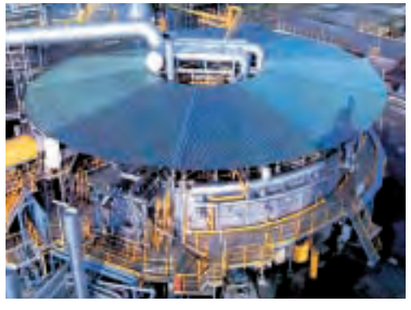
Steel Plants

Blast Furnaces
Nippon Steel Engineering has constructed numerous high-production, long-life blast furnaces using its wealth of experience in constructing and relining blast furnaces in Japan and overseas. In recent years, it has contributed to high-efficiency operations by developing and applying technologies for relining with a minimum downtime and extending the life of furnaces.



Rotary Hearth Furnaces
(Facility for producing DRI and dust recycling)
A rotary hearth furnace adds coal to fine ore and produces direct reduced iron (DRI) through a process of mixing, agglomerating, and heating. By replacing fine ore with steel dust, dust can be effectively recycled into steel.

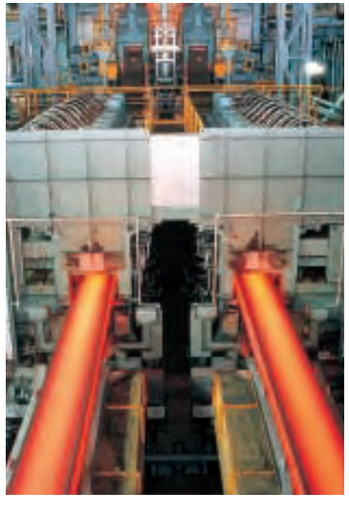
Off Gas Treatment Equipment for Electric Arc Furnace
This equipment efficiently reduces dioxins from offgas through the optimum combination of air cooling, combustion, rapid cooling and new filters.

Taking Advantage of Production and Plant Technologies

As a leading supplier of steelplants, the Plant & Machinery Division meets the diverse needs of its customers using the advanced technologies and wealth of experience it has acquired by constructing many plants in Japan and overseas.

Coke Dry Quenching (CDQ) facilities
CDQ uses inert gas in cooling towers to cool red-hot coke and recover waste heat in the form of thermal energy. As well as preventing the dust and soot pollution caused by conventional wet quenching methods, CDQ conserves energy through effective use of thermal energy.

Electric Arc Furnaces
Nippon Steel Engineering's extensive technology base and wealth of experience are used to provide electric arc furnaces and ancillary equipment that meet customers' needs for enhanced energy efficiency and greater environment friendliness.



Continuous Casting Machine
Equipment such as electromagnetic stirrers and plasma heating improves yield rates for high-quality steel materials and enables a comprehensive range of products.

Nippon Steel Engineering's Strengths

Our Competence Begins with Our Steel Plants

As well as supplying production process of high-quality steel, our Plant & Machinery Division also provide a platform for the development of environmental-friendly processes, such as the recycling of by-products and energy conservation. The cutting-edge technologies developed here are applied to environmental plants, such as waste processing centers and recycling facilities.

Solution

Steel Plants

Basic Oxygen Furnace (BOF)
Highly acclaimed by our many users in Japan and overseas, our BOF and ancillary equipment boast high reliability based on the wealth of operational experience within the Nippon Steel Group.

RH-MFB
The RH process, which is indispensable for the manufacture of high-quality steel, degasses and decarburizes by circulating molten steel in a vacuum tank. Combining this process with our proprietary multi-functional burner (MFB) enables the efficient production of various types of steel.

Regenerative Burner Reheating Furnace
The superior performance of our regenerative burner reheating furnace with its proprietary compact design saves energy by recovering exhaust gas heat, maintains a uniform temperature inside the furnace, and reduces generation of NOx.

Continuous Hot-Dip Galvanizing Line (CGL)
The Nippon Steel Group has operated and installed CGL for over 40 years. That technology base provides customers worldwide with products for a wide range of applications, from building materials to automotive body panels.

Continuous Annealing and Processing Line (CAPL)
Conventional cold-rolled steel sheet manufacturing methods involved five separate steps at the final processing stage. By concentrating those five steps into a single continuous process, C.A.P.L. reduced production lead time from five days or more to a mere 10 minutes and achieved stable, high-quality, low-cost production of a wide range of products from mild steel to high strength steel.

Color Coating Line (CCL)
More than 40 years' experience in operating color-coating lines enables us to supply a large number of users with high-quality products in a short period.

Nippon Steel Engineering's Strengths

Technology That Expands to China's Mega-Market

China is upgrading infrastructure with a view to hosting the Beijing Olympics in 2008 and the Shanghai Expo in 2010, and Nippon Steel Engineering is playing its part in meeting rapidly growing demand for steel. From our subsidiaries in Beijing and Shanghai, we are supporting China's progress with cutting-edge technology matched to needs for energy conservation and environmental protection.

Kobe Steel, Ltd. / No. 3 Blast-Furnace Relining

PMD has been awarded a contract by Kobe Steel, Ltd. (Kobe Steel) for the fourth relining of the No. 3 blast furnace of its Kobe Works. At present, in preparation for the BF blow-down in November 2007 and the start of relining, the design and manufacture of the furnace proper and preliminary works at the site are in progress.

Kobe Steel, operating under the present single-BF (No. 3) setup, is producing materials requiring advanced manufacturing technologies; in particular, automotive valve-spring steel and other special steels. In BF-relining, therefore, it is imperative that the influence of the blow-down on production should be minimized by completing the relining in the shortest possible term.

Consequently, for over a year from around 2004, we conducted surveys and studies to find a method by which to realize a short relining term within the space limitations and restrictive conditions of the BF site. We came up with our proposal in which, using our unique "ring method", the relining can be completed in 48 days, the shortest term among the relining projects for BFs of similar sizes. This proposal has been accepted by the client.

According to the "ring method" to be employed for this relining, the steel shell of the existing furnace body is cut crosswise into five ring-like-sections, which are then dismantled and removed, using a large crane (3,200t crawler crane), center-hole jacks and other such special tools; and, subsequently, the five new rigged-out shell rings are installed by the use of special tools.

Also, the furnace-body configuration is changed to be suitable for Kobe Steel's characteristic all-pellet BF operations and is also expanded in inner volume from the present 1,845m^3 to 2,112m^3, aimed at improving the permeability of the furnace gas.

Apart from the Kobe Steel / Kobe Works No. 3 BF relining, we have also received a relining contract for the No. 2 BF of Kobe Steel / Kakogawa Works (inner volume: 5,400m^3) and are now working in full force to be in time for the blowing-in in March 2007.

We shall make determined efforts to strengthen our blast-furnace business base by responding to needs for blast-furnace relining and construction in Nippon Steel and other mills in Japan and elsewhere in the world.

Recent Short Term Reline by PMD

1. Referece

Blow-In	Company/Works/BF	BF Volume after Reline (m^3)	Reline Period(day)		Size of One Ring
			Plan	Actual	
May, 2004	Nippon Steel/Oita/No.2BF	5,775	83	79	Max:3,900t
May, 2003	Nippon Steel/Kimitsu/No.4BF	5,555	88	88	Max:2,000t
Nov, 2001	Hokkai/No.2BF	2,902	82	82	Max:250t
April, 2000	Nippon Steel/Nagoya/No.3BF	4,300	93	93	Max:2,100t

2. Plan

Scheduled Blow-In	Company/Works/BF	BF Volume after Reline (m^3)	Reline Period (day)	Size of One Ring
Dec, 2007	Kobe Steel/Kobe/No.3BF	2,112	48	Max:300t
March, 2007	Nippon Steel/Nagoya/No.1BF	5,400	83	Max:3,400t

No3 Blast-Furnace

Asahi Kogyo Co., Ltd. and China Steel Corporation / Steel-Mill-Dust Recycling Facility (RHF)

PMD obtained an order for an Rotary-Hearth-Furnace (RHF) facility for dust recycling from Asahi Kogyo Co., Ltd. (Asahi Kogyo) in January 2006, and in March 2006, another from China Steel Corporation (CSC), Taiwan.

The RHF facility for Asahi Kogyo will treat electric-furnace dust. At present, electric-furnace dust is mostly moved out of steel mills for contract-treatment by zinc-refiners, but rising treatment costs have been a problem for electric-furnace mills. Recently, the RHF facility has attracted interest because it can eliminate emissions altogether by treating mill-dust within the mill and recycling zinc as well as iron.

The RHF facility for CSC will be treating dust, sludge, etc. being generated inside the integrated steelworks. At present, some of the mill-dust is treated by an outside contractor, but the introduction of this RHF facility will make it possible to recycle nearly all mill-generated dust, sludge, etc. and also recycle iron and zinc content, all within the steelworks.

These two RHF facilities are a process for high-temperature reduction of electric-furnace dust or steel-mill dust, sludge, etc. The reduced iron is charged into the electric furnace or the blast furnace as direct-reduced iron (DRI). In the case of the blast furnace, it means a cut in coke and sinter consumption for reduction. Further, concentrated zinc oxide in the secondary dust in emitted gas can be recycled as a zinc material.

For PMD, these two RHF facilities are the third and fourth orders received, following the first from Nippon Steel & Sumikin Stainless Steel Corporation (for treating stainless electric-furnace dust) and the second from Nippon Steel's Kimitsu Works (for blast-furnace- and BOF-dust & sludge). The CSC order is the first from a mill overseas.

With growing concern about the environment and the price of raw materials soaring, steel mills are becoming increasingly interested in the RHF facility. We will use this opportunity to promote the RHF facility as one of our environmental products and launch a sales-expansion drive, targeting blast-furnace and electric-furnace steel producers at home and overseas.

What is the RHF process?

Briquettes formed from the mixture of coal dust and ore fines are spread over the doughnut-shaped hearth of the rotary furnace and heated at high-temperatures by burners to reduce iron oxide within a very short time. This technology for manufacturing reduced iron is applied to the high-temperature, short-time reduction/treatment of dust containing mill-generated iron oxide, zinc oxide, nickel oxide, etc. to permit economical recycling and "zero" emission.

Outline of Project

- Asahi Kogyo RHF
  - ①Dust treating capacity : approx. 10,000t/y
  - ②Scheduled start of operation: spring of 2007
- CSC RHF
  - ①Dust treating capacity : approx. 180,000t/y (on a wet- dust basis)
  - ②Scheduled start of operation: December 2007

Project Staff＜PMD & CSC＞

Qian'an Zhonghua Coal-chemical Industrial Co., Ltd. / CDQ

PMD has received an order for two Coke Dry Quenching equipment (CDQ) units from Qian'an Zhonghua Coal-chemical Industrial Co., Ltd. (Qian'an Coke), located in Qian'an, Hebei province, China.

Qian'an Coke is a joint venture between Shougang Group (Shougang), which ranks fourth in raw-steel production in China, and Kailuan Group, a coal company. With the Beijing Olympics to be held in 2008, Shougang is scheduled to move out of Beijing, and two new integrated steelworks are now being built, one at Qian'an, Hebei (4-million t/y), and the other at Caofeidian Industrial Park on Hebei seaboard (8-million t/y).

At the Qian'an Works, the Nos. 1 and 2 coke-oven batteries will be equipped with the two CDQs ordered to PMD. The No. 1 coke plant, which has been in production since July 2005, using the wet quenching method, is to be converted to the dry quenching type. For the No. 2 coke plant, CDQ will begin at the same time as the plant start-up in October 2006. PMD's CDQ technology, demonstrated by the previous on-time deliveries to Shougang despite short lead times, and well proven by their subsequent smooth operation, has led to the present order for two CDQs.

In 2003, PMD and Beijing Shougang Design Institute together established Beijing JC Energy & Environment Engineering Co., Ltd.(BE3), a joint venture for the design, manufacture and sale of CDQ and other energy-saving and environmental equipment. Aggressive business promotion has since been under way. The recent order for two CDQs has been jointly received by BE3. BE3 has been steadily improving its business performance, starting with the No. 2 CDQ of Wuhan Iron and Steel (Group) Corp. in June 2004 and then a CDQ of Jinan Iron & Steel (Group) Co., Ltd., which had the country's largest quenching capacity (150t/h) in June 2005.

CDQ

With the award of this Qian'an order, PMD's CDQ deliveries total 47 new units and 6 modified units, in keeping with its position as the world's top CDQ supplier.

The Chinese government, which has a policy of encouraging development of the steel industry, is promoting capacity expansion of blast furnaces, coke ovens and other steel facilities, intensification of equipment, and energy-saving and environmental investments. PMD, operating from the base of BE3, is going to make strong efforts to supply not only CDQs but also Coal Moisture Control equipment (CMC) as well as various recycling technologies, and will explore future business prospects for selling more of its environmental and energy-saving products in the Chinese market.

BAOSHAN IRON & STEEL CO., LTD. / Electrolytic-Tinning Line and Tin-Free Steel Line

PMD received orders for an Electrolytic Tinning Line (ETL) with its proprietary insoluble-anode system, and for a Tin-Free Steel Line (TFSL), from Baoshan Steel Group. Fierce competition between the European competitors took place, although PMD's technology and past delivery records proved to be the decisive factor. What particularly carried weight was the performance of the ETL of Baoshan's No. 2 cold rolling mill, delivered by PMD in 1994, and PMD's inimitable follow-up services rendered during that period. The two new lines have a capacity of 200,000 tons each and are both scheduled for the start of operation at the beginning of 2008.

1. Electrolytic Tinning Line (ETL)

ETL is a process for plating tin on steel surfaces. PMD adopts "Insoluble-Anode System" for its ETL. This system plates the steel surface by tin which is already dissolved in the plating solution. This system features:

(1) The electrodes replacement is unnecessary. This allows operator reduction.
(2) Reduction of edge over coating (increase in coating weight at both edges of the strip). This allows greater uniformity in plating.

2. Tin-Free Steel Processing Line (TFSL)

TFSL is a surface-treating process which plates the strip surface by two layers of chromium. This is the first TFSL facility in China. PMD adopts a Two-Step Process; metallic-chromium plating for the undercoat and chromium-oxide plating for the top coat, which are individually performed. The characteristic of this Two-Step Process is that respective plating layers are accurately controlled.

China's crude-steel production, currently about 350-million-tons, is predicted to reach 500-million-tons, and will continue to grow for the Beijing Olympics in 2008 and the Shanghai EXPO in 2010. Reportedly, there also are plans to abolish small-scale steelworks and build a 10-million-tons class steelworks. Based on PMD's proven technology and supply records, our marketing group will be focusing on these business opportunities.

Our engineering group will concentrate on achieving the steady and smooth start-up of the facilities, and by gaining accumulation of technology and trust from our clients, we will continue to forge ahead to further secure our company's position in the market.

Signing Ceremony

Main Specification

Item	ETL	TFSL
① Production capacity	200,000 t/y	200,000 t/y
② Strip Thickness	0.1 - 0.5 mm	0.1 - 0.5 mm
③ Strip Width	700 - 1,050 mm	700 - 1,050 mm
④ Line speed	500 mpm max.	450 mpm max.
⑤ Process	Insoluble anode system	2-Step Process

Basic Design Liaison

Project Staff

Nakayama Steel Works, Ltd. / Slab Continuous Casting Machine

Main Specification

①Productivity	: 115 t/h
②CC-slab size	: 173, 200 & 230 mm thick x 950- 1350mm wide x 3200-10500 mm long
③Strands	: single strand
④Casting speed	: 1.6 m/min. max.

1. Outline of the Project

In January 2006, we received order from Nakayama Steel Works, Ltd. (Nakayama Steel) for slab width and thickness expansion of the No. 2 continuous casting machine (CC-machine) of the electric-furnace plant.
With the objective of enhancing its competitive strength by improving the quality of hot-rolled coil and reducing costs, Nakayama Steel planned the expansion to the slab width and thickness of the No. 2 CC-machine at its electric-furnace plant, and has awarded the contract to us.
In addition to the slab width and thickness -expansion work, construction of a new reheating furnace was planned. In order to make optimal use of the capacity of this new reheating furnace, the maximum cross-section size of CC-slab is to be increased from the present 170 x 800 mm to 230 x 1350 mm.
The revamped CC-machine is now being designed and is scheduled for a hot run at the end of July 2007.

2. Tenor of the Contract

Nakayama Steel's request, minimized scope of modification work, necessitated utilization of the existing plant building and the existing casting floor equipment. The concern was that the circular arc of the revamped machine, which required to be the same as the existing one, and the slab-thickness, to be increased from 170mm to 230 mm, might adversely affect slab quality, due to the increased strains at unbending points may lead to internal and/or surface cracks.

Our proposal offered our full engineering capabilities, such as multi-point-unbending profile design technology to reduce surface and internal cracks induced from the thicker slabs, small-circular-arc machines, and slab uniform cooling technology using mist cooling for secondary cooling system. These technologies are proved by the experience and expertise gained from building and revamping many CC-machines in the past, assuring a machine revamping plan for casting slabs of high quality.

3. Conclusion

We will continue our marketing endeavors to obtain more CC-machine contracts, regardless of new installations or revamping.

Project Staff

Wuhan Iron and Steel (Group) Corp. / No. 2 CDQ

Main Specification

① Amount of coke quenched	: 140t/h max.
② Amount of steam generated:	83.7t/h max. (3.82MPa, 450℃)
③ Generator capacity	: 6000KW (back-pressure steam turbine)

The No. 2 Coke Dry Quenching Equipment (CDQ) of the Coke Plant of Wuhan Iron and Steel (Group) Corp. (Wuhan) is the second CDQ built at Wuhan under the contract signed between Wuhan and PMD on June 6, 2004. Wuhan's No. 2 CDQ is designed for environmental, energy-saving and coke-quality improvements.

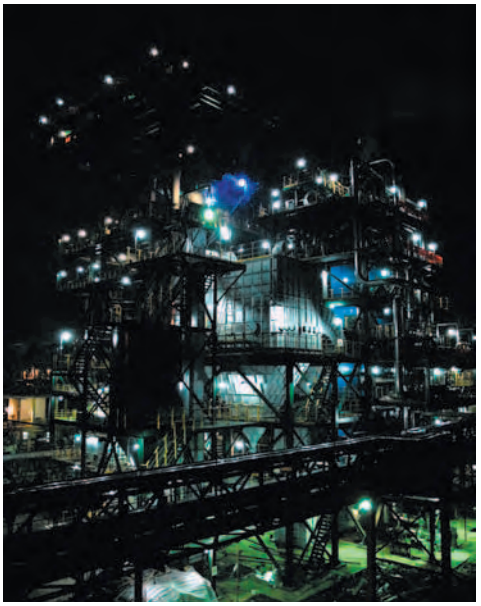
PMD is the top supplier of CDQs, and the award of the No. 2 CDQ contract was based on ① our independently-developed, advanced CDQ technologies, ② past successful deliveries of more than 40 CDQs, ③ the smooth operation of the No. 1 CDQ previously delivered by us to Wuhan, and ④ our proven total capabilities to undertake a comprehensive project at a reasonable price, which was made possible by the strategic existence of a joint venture in China (formed between PMD and Beijing Shougang Design Institute).

In the implementation of the No. 2 CDQ Project, under the consortium agreement, general project management is undertaken by the above joint venture, Beijing JC Energy & Environment Engineering Co., Ltd. (BE3), basic design and imported machines and equipment by PMD, and detailed design and construction work by Beijing Shougang Design Institute.

As the Wuhan No. 2 CDQ was the first CDQ contract given to BE3, PMD dispatched experts to BE3 and, working closely with their staff, undertook management of the project, with primary emphasis on the quality of equipment and the quality of execution work. Regarding the quality of the design, in cooperation with Beijing Shougang Design Institute, we were able to appropriately accommodate and respond to the requests and desires of the client based on the design of existing No.1 CDQ. As for execution of the work, we achieved actual delivery in 17 months and 20 days, the shortest delivery term ever recorded for CDQs, making it possible to throw in red-hot coke as early as November 26, 2005, 10 days earlier than the contracted term. The power generator also started up smoothly, quickly passing the final performance test.

The client said that it thought highly of the project-management capabilities, shortened delivery term, and high quality of the CDQ delivered. That project indeed provided a wonderful opportunity to deepen friendly ties between the client and the PMD consortium.

With the successful No. 2 CDQ project as a beginning, we at PMD and BE3 are determined to firmly establish ourselves as a CDQ supplier in China, contributing to the promotion and spread not only of CDQs but also Coal Moisture Control equipment (CMC) and other such energy-saving and environmental facilities.



No.2 CDQ

Usinas Siderúrgicas de Minas Gerais S.A. / New Turbo Blower for Blast-Furnace No. 3

The No. 6 Blower System for the No. 3 Blast Furnace of the Intendente Cámara Works of Usinas Siderúrgicas de Minas Gerais S.A. (USIMINAS) was a full turn-key project jointly undertaken by PMD and Mitsui & Co., Ltd.
PMD executed the delivery, erection, and commissioning of the equipment of the Blower System, and Nippon Steel PMD Indústria Ltda. (NSPMD), a local subsidiary of PMD, executed the local portion of the project as a contractor.
The blow-in of the No. 3 Blast Furnace began in March 2006. The Blower System has since been operating smoothly, serving to improve operational stability of the blast furnace. In addition, the increased capacity of the Blower System has also served to increase the amount of iron tapped from the No. 3 Blast Furnace, which is the mainstay of the company, thereby making a substantial contribution to the profit of USIMINAS.
This first full turn-key project to be undertaken in a long time in Brazil, by the successful use of our local subsidiary, and, in the process, we were also able to acquire much useful knowledge and information. The next project of Hot Stove waste-heat recovery for BELGO undertaken soon after, also on a full turn-key basis, was completed very smoothly.
Making the best use of these experiences, we are going to make vigorous efforts to obtain further orders for blast furnaces and peripheral equipment in Brazil and elsewhere, as well as at home.

Main Specification

①Blower	: Turbo blower	6,400 Nm^3/min 4.2 kg/cm^2 30,860 kW
②Turbine	: Steam turbine	35,250 kW
③Generator	: AC generator	5,250 kVA (4.2MW)

Turbo Blower for BF No.3

Mitsubishi Shindoh Co., Ltd. / Electrolytic Tinning Line

Main Specification

①Materials	: copper and copper-alloy
②Strip thickness/strip width	: 0.1-1.2 mm/350-670 mm
③Line speed	: 40 mpm max.
④Coating thickness	: Cu 0.5μm, Sn 1.0μm

This project is for an Electrolytic Tinning Line (ETL) for copper and copper-alloy strip, which is an application of our PMD's long-established electrolytic plating technology for steels to non-ferrous materials. We obtained this contract for the supply of a complete line jointly with Nittetsu Elex Co., Ltd. in February 2005. Our client, Mitsubishi Shindoh, with a top-class production share in the industry, made this capital investment in anticipation of long-term growth of demand for automotive and electronic parts in the future.
Our ETL features high-current-density insoluble-anode plating technology, which allows to substantially reduce the number of plating cells compared with soluble-anode technology, which is the mainstream technology in the copper-rolling industry. Insoluble anode plating also significantly reduces plating thickness fluctuation.
Minimizing the fluctuation for plating is an important element when plated products from copper rollers are fabricated into electronic materials and other such precision parts and components for final applications. Our technology was highly graded by Mitsubishi Shindoh, which lead to the order.
At this moment, this project is in the final commissioning stage for finalizing the quality of plating.
This is an important project for PMD at the non-ferrous sector, which is currently maintaining prosperity. By the work experience with Mitsubishi Shindoh, we wish to expand the orders at this sector.

ETL

PT. Gunung Garuda / High-performance industrial furnace (NEDO model project)

The high-performance industrial furnace contract for PT. Gunung Garuda, Indonesia, awarded to and executed by PMD as a New Energy & Industrial Technology Development Organization(NEDO) model project for increasing the efficient use of energy, was constructed on schedule, commissioned and, after a demonstration operation, inaugurated on May 29, 2006.

The inauguration ceremony was held in grand style on the premises of Gunung Garuda in Cibitung, Indonesia, attended by Mr. Mitsukawa, Deputy Managing Director of NEDO, Mr. Ansari, Director General of Metal, Machinery, Textile and Multifarious Industries of Indonesia, Mr. Djamaluddin, Chairman of PT. Gunung Garuda and many other Japanese and Indonesian dignitaries associated with this project. PMD was represented by Mr. Takahashi, Director.

This project was launched as one of the activities of Japan's Ministry of Economy, Trade and Industry/NEDO, for promotion of energy conservation and environmental preservation in the Asian region. This Japanese-Indonesian joint project was the first model project of its kind in Indonesia.

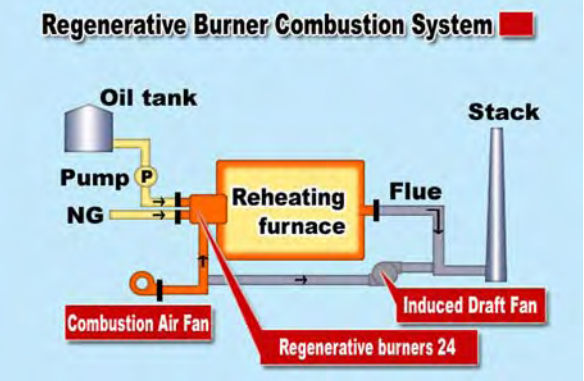
The furnace equipment installed by this project efficiently recovers sensible heat of the combustion exhaust gas of the steel-slab reheating furnace, for preheating combustion air. When introduced, this equipment makes it possible to cut natural-gas consumption by about 4.44 million Nm^3 a year (about 4,940 tons in crude-oil equivalent), a major contribution to the effective use of energy. At the same time, this equipment also permits a reduction in greenhouse gas. Specifically, it can reduce carbon-dioxide emissions by about 15,000 tons a year, helping to prevent global warming.

The spread of the energy-saving technology adopted for this model project will certainly contribute not only to energy savings, conservation of resources and environmental improvements in Indonesia but also, hopefully, for solutions to global-scale energy and environmental issues. At PMD, we intend to vigorously promote the spread of our energy-saving technology, including this high-performance industrial furnace equipment based on the Regenerative Burner Combustion System.

Main Specification

① Heating capacity:80 tons/hour

② Regenerative Combustion System Type
Walking Beam Reheating Furnace



Regenerative Burner Combustion System

Inauguration Ceremony

Nippon Steel's Kimitsu and Nagoya Works / CGL Renewal Projects

In August 2004, PMD received two contracts for renewal of the obsolete hot-dip continuous galvanizing lines (CGL): namely, the Kimitsu No. 5 CGL and the Nagoya No. 2 CGL of Nippon Steel Corporation. The purpose of the renewal was to correspond to the increasingly stringent quality requirements to the surface treatment of sheet steels for automobiles, electrical appliances, etc.

As scheduled, the Kimitsu No. 5 CGL has been under commercial operation since June 15, 2006. The Nagoya No. 2 CGL is now in the commissioning stage, in preparation for the scheduled start up of commercial operation on September 15, 2006. Equipment specifications for these two CGLs are:

Kimitsu No. 5 CGL
〈No. 2 CGL (start of operation in 1970) renewal〉

①Capacity	: approx. 40,000 t/m
②Sheet thickness:	0.4 - 2.3 mm
③Sheet width	: 600-1890 mm
④Start up	: Middle of June, 2006

Nagoya No. 2 CGL (start of operation in 1966) renewal

①Capacity	: approx. 20,000 t/m
②Sheet thickness:	0.6-3.2mm
③Sheet width	: 600-1700 mm
④Start up:	Middle of September, 2006

Project staff ＜Kimitsu CGL＞

Project staff ＜Nagoya CGL＞

Nippon Steel Kimitsu Works / Operation-Floor Equipment and Mold Equipment of No. 6 Continuous Casting Machine

Kimitsu Works, one of the main production centers of Nippon Steel Corporation (located in Kimitsu City, Chiba Prefecture), has determined to build the No. 6 continuous casting machine (CC-machine).

The No. 6 CC-machine, which is a new installation intended to increase production of high-grade steels, is scheduled to begin operation in November 2006. Its productive capacity is approximately 2 million tons a year. Once it is in operation, Kimitsu Works will increase the percentage of high-grade steels, and will be capable of stable production.

CC-machine is a machine to solidify and to form the molten steel into slabs, after the refining process. And CC-machine plays an important roll in steel making, as it has major influence to the output, quality and product mix of all the "upstream processes" including the blast furnace.

PMD, receiving the order for handling and molding facilities for teeming and solidifying the molten steel on the operation floor, has completed the design and manufacture and is now under construction at the site.

Project Staff

Kotobuki Steel Mfg. Co., Ltd. / Tundish Plasma Heating System

PMD has commercialized the Tundish Plasma Heating System for continuous casting machines and offers a full range of this System, from the planning of the whole system (including the layout arrangement, the design of refractories, molten-steel flow analysis, etc.) to the manufacturing of the plasma torch.

In March 2005, we received an order for the Tundish Plasma Heating System from Kotobuki Steel Mfg., (Kotobuki) and has begun operation in April 2006. Kotobuki's one-strand continuous casting machine produces large-section blooms of special steel for both domestic and oversea customers. To improve the quality of blooms through greater uniformity in molten-steel temperatures, and also to avoid clogging of the teeming nozzle and other operating troubles, Kotobuki decided the installation of the Tundish Plasma Heating System.

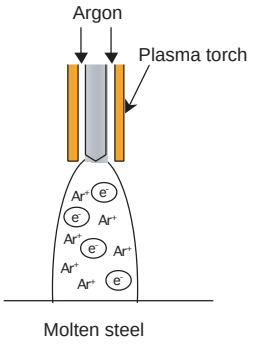
For this Kotobuki's System, the direct-current single-torch type was adopted. There are the two kinds of torch available in our lineup; large-capacity (maximum current: 7,000A) and small-capacity (maximum current: 5,000A). The small-capacity torch was selected to suit Kotobuki's relatively low quantity of production. As the small-capacity torch is compact, including the torch itself and the support device, this allows ①easy modifications to the peripheral equipment of the tundish and ②reduction to the consumption of argon gas, which also leads to the reduction of running costs.

Presently, uniformity in molten-steel temperatures obtained by the application of this Plasma Heating System has gained numerous acheivements in Kotobuki's operations.

Main Specification

①Torch	Type	Direct-current-transfer-arc and single-torch type
	Electrode	Cathode type, specially made of tungsten
②Electric current		Maximum: 3,000A
③Voltage		Approx. 100 to 120V
④Operating gas		Argon gas

View of the plasma heating system, and one in operation.



Plasma arc.

High-Concentrated Hydrogen-Gas Jet Cooler in Continuous Annealing of Steel Strip

1. Foreword

Cold-rolled flat products are difficult for pressing, as work hardening occur during the cold rolling process. Thus, to manufacture the steel sheets for pressing , annealing plays an important roll for steel.

PMD has successfully developed a new cooling system (High Concentration Hydrogen Gas Jet Cooler) to its Continuous Annealing and Processing Line (C.A.P.L.) . The following are the details of how it was developed and its characteristic features.

2. Features of the Nippon Steel type Continuous Annealing and Processing Line (C.A.P.L.)

(1) Heat-treating cycle

To improve the workability of sheet steels, it is important to increase grain sizes of the steel sufficiently, and also minimize solute carbon contained in the steel. To meet this conditions with aluminum-killed steels, the continuous annealing furnace will require processes which as are described below.

First, the steel strip is heated above the recrystallization temperatures in the heating zone, then held at temperatures of 700 - 850℃ for a certain specified period of time. During these processes, as the steel recrystallizes, and the grain growth proceeds, the steel strip becomes flexible, while at the same time attaining high workability.

However, as the carbides which are in a dissolved state in the structure of the steel due to heat-treatment at high temperatures are rapidly cooled, large amounts of solute carbon becomes present in the steel. This solute carbon's transition becomes fixed with the elapse of time, and the fixed transition causes large yield-point elongation. Therefore, the existence of the solute carbon is not welcomed for steel strips for pressing .

To reduce the presence of solute carbon in the steel as much as possible, the steel, after soaking and cooling process, is subjected to over-aging treatment in the over-aging zone where the steel is held for a certain period within the temperature region (approximately 400℃) in which solute carbon can diffuse. By this method, solute carbon is precipitatesd as cementite (Fe_3C), and the presence of solute carbon in the steel is greatly decreased.

At this point, in order to accelerate over-aging treatment, the rate of cooling in the rapid-cooling zone becomes important. The steel, after soaking and having been cooled slowly to certain temperatures under the A1 transformation point (723℃), is rapidly cooled to over-aging temperatures in the rapid-cooling zone. At the rapid-cooling end-point, excess carbon beyond the carbon solid-solution limit at such temperatures in the Fe-C system equilibrium diagram becomes solid-soluble in the ferrite matrix. This state of over-saturation accelerates the precipitation of cementite during over-aging. The rate of cooling necessary for achieving this over-saturated state is more than 60℃/s metallurgically and more than 80℃/s, desirably.

Further, in recent years, by adopting high rates of cooling, it has become possible to manufacture a wide variety of high-strength steels.

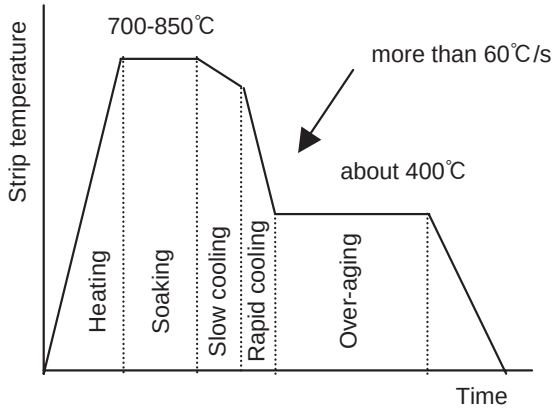


Fig.1 Heat-treating cycle.

(2) Conventional rapid-cooling techniques

Table-1 shows a comparison of the cooling systems of C.A.P.L.

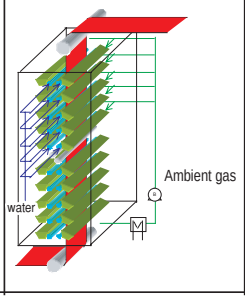
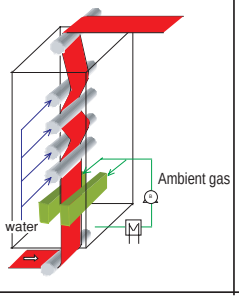
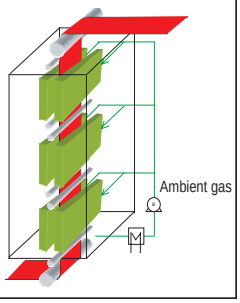
Gas-atomized mist cooling (Accelerated cooling /AcC) which sprays the steel gas-atomized mist as a cooling medium. While this system has excellent cooling rate and operating stability, it requires an after-treatment facility to remove thin oxide films formed on the steel surfaces.

Roll cooling (RC) winds the steel around the roll whose inside is water-cooled. It can achieve high cooling rates, but shape may sometimes become unstable when strip temperatures are high or the strip is thin and wide. Therefore, this system is ordinarily used in combination with gas jet cooling.

High cooling rate gas jet cooling (H-GJC) cools the ambience inside the furnace (1-5%: H_2, rest: N_2) and sprays it at high velocity onto the steel. While providing stability in product quality and operation, it has difficulty achieving high cooling rates with materials having large thickness. Therefore, it is suitable for application to the producing of thin gauges.

PMD has been successful to add an additional method to the above C.A.P.L. cooling system which is the non-oxidizing (dry) type, with high cooling performance, and with excellent operating stability.

Table 1 Primary cooling system of C.A.P.L.

		Accelerated cooling (AcC)	Roll cooling (RC)	High cooling rate gas jet cooling (H-GJC)
Quality	Cooling Performance (strip thickness:1mm)	High 50-200℃/s	High approx 100℃/s	Medium approx 50-60℃/s
	Cooling-rate stability during change to strip thickess and line speed.	Very stable. Cooling rate is constant.	Stable operation.	Stable operation.
Operation	Stability of Strip Shape	Stable	Unstable	Stable
	Ease of maintenance	Good	Good	Good
				

3. Development of the H_2-High cooling rate Gas Jet Cooler (H_2-HGJC)

(1) Selection of the cooling method and the cooling medium

In the case of current development, H-GJC was focused on, as a non-oxidizing cooling method where the operationally stable non-oxidizing-gas jet stream is sprayed on the steel for rapid cooling. First, the possibility of improving the cooling performance by changing the composition of the gas was studied and trial values was obtained as shown in Table-2. From among them, high-concentration hydrogen-gas was selected as the medium most likely to succeed industrially.

Table 2 Comparison of gas types in cooling performance.

Cooling Medium (100℃)	Cooling-Performance Ratio
95%N_2 + 5%H_2	1.000 (base value)
He 100%	1.522
H_2 100%	1.725
Ar 100%	0.666

(2) Test at the Pilot-line

When the metallurgically required cooling rate of 80 ℃ is our target, whether the use of the above selected high-concentration hydrogen-gas can achieve this target needs to be ascertained. Thus, a test was conducted to ascertain the cooling-performance characteristics in the high-concentration hydrogen-gas region (under the influence of high hydrogen-gas concentration and high gas jet velocity), using the pilot line schematically represented in Fig. 2.

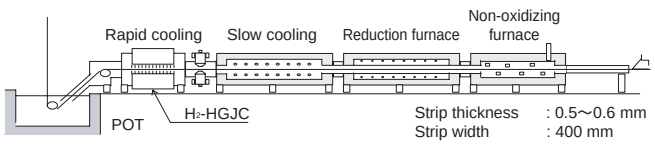


Fig.2 The Pilot line

H-GJC was used for the cooling zone of the pilot line, and by changing the hydrogen concentration of the cooling gas and velocity of the gas jet, their respective heat transfer coefficient were obtained. Heat transfer coefficient was measured by "couple runs", in which thermocouples were directly mounted on the steel to obtain accurate strip-temperature measurement data.

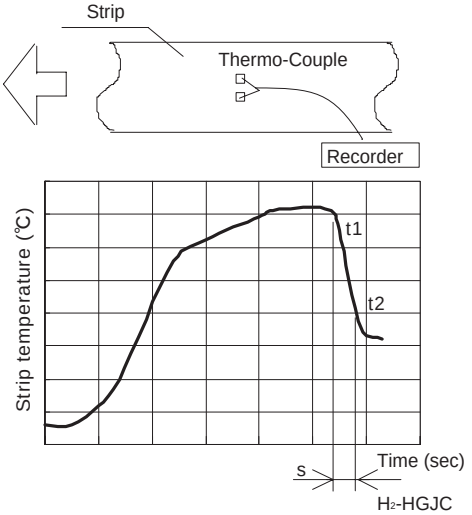


Fig.3 Example of Couple-run Data

(3) Test results

From the test results, the relation between hydrogen-gas concentration and spray-gas-jet velocity and cooling performance was obtained. As a result, it was ascertained that the targeted cooling performance is achievable by increasing the hydrogen-gas concentration of the spray gas and increasing the jet velocity. It was also confirmed that the near maximum cooling performance was achieved by hydrogen-gas concentration of 60%, and that not much further improvement in cooling performance can be achieved by additional increase to the hydrogen-gas concentration. From these test results, a regression formula of heat transfer coefficient against hydrogen-gas concentration and

spray-gas jet velocity (1) was established and engineering data were structured. In this way, commercialization of H_2-HGJC (H_2-High cooling rate Gas Jet Cooler) has been enabled.

Table 3 Relation between hydrogen-gas concentration and spray-gas-jet velocity and cooling performance

Spray Gas Jet Velocity	Hydrogen-Gas Concentration		
	5%	50%	70%
Conventional (100%)	50℃/s	65℃/s	70℃/s
High-velocity jet (130%)	55℃/s	80℃/s	85℃/s

$$H = K \times \lambda \times Pr^a \times V^b \times N^c \quad \text{.....(1)}$$

where H: Heat transfer coefficient
λ: Thermal conductivity of the gas
Pr: Prandtl number of the gas
V: Jet velocity of the gas
N: Kinematic viscosity coefficient of the gas
Ka, b, c: Constant

4. Commercialization of H_2-HGJC

(1) Determination of hydrogen-gas optimum concentration

Taking running cost into overall consideration and to secure the cooling performance required for a commercial facility, the determination of the optimum concentration of hydrogen-gas and spray-gas jet velocity is required.

Increase in concentration of hydrogen-gas in the spray gas leads to an increase to the cost for the gas, and the increase in gas-jet velocity leads to an increase in power consumption of the blower. Conversely, higher concentration of hydrogen-gas will be effective in decreasing the gas-jet velocity required to secure the same cooling performance, and that the lowered relative density of the gas will have an effect of decreasing power consumption of the blower.

As a result of our studies, overall running-cost indices of cooling gas and power reaches a minimum point when the hydrogen-gas concentration is around 40 to 50%, as shown in Fig. 4. Therefore, taking equipment expenditures into consideration, we decided to set the hydrogen-gas concentration at 50% for application to the actual equipment.

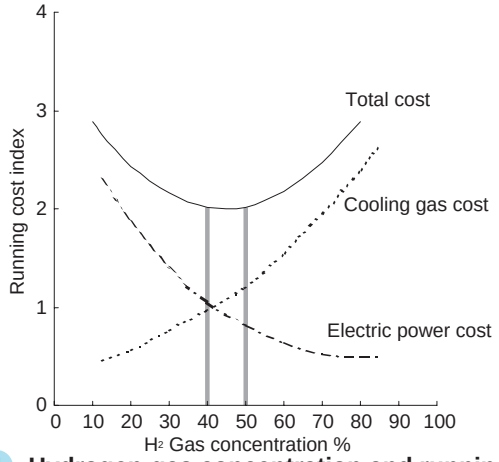


Fig.4 Hydrogen-gas concentration and running cost.

(2) Adoption of H_2-HGJC in C.A.P.L. at BSSP (currently CORUS)

In the actual equipment, the sealing system was installed before and after the cooling section to reduce the running costs. The hydrogen-gas concentration was increased in the primary cooling zone alone. As a result of the start-up, it was confirmed that the required cooling performance was attained, as well as the scheduled performance in both product quality and operating stability. The line is still in smooth operation.

5. Improved Performance of H_2-HGJC

After the commercial application at BSSP-C.A.P.L., it was confirmed that the cooling performance improved (80℃/s to 85℃/s) furthermore by the optimization of the nozzle configuration and the arrangement of the Cooling Gas Chamber. PMD continue it's efforts toward further performance improvement.

6. Conclusion

PMD have developed H_2-HGJC as a new process for non-oxidizing high-velocity cooling process for the C.A.P.L. Optimum specifications were studied using the engineering method based on the test results on the pilot line, and were applied to the BSSP-C.A.P.L. Development work for further improvement in cooling performance is continuing.

With these proven performance records and developments made, options have now been broadened by including H_2-HGJC for future C.A.P.L. projects. This process enables each individual steel mill to select a process which is most suitable in terms of productive capacity, product mix, and other conditions and needs, with greater flexibility.

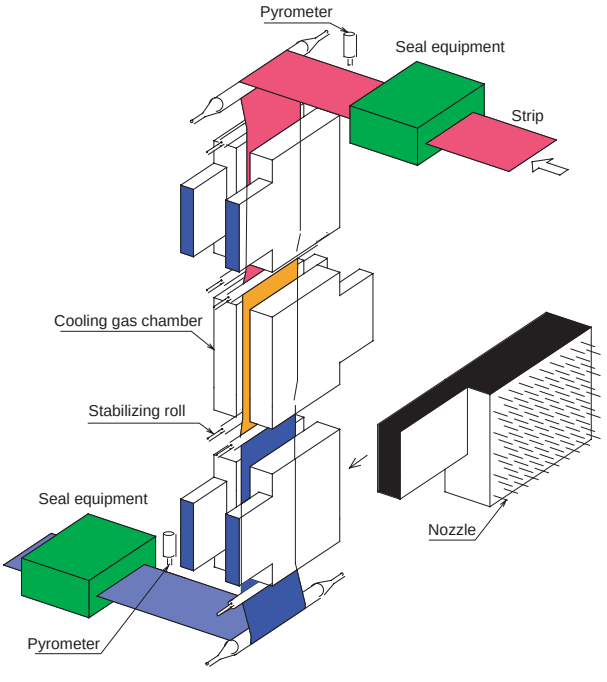


Fig.5 Schematic diagram of a practical application of H_2-HGJC.

PMD's Regenerative Burner System Technology License Granted to Beijing Phoenix Industrial Furnace Co., Ltd.

PMD has granted a license for its proprietary technology for the regenerative burner system to Beijing Phoenix, a leading reheating-furnace engineering firm in China, under a license agreement signed in June 2006.

This technology has the following two features:

① Greatly improved energy-saving effects of the burner combustion control system.

② Burner construction which is compact in size, very easy to maintain and effective in reducing nitrogen oxides (NOx).

Recently, Chinese steel mills have been increasingly aware of the acute need to make equipment investment with consideration for environmental preservation and energy conservation.

By tying in with Beijing Phoenix, who are fully experienced in the design of steel-plant reheating furnaces, procuring equipment and carrying out construction work, we aim to further spread this technology which can contribute to environmental preservation and energy conservation in China.

Signing Ceremony