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Recent Advances and Future Prospects of Refining Technology

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Abstract:

To meet the increasingly sophisticated performance requirements and diversifying needs for steel products, Nippon Steel's refining technology has made remarkable progress on the basis of the BF-BOF process in parallel with the revolutionary development of continuous casting technology. In the 1980s, the hot metal pretreatment process, BOF top-and-bottom blowing process and high-performance secondary refining process were developed and put to practice in succession. The high-grade steel mass production system established by dividing the refining functions heretofore performed largely in the BOF is the vital technology for Nippon Steel to meet customer needs and preserve its cost and quality competitiveness. The present paper describes recent advances in refining technology at Nippon Steel from the viewpoint of the division of refining functions, and discusses the future outlook refining technology in responding to the harsh environment surrounding the steel industry.

1. Introduction

The present refining technology of Nippon Steel originated in Japan's first oxygen top-blown converters (LD converters) introduced at Yawata Works in 1957. Since then, Nippon Steel's refining technology has made remarkable progress in parallel with the advancement of the continuous casting process in response to the industrial needs for steel quality sophistication and product diversification. In the 1980s, in particular, the steel refining functions came to be subdivided through the introduction of hot metal pretreatment furnaces and high-performance secondary refining furnaces. The converter itself is now complete as a combined decarburizing furnace with extremely high productivity, and is the backbone of the process technology that supports the company's cost and quality competitiveness.

This article reviews the recent advances of refining technology at Nippon Steel, centering on the combined-blown converter steelmaking process, describes recent changes in the environment surrounding the steel industry, and touches on the future prospects of refining technology.

2. Recent Advances of Refining Technology at Nippon Steel

2.1 Changes in refining technology

Table 1 shows the transition of refining technology at Nippon Steel. The whole period of transition may be divided into the following three periods:

First period: From 1957 to 1970 when the LD converter process was introduced and developed.

Second period: From 1970 to 1980 when the vacuum degassing process was spread and the LD converter process was innovated (for combined blowing).

Third period: From 1980 to date when the refining function came to be subdivided through the introduction of hot metal pretreatment, thereby to bring the refining technology to maturity.

In the first period during which crude steel production rapid-

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Table 1 Transition of steel refining technology after introduction of Japan's first oxygen top-blown converters (LD converters) at Nippon Steel

Year		Change in steel refining technology
	1955	
		Introduction of Japan's first LD converter steelmaking process (Yawata, former Yawata Steel)
		Introduction of Japan's first DH process (25-ton test equipment) (Yawata, former Yawata Steel)
	1960	
		Introduction of DH process (75-ton equipment) at converter plant (Yawata, former Yawata Steel)
First period		Introduction of shaking ladle hot metal desulphurizing process (Yawata, former Yawata Steel)
		Introduction of Japan's first RH process (Hirohata, former Fuji Steel)
	1965	Development of KR desulphurizing equipment (Hirohata, former Fuji Steel)
		Converter static control technology ; Introduction of continuous casting technology (Muroran, former Fuji Steel)
	1970	Inauguration of Nippon Steel (Merger of Yawata and Fuji) <Start of rise in continuous casting ratio>
		Torpedo car desulphurizing technology (Nagoya and Sakai)
		RH-OB process (Muroran) <Startup of steelmaking plant with total volume continuous casting (Oita)>
		Converter sublance dynamic control technology
		LF process (Yawata)
Second period	1975	RH-OB-FD process
		RH light treatment technology (Oita)
		Combination-blown converter steelmaking process (LD-OB process) (Yawata and Oita)
		Slag minimum process (SMP) (Muroran)
	1980	Total RH treatment-constant turndown operation technology (Oita)
		Ladle powder injection hot metal desulphurizing process (KIP) (Kimitsu)
		High-volume hot metal pretreatment process (torpedo car dephosphorizing process) (Kimitsu)
		LD-CB process (Sakai)
		Vacuum powder injection process (V-KIP) (Kimitsu) and development of LD-PB process (Nagoya)
	1985	RH-injection process (Oita) and RH-PB process (Nagoya)
Third period		High-volume hot metal pretreatment process (ladle dephosphorizing process) (Oita)
		High-volume hot metal pretreatment process (torpedo car dephosphorizing process) (Yawata)
		High-volume hot metal pretreatment process (converter dephosphorizing process) (Nagoya)
	1990	
		Converter scrap melting process (Hirohata)

ly grew, large converters were installed, old plants were replaced with fewer latest-type plants, the refining processes were innovated, and the crude steel productivity was drastically increased. Steady progress was witnessed in such off-converter refining processes directly linked to quality sophistication as the DH and RH vacuum degassing processes and the hot metal desulphurizing process. Their application, however, was still confined to a limited number of steel grades such as specialty steels and some general-purpose high-grade steels.

When crude steel production was stabilized at the level of 100 million tons in the second period, the market called for steels of higher quality and functionality. Aggressive measures were taken to raise the production yield from the point of view of resources and energy savings. The rapid progress of continuous casting for the mass production of sheet steel had a heavy impact on the upstream steelmaking and refining process. In the upstream process, the requirement to stably supply molten steel to the downstream process (the need for simultaneous chemistry and temperature hitting accuracy at each turndown) had the effect of improving the refining control technology. Likewise, the requirement to ensure acceptable molten steel quality for smooth continuous casting operation (need for raising the steel cleanliness though such advanced refining practices as ladle injection and vacuum degassing) further enhanced stability in the operation of continuous casters that has a crucial effect on the end product quality. Incidentally, it was in the refining processes that the on-time concept took its root.

The steelmaking plant at Oita Works went into operation on the basis of total slab continuous casting in 1972. This plant also adopted a total RH treatment system with light RH degassing treatment from the standpoint of on-time process takeover, and achieved excellent results in the control of molten steel temperature and compostion with narrow tolerances, improvement of alloy yield, and buffer between the converter and caster. The RH-OB process developed at Muroran and Nagoya was positively employed to secure a constant turndown carbon in the converter operation. These mass vacuum treatment systems greatly contributed to the stabilization of continuous casting and assurance of quality, in addition to the improvement of converter productivity, and to the rapid spread of continuous casting.

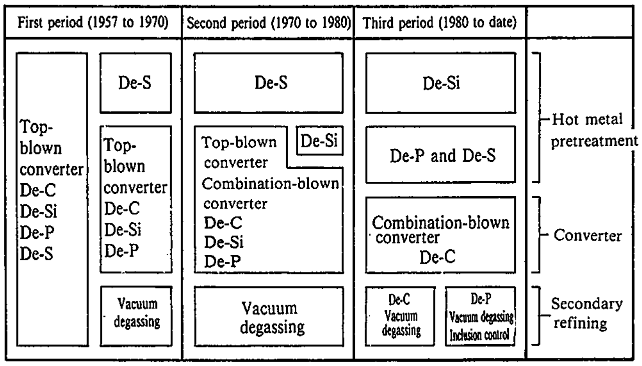
The 1977 introduction of Q-BOP process by Kawasaki Steel prompted all other steelmakers to switch from top-blown converters to combination-blown converters. Nippon Steel conducted combination-blown converter development tests at Yawata No. 5 steelmaking plant from 1977 to 1979, and installed in 1980 a 350-ton converter as the first commercial LD-OB (agitation by oxygen bottom blowing) process unit at Yawata No. 3 steelmaking plant. Since then, the LD-OB process has worked as basic refining technology together with the LD-CB (LD-CO_2 bottom bubbling) process.

In the third period in the 1980s, the combination-blown converter processes were applied throughout the company to achieve a sharp improvement in cost competitiveness and to meet the increasing stringency of steel quality requirements. The hot metal pretreatment and secondary refining functions were further enhanced, and the refining function was more finely divided. A typical example is the hot metal pretreatment process developed at Kimitsu Works, commercialized in 1982, and designated the Optimizing Refining Process (ORP). The ORP process has a quality process capability to manufacture superhigh-purity and high-cleanliness steels for offshore structures and hydrogen-induced cracking resistant pipe line. It provides a sizable refining cost saving when combined with intense bottom gas-induced bath agitation. It later won an "Okochi Memorial Production Prize".

Optimizing the combination of hot metal pretreatment (desiliconizing, dephosphorizing and desulphurizing) and slagless converter blowing according to the specific conditions of each works, the ORP process was successively introduced at Oita, Yawata and Nagoya to cover the entire steel production there. It is a basic technology to support the cost competitiveness of each works.

In the field of secondary refining, various multifunctional secondary refining furnaces were developed to combine vacuum degassing with powder injection. A vacuum powder injection process (V-KIP) was commercialized at Kimitsu in 1984, while an RH-Injection process was practically applied at Oita in 1985. Further, an RH-PB (RH-powder blowing) process was developed at Nagoya. These multifunctional refining furnaces combined vacuum degassing and powder injection into one operation, alleviated the thermal load of converters, and made it possible to manufacture ultralow-sulfur steel with a sulfur content of less than 10 ppm.

The progress in the functional division of refining processes are schematically illustrated in **Fig. 1**[1]. As shown, the refining technology has progressed mainly through the division of refining functions ultimately into the present process structure consisting of hot metal pretreatment, top-and-bottom-blown converter steelmaking and secondary refining.



De-C: Decarburizing De-P: Dephosphorizing
De-Si: Desiliconizing De-S: Desulphurizing

Fig. 1 Progress in the division of refining function at Nippon Steel

2.2 Advances in combination-blown converter steelmaking technology

The combination-blown converter process is characteristic in that bottom blowing of about 10% of oxygen gives approximately the same benefit as does the Q-BOP process that bottom blows all the oxygen. As shown in **Fig. 2**, the oxygen content of steel in the low-carbon region at the end of refining for the combination-blown converter process (LD-OB process) is near the lower limit for the conventional top-blown converter process (LD process) and is practically the same as for the bottom-blown converter process (Q-BOP process)[2]. Intense agitation by bottom blowing reduced the steel oxygen content and slag iron oxide (T.Fe) concentration, further homogenized the molten steel, and thus drastically improved the molten steel yield, turndown manganese, refractories consumption and other cost parameters. Turndown carbon was successfully lowered without bringing about peroxidation, thus, facilitating the manufacture of ultralow-carbon steel.

Nippon Steel developed three original combination-blown converter steelmaking processes discriminated by the bottom tuyere construction, gas type, and gas flow rate, as shown in **Table 2**.

With the LD-OB process[3-5], a large amount of oxygen is blown through the inner pipe of the double-pipe tuyere, and the cooling liquefied petroleum gas (LPG) is passed through the annular space between the two pipes. The bath can be intensely stirred by oxygen, an indispensable gas for decarburizing, so that the highest possible stirring force can be obtained. After its effectiveness was confirmed at Yawata in 1980 as already described, the LD-OB process was installed at Yawata, Nagoya, Kimitsu, and Oita to best exploit its features in the mass production of low-carbon steel.

Production of chromium stainless steel requires a large heat input and intense bath agitation. To meet these requirements, the LD-OB process at Yawata No. 1 steelmaking plant is provided with an additional function of kerosene heating.

The LD-CB process[6] injects carbon dioxide (CO_2) through

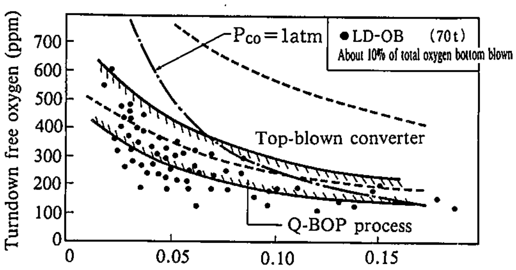


Fig. 2 Relation between turndown free oxygen and turndown carbon in top-blown, bottom-blown, and combination-blown converter

Table 2 Outline of combination-blown processes at Nippon Steel

Process	Bottom tuyere construction	Bottom gas type	Bottom gas flow rate (Nm^3/t/min)
LD-OB	Double-pipe tuyere	O_2, Ar, CO_2, N_2, LPG	0.10 to 0.60
LD-CB	Small-diameter pipe assembly plug	CO_2, N_2, (O_2)	0.01 to 0.10
LD-PB	Double-pipe tuyere	O_2, Ar, CO_2, N_2, LPG	0.015 to 0.12

a bottom plug or an assembly of small-diameter stainless steel pipes and intensely stirs the bath. The wear of the plug is prevented by this nozzle construction and the cooling effect of CO_2. The bottom gas flow rate cannot be made as high as in the LD-OB process, but can be changed over a wide range. This characteristic is particularly benefitial in dephosphorizing that is indispensable during the catch carbon period of blowing high-carbon steel. The LD-CB process was put to test operation at Sakai in 1980, brought into commercial operation at Sakai and Hirohata in 1982, and then was introduced at Yawata (No. 1 steelmaking plant), Muroran and Kimitsu (No. 1 steelmaking plant), where there were strong needs for medium-carbon steel production. Its low equipment cost and high operability have attracted many inquiries from abroad. At present, 25 LD-CB converters are operating in Japan and abroad, including those built under technology export.

The LD-PB process[7] injects carbon dioxide (CO_2) and finely ground lime ($CaCO_3$) through a single pipe. The $CaCO_3$ mixing ratio can be changed to adjust the amount of CO_2 generated by thermal decomposition. Fine CO_2 bubbles accelerate the dehydrogenizing reaction and facilitate the production of low-hydrogen steel. In 1984, the LD-PB process was started up at Nagoya where there was an urgent need for low-hydrogen steel.

Fig. 3 shows the change in the application ratio of the combination-blown converter processes at Nippon Steel. This ratio rapidly grew in the early 1980s, because Nippon Steel early recognized the benefit of combination blowing and aggressively worked on the commercialization of combination-blown converter processes.

2.3 Division of refining functions

2.3.1 Development of hot metal pretreatment technology

Hot metal pretreatment technology started with hot metal desulphurizing for specialty steels. Then, following the introduction in 1982 of a total desiliconizing-dephosphorizing (simultaneous desulphurizing) process at Kimitsu, it made rapid progress, and is now a principal refining process of Nippon Steel. Each works has adopted an optimum hot metal pretreatment system to suit its existing equipment conditions, layout, and other factors.

(1) Torpedo car system

A hot metal pretreatment process that uses the torpedo car (TPC) as a reactor was commercialized at Kimitsu in 1982 and at Yawata in 1988[8-11]. Kimitsu's example is shown in **Fig. 4**. It basically consists of casthouse desiliconizing and torpedo car dephosphorizing and desulphurizing with lime-based flux. For ultralow-sulfur steel, desulphurizing with burnt lime precedes dephosphorizing. In the dephosphorizing step, the weight ratio of CaO in the flux to oxygen in the oxidizer (CaO/O ratio) is raised, the oxygen potential is lowered, basicity is raised, desulphurizing is simultaneously performed, and the manganese yield is improved. Iron oxide is used mainly as oxidizer, and oxygen is additionally used to prevent the hot metal temperature from dropping during the dephosphorizing treatment. The oxygen addition is an effective means of improving the thermal surplus.

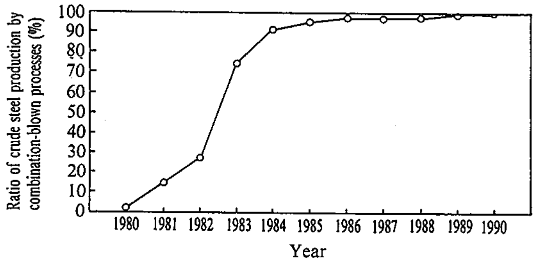


Fig. 3 Change in ratio of crude steel production by combination-blown processes at Nippon Steel

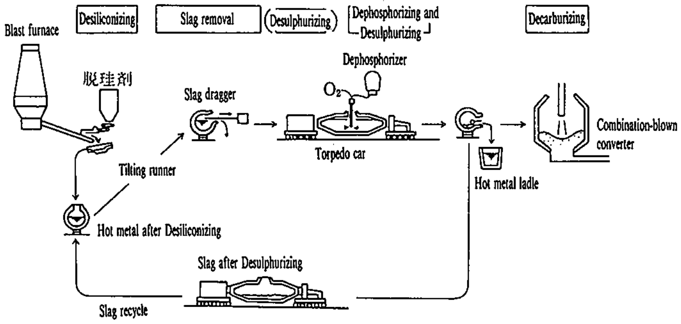
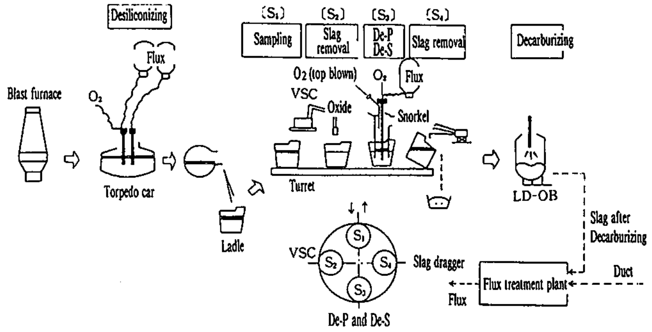


Fig. 4 Example of torpedo car hot metal pretreatment process (Kimitsu, Nippon Steel)



VSC: Vacuum Slag Cleaner, De-P: Dephosphorizing, De-S: Desulphurizing

Fig. 5 Example of ladle hot metal pretreatment process (Oita, Nippon Steel)

(2) Ladle system

Oita commercialized a hot metal pretreatment process comprising torpedo car desiliconizing and ladle dephosphorizing and desulphurizing in 1986[12,13]. **Fig. 5** shows the flow of the process. A hot metal ladle with good mixing performance is used as a reactor to accommodate two converters with one hot metal pretreatment station, and an immersion tank is adopted to prevent the spill of hot metal and slag during the treatment. These measures provide high-speed dephosphorizing and allow the single station to pretreat hot metal at a rate of about 500,000 tons per month. As in the torpedo car system, dephosphorizing is performed together with desulphurizing by using a CaO flux of high CaO/O ratio. Oxygen sources are iron oxide and oxygen injected together with the flux through the immersion lance and top-charged iron oxide. Oxygen is also blown through the top lance for post combustion.

(3) Converter system

Nagoya modified the aforementioned LD-PB converter into a hot metal pretreatment converter and brought it into operation in 1989[14,15]. The flow of the process is shown in **Fig. 6**. The converter can prevent slopping and spitting, and can blow a large amount of oxygen at high speed on the strengh of its large volume. The intense bottom stirring equipment of the LD-PB process can be utilized also to complete the dephosphorizing in a short time of about 10 min. The top blowing of oxygen and top charging of iron oxide allow the hot metal to be dephosphorized with a

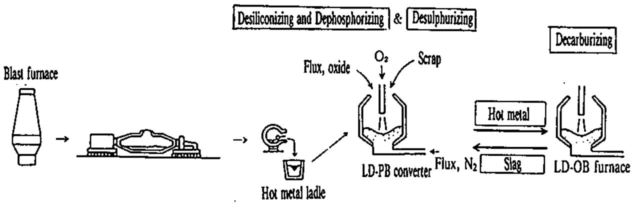


Fig. 6 Example of converter hot metal pretreatment process (Nagoya, Nippon Steel)

low CaO/O ratio, high oxidizing power, and low basicity. In other words, the hot metal can be desiliconized and dephosphorized in the same reactor vessel without prior desiliconizing. The decarburizing reaction heat generated when the oxygen feed rate is increased is utilized as a heat source for scrap melting in the converter.

2.3.2 Development of secondary refining technology

(1) Secondary refining technology at Nippon Steel

The functions required of secondary refining cover a wide spectrum, including impurities removal, inclusion shape control, and composition and temperature adjustment. **Table 3** lists the refining functions of secondary refining units.

(2) Establishment of multifunctional secondary refining technology

With the increasing sophistication of steel quality and severity of quality requirement as well as the tightening coordination with continuous casting in the 1980s, the converter steelmaking process came to be functionally divided into hot metal pretreatment, combination blowing, and secondary refining. Every steelmaking plant of each steel company was now equipped with two or more secondary refining units. These developments permitted steelmaking plants to select and combine the most economical processes to suit their respective product lines. In the manufacture of steel for oil and gas linepipe, a typical high-purity and high-cleanliness steel, Nippon Steel at first combined the operations of powder injection desulphurizing unit (ladle) and the vacuum degasser in the secondary refining stage, as shown in **Fig. 7(a)**. This system, however, prolonged the refining time and worsened the temperature drop, increasing the converter load and decreasing productivity. This problem was solved by formulating multifunctional secondary refining technology under which the powder injection function is incorporated in the vacuum degasser. This technology can perform powder injection for desulphurizing simultaneously with degassing and composition adjustment as shown in **Fig. 7(b)**, and shorten the secondary refining time by a maximum of two-thirds. As a result of the reduction in time and temperature losses, high-grade steels now can be mass produced with wide cost savings. Examples of multifunctional secondary refining furnaces are shown in **Figs. 8** to **10**[16-20)].

Besides the multifunctional secondary refining technology discussed above, technology for making ultralow-carbon steel, the original purpose of vacuum degassing, is being developed in earnest, which will be described in detail in a separate article.

2.3.3 Benefits of dividing refining functions

(1) Improvement in converter blowing technology

In a refining process functionally divided into hot metal pretreatment, combination-blown converter steelmaking, and secondary refining, the converter performs slagless blowing centering on decarburizing, and its function of composition and temperature adjustment is effectively backed up by secondary refining. This brought about a marked improvement in the operability of the converter. **Table 4** shows an example. As is clearly seen from the table, the LD-OB process and hot metal pretreatment process drastically raised the operating performance,

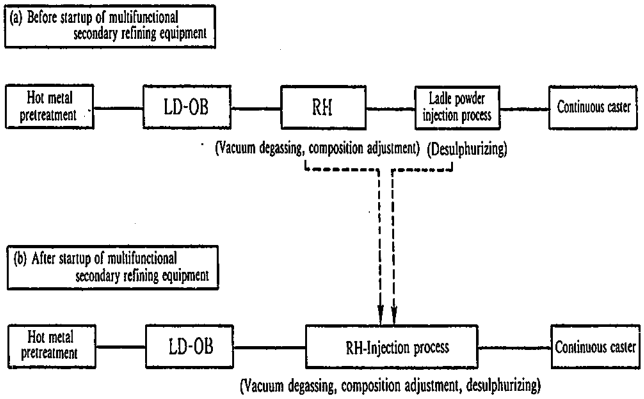
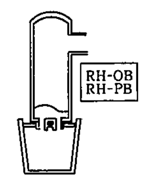
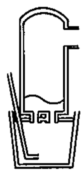
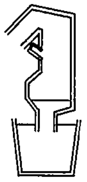
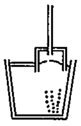
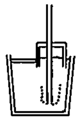
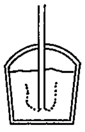
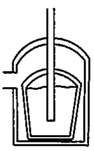
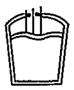


Fig. 7 Change in ultralow-sulfur steelmaking process with multifunctional secondary refining equipment (Oita)[19)]

Table 3 Refining functions of secondary refining equipment at Nippon Steel

		RH			DH	CAS		KIP		LF
		RH-OB	RH-PB	RH-INJ		CAS-OB	CAS-OB-PI	KIP (PI)	V-KIP	
Equipment outline		 RH-OB RH-PB								
Function	Deoxidizing	○	○	○	○	○	○		○	○
	Decarburizing	○	○	○	○				○	
	Dehydrogenizing	○	○	○	○				○	
	Desulphurizing		○	○			○	○	○	○
	Heating	○	○	○		○	○			○
	Composition adjustment	○	○	○	○	○	○	○	○	○
	Clean steel	○	○	○	○	○	○	○	○	○

productivity, and cost index of the converter. **Fig. 11** shows the effect of slagless refining on the yield of manganese in the molten steel at the blowing end point. Hot metal dephosphorizing sharply reduced the amount of slag formed in the converter and provided a high manganese yield in excess of 60%. By adding manganese ore in an effective exploitation of this benefit, the turndown manganese concentration can be raised and the consumption of ferromanganese can be reduced.

(2) Improvement in high-purity steelmaking technology

Figs. 12 and **13** show the transition of high-purity steelmaking technology marked at Nippon Steel for respective impurity elements. The ultimate level of each element was improved through the introduction of hot metal pretreatment and positive employment of secondary refining. The most recent figures are [C] = 8 ppm, [P] = 25 ppm, [S] = 3 ppm, [N] = 15 ppm, [H] = 1 ppm, [O] = 5 ppm. Now that the high-purity steelmaking technology has made a significant progress as stated above, the customer demand for high-purity and high-cleanliness steels, typically hydrogen-induced cracking resistant linepipe steel, offshore structural steel, superhigh-formability steel plate and bearing steel, can be properly responded to.

3. Future Prospect and Issues of Technology Development

The history of refining technology at Nippon Steel has been

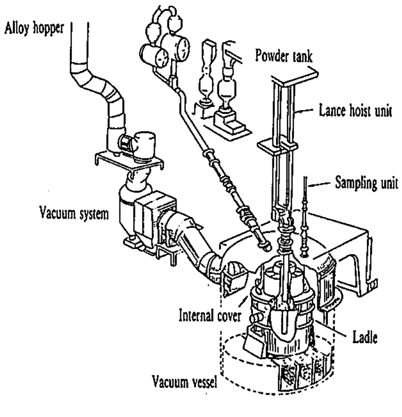


Fig. 8 Example of multifunctional secondary refining equipment (Kimitsu: Vacuum powder injection process V-KIP)[17)]

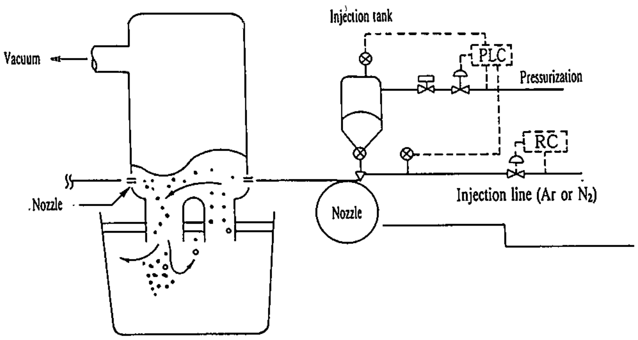


Fig. 10 Example of multifunctional secondary refining (Nagoya: RH-PB process)[20)]

Table 4 Changes in converter operating data with introduction of hot metal pretreatment and LD-OB processes (Kimitsu)

	LD process (1981)	Hot metal pretreatment and LD-OB processes (1989)
Monthly crude steel production capacity (t/furnace/month)	200,000	407,000
Hot metal pretreatment ratio (%)	0	69
Availability (%)	55.2	85.5
Tap-to-tap time (min)	34	28
Furnace life (heats)	1,795	5,340
Molten steel yield (%)	93.6	95.1
Total CaO consumption* (kg/t)	54.2	39.3
Ferromanganese consumption (kg/t)	6.4	4.2

*Total consumption of CaO (including CaO in dolomite) in both hot metal pretreatment and converter processes

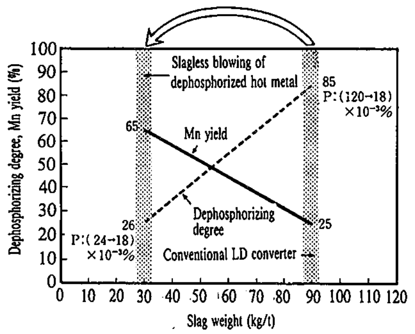


Fig. 11 Effect of slag weight on dephosphorizing degree and turndown manganese content (Oita)

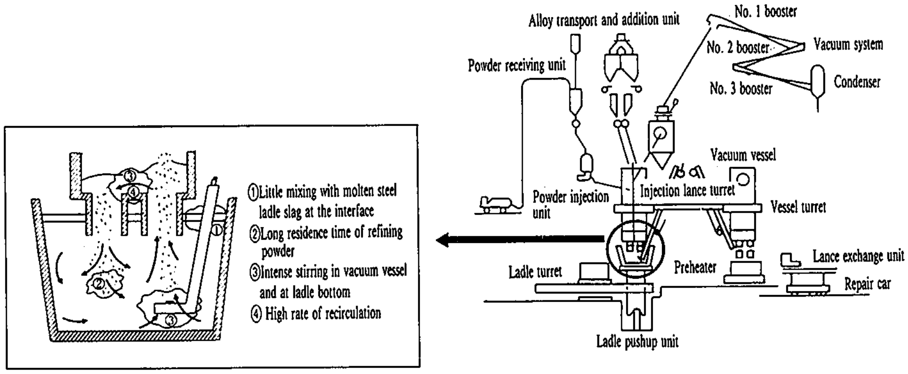


Fig. 9 Example of multifunctional secondary refining equipment (Oita: RH-Injection process)[19)]

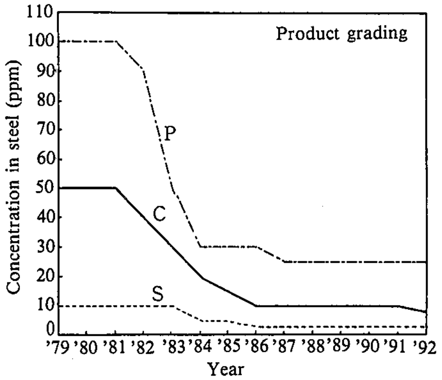


Fig. 12 Changes in high-purity steelmaking technology at Nippon Steel ([C], [S], [P])

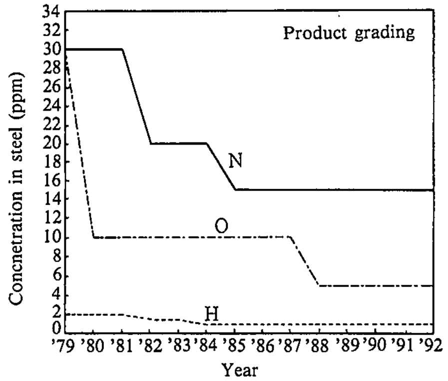


Fig. 13 Changes in high-purity steelmaking technology at Nippon Steel ([N], [O], [H])

reviewed above, centering on the introduction of combination-blown converter steelmaking processes and the division of refining functions. Discussed next are the surrounding conditions and technology trends of the Japanese steel industry including Nippon Steel, and the future prospect and issues of technology development to from the standpoint of changing environment for the industry.

3.1 Pursuit of ultimate functionally divided refining process

High-purity and high-cleanliness steel manufacture with reduced refining cost was achieved by practising combination blowing and dividing refining functions. There still remain problems to be solved. Among them are controlling the variability of refining reactions, reducing the slag formation, raising the quality of slag recycling, and suppressing the heat loss and the drop of furnace availability that inevitably accompany the division of refining functions. To solve these problems, it is essential to pursue the ultimate efficiency of refining and to optimize refining parameters by product type so that over-specification may be minimized.

3.2 Scrap recycle and iron source diversification

Fig 14[21)] shows transitions of steel accumulation in the United States, Japan, West Germany, and Britain. With the increase of social capital, Japan's steel accumulation rapidly grew after 1965, and reached 1 billion tons in 1990. It is expected to continue increasing by about 40 million tons per year, and the surplus scrap undertone is considered to drag into the future.

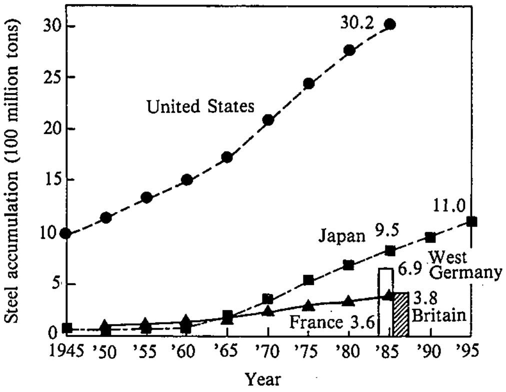


Fig. 14 Changes in steel accumulation in four advanced countries

As technology to use large amounts of scrap, the converter scrap melting process started full-fledged operation at Hirohata at the end of June 1993. Today's functionally divided process of hot metal pretreatment, combination-blown converter steelmaking, and secondary refining provides very large cost and quality benefits as discussed above, but on the other hand involves a large heat loss. Therefore, an important future theme of development will be a new process reconsolidating the divided refining functions without sacrificing the merit of functional division and using large amounts of scrap.

Market-generated scrap is expected to increase in quantity, deteriorate in quality, and become more difficult to recycle. As scrap increases in the contents of such tramp elements as copper, tin, nickel and molybdenum that cannot be removed by the present oxygen steelmaking process and of such trace elements zinc and lead that evaporate during melting, some technology will be needed to remove these elements or render them harmless. In this connection, an "Advanced Steelmaking Process Forum" organized as a national project has been engaged in research activities to develop such technology. Nippon Steel is a core member of the forum, and has been positively engaged in commissioned elementary research themes. Great expectations are entertained in the achievements of this project.

The smelting reduction process that uses iron ore as raw material is under research and development, with the object of developing new processes that make direct use of noncoking coal and fine iron ore. This technology has already been described in detail in a separate report[22)].

The blast furnace-converter route that uses hot metal as main steelmaking raw material will remain a central steel production process in the future. Given the foreseeable changes in steelmaking raw materials and progress of research into next-generation steelmaking processes, we must now pay attention also to the electric arc furnace steelmaking process that uses scrap as main raw material and fossil fuel-based smelting processes. Response to diversifying iron sources, including the mass use of scrap, is considered to assume increasing importance in the future.

4. Conclusions

Refining technology at Nippon Steel has progressed through the division of refining functions following the introduction of combination-blown converter steelmaking, hot metal pretreatment, and secondary refining. With the 21st century just around the corner, we must aim at establishing discriminative steel refining technology so that diverse steel applications can be flexibly met at low cost. It is also important from the viewpint of world resources preservation and environmental protection to establish efficient steel scrap recycling technology in cooperation with the government authorities and industries concerned. Also to be realized is a steel industry that provides more comfortable workplace environment. We intend to push forward with technology development to meet these challenges, and thereby to contribute to the growth and prosperity of society.

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