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.

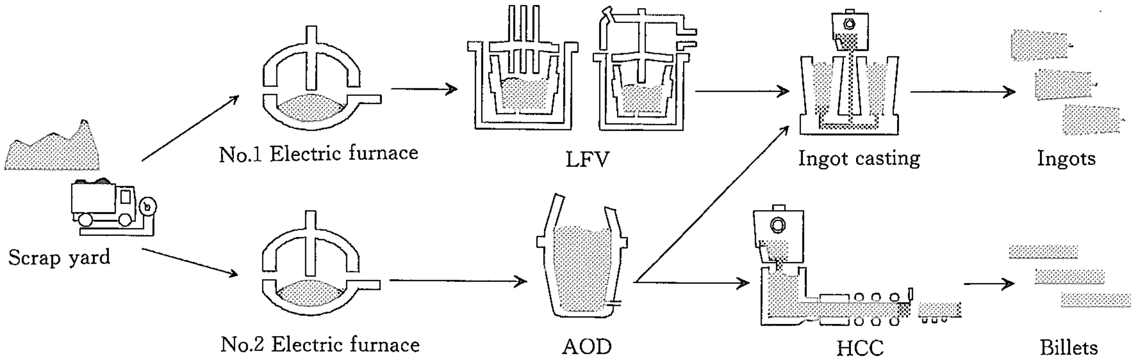
In this report, we mainly introduce the process control system installed at the same time.

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.



where LFV : Ladle Furnace and Vacuum treatment
AOD : Argon and Oxygen Dcarburization
HCC : Horizontal Continuous Casting

Fig. 1 New process flow

Table 1 Specification of main equipment

Equipment	New construction: N Reconstruction: R	Item	Specification
EF	N	Capacity	40-ton
		Power	Direct current arc
		Type	Twin-shell type
LFV	R	Capacity	40-ton
		Application	Refining for carbon steel
		Processing time	90 min
AOD	N	Capacity	40-ton
		Application	Refining for stainless steel
		Processing time	Max 120 min
HCC	R	Application	Casting for stainless steel
		Billet size	265ϕ-304ϕ
		Drawing type	Pushing back
		Withdrawal time	120 min
		Withdrawal speed	Max 0.96 m/min
Ingot-casting	N	Application	Casting into mold
		Type	Casting mold in bogie
		Layout	7 bogies in 3 lines

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

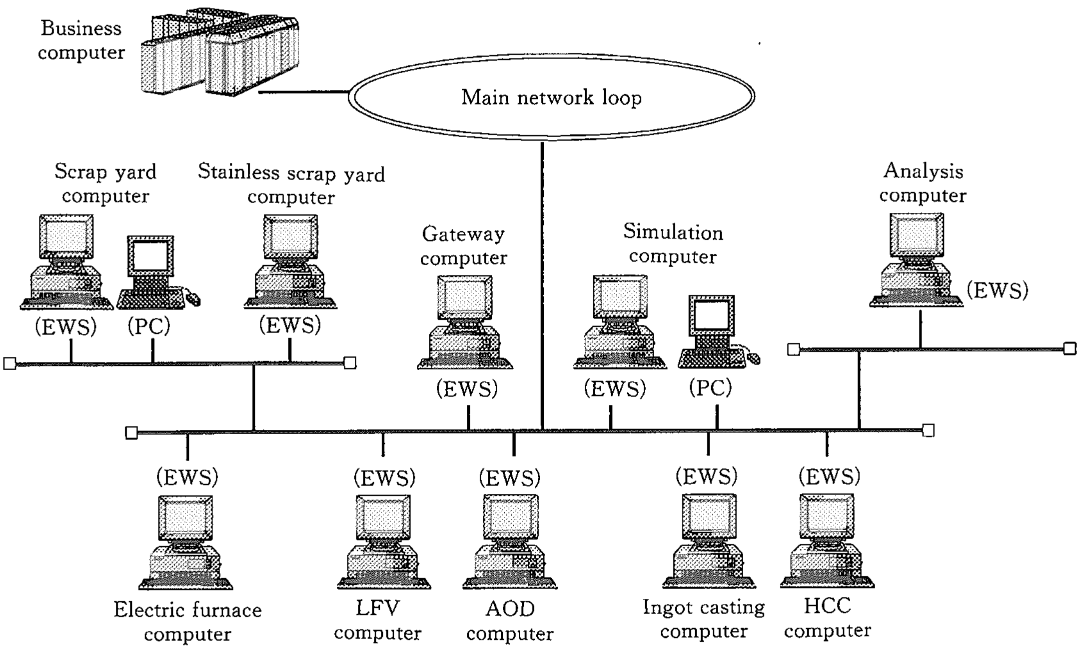


Fig. 2 Computer system configuration

4. The Developed Technique

Table 2 shows the unique techniques developed and introduced in 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 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 the from 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

Table 2 The unique developed technique

Equipment	Introduced technique	Content
	Physical distribution simulation	The simulation method to check whether the production planning is adequate or not and to decide the final planning
Material yard	The installing calculation	The calculation to decide to minimize the total cost of the scrap iron installed into electric furnace
LFV	The regulation of element by using Artificial Intelligence	Automatically to calculate the quantity of alloy installed into LFV by using Artificial Intelligence and to set it up to PLC
AOD	The automatical blowing control by pattern	To predict carbon component value from the efficiency of decarburization and to decide the gas flow rate by using its value
HCC	The position control of electro-magnetic agitator	To control position of electromagnetic agitator for making the center of billet optimum state
	The cutting control	To control the position of gas cutter
	The combination calculation	To calculate the gas cutter position of billet which the yield of last steel in casting achieves maximum value

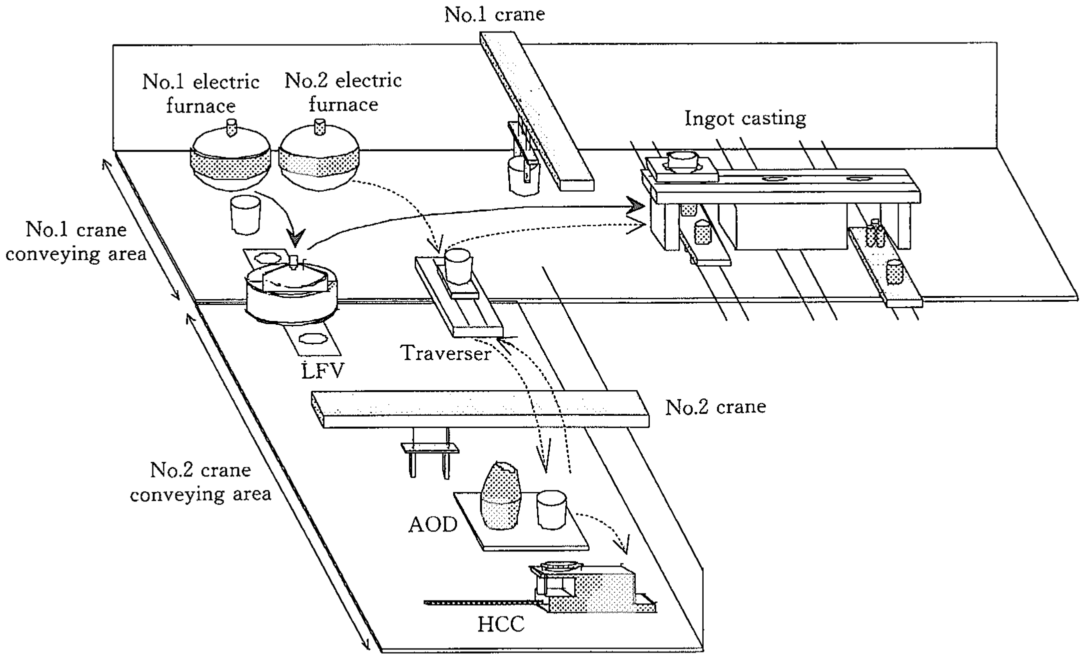


Fig. 3 Facility layout

Table 3 Example of automatic refining in AOD

Group	A								
Stage		1	2	3	4	5	6	7	8
Target of carbon element	%	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.01
Oxygen efficiency	%	80	70	70	70	60	50	30	5
Argon setting flow quantity	Nm³/H	480	480	600	800	1 200	1 600	1 600	1 600
Actual quantity of Argon	Nm³	88	16	20	30	40			
Oxygen setting flow quantity	Nm³/H	1 920	1 920	1 800	1 600	1 200	800	533	400
Necessary quantity of Oxygen	Nm³	353	63	63	73	88			
Actual quantity of Oxygen	Nm³	353	64	63	73	40			

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.

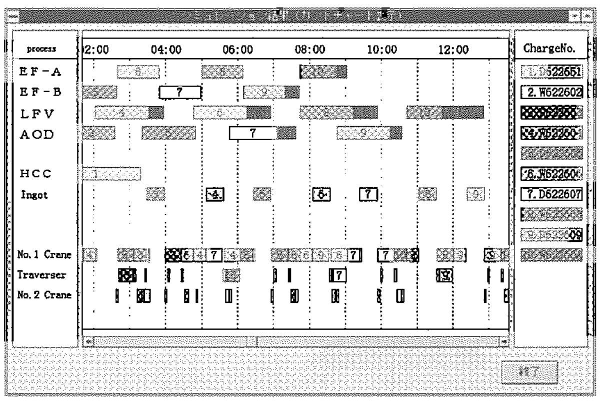


Fig. 4 A screen example indicating a simulation result

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.

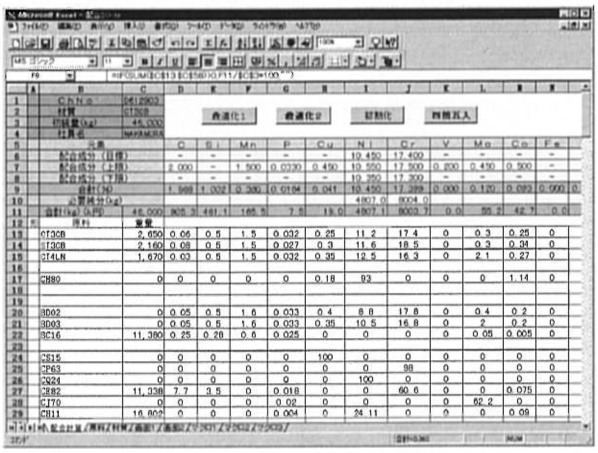


Fig. 5 A screen example of raw materials combination calculation

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-

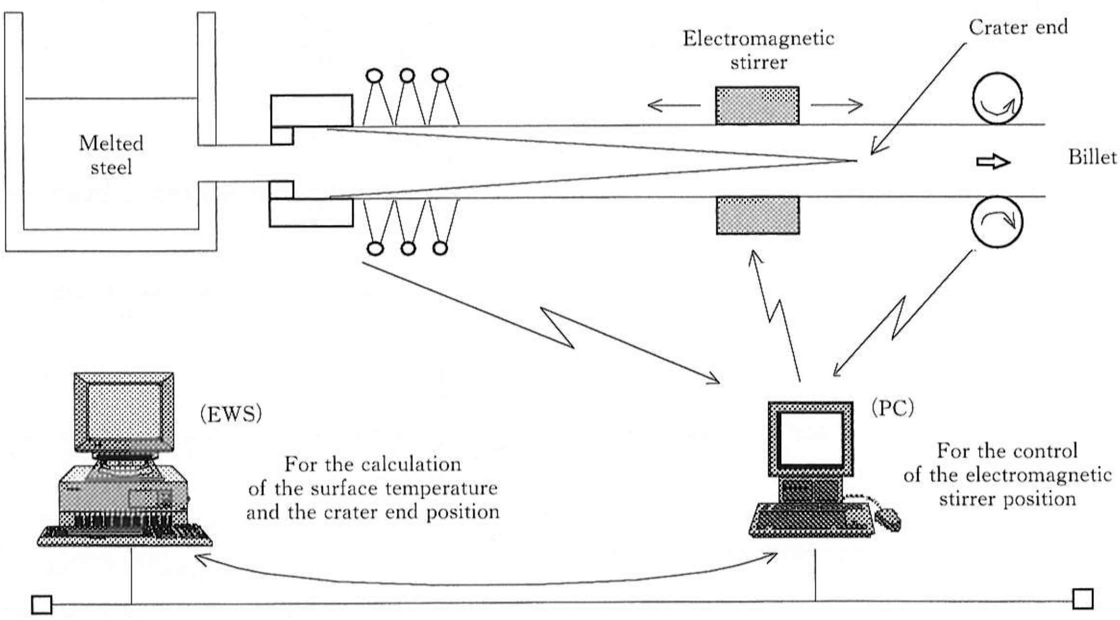


Fig. 6 HCC crater-end electromagnetic stirrer position control system

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.

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Reference

1) O. Sugiyama, K. Watsuji, and M. Seike : NUA(NEC User Association) February 1997, p.353