of alloy installed into LFV by using Artificial Intelligence and to set it up to PLC</td>
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<td>AOD</td>
<td>The automatical blowing control by pattern</td>
<td>To predict carbon component value from the efficiency of decarburization and to decide the gas flow rate by using its value</td>
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<td>HCC</td>
<td>The position control of electromagnetic agitator</td>
<td>To control position of electromagnetic agitator for making the center of billet optimum state</td>
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<td>To calculate the gas cutter position of billet which the yield of last steel in casting achieves maximum value</td>
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plan for one day and can find falls in the distribution efficiency due to facility competition in advance and can judge the best conveying method in order to reduce the influence that the various competitions have on the overall operation.

**Figure 4** shows a screen example indicating a simulation result. In this figure the red parts mean that it is impossible to convey for the reason that the next manufacturing process is being used. If there are many red parts, we need to review the operation plan or change the priority given to the facilities in competition.

This system contributes to the adequacy of the operation plan in the drafting of the operation plan.
4.2 Raw Materials Combination Calculation System

Raw materials thrown into the electric furnace are mainly classified in the following three types:
(1) scrap which occurs in this works
(2) scrap which is purchased from outside
(3) alloy which is purchased from outside
The relation of their cost is generally (1) < (2) < (3).
When these materials are thrown into the electric furnace and mixed, we need to adequately mix in accordance with the quality of the materials and restrain the cost to the minimum.

In this system, we customized general spreadsheet software for simple calculations such as screens and ingredient calculation by materials combination on a PC (Fig. 5). We applied the mathematics, software XPRESS (Dash corp.) for the most suitable solution for materials combination on an EWS.

By the introduction of this system, we have contributed to the reduction of materials cost and to the shortening of combination calculation times.

4.3 Automatic Refining System in AOD

AOD is a facility which refines steel melted in the electric furnace and reduces its carbon with Argon and Oxygen. During the refining, we need to precisely set up the flow quantity of Argon and Oxygen according to the progress of the refining.

In this control system, the refining manufacturing process is divided into stages based on the Carbon element and the flow quantity of Argon and Oxygen is decided in every stage.

The details are as follows:

[Preparation]
(1) Grouping the quality of materials and resolving the refining manufacturing process into some stages according to the carbon element in every group.
(2) Deciding the target value of Carbon element, Oxygen efficiency, Argon setting flow quantity and Oxygen setting flow quantity for every stage (Fig. 6).

[Operation]
(1) Updating the stage by the carbon ingredient value which is predicted from the Oxygen efficiency and the actual value of Oxygen or by the carbon element on the basis of the latest analysis results.
(2) Deciding the flow quantity of Argon and Oxy-

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Fig. 5 A screen example of raw materials combination calculation

Fig. 6 HCC crater-end electromagnetic stirrer position control system
gen and setting it up in the instrumentation device. By means of this system, we have the possibility to achieve automatic refining in AOD (the flow quantity control of Argon and Oxygen).

4.4 HCC Crater-End Electromagnetic Stirrer Position Control System

In the HCC type, the electromagnetic stirrer unit is effective in producing uniform solidification of the material.

The system estimates the surface temperature and the crater end position of billets in casting by using a heat conduction equation based on the biography heat calculation model and controls the electromagnetic stirrer position.

Figure 6 shows the constitution of the total system. This system distributes functions by arranging the PC for the operation results data handling and EWS for the highly precise/speed dynamic operation for the biography heat calculation handling.

By the application of this system, the internal billet quality can be stabilized.

5. Conclusions

On the occasion of the development of Integrated Production Control System for Electric Arc Furnace Process, we aimed for a distributed, open system and introduced some new techniques. As a result, we could construct a system which adhered closely to the field requirements. This system has been operating since November 1995 and contributing to the successful operation of the factory.

Reference


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