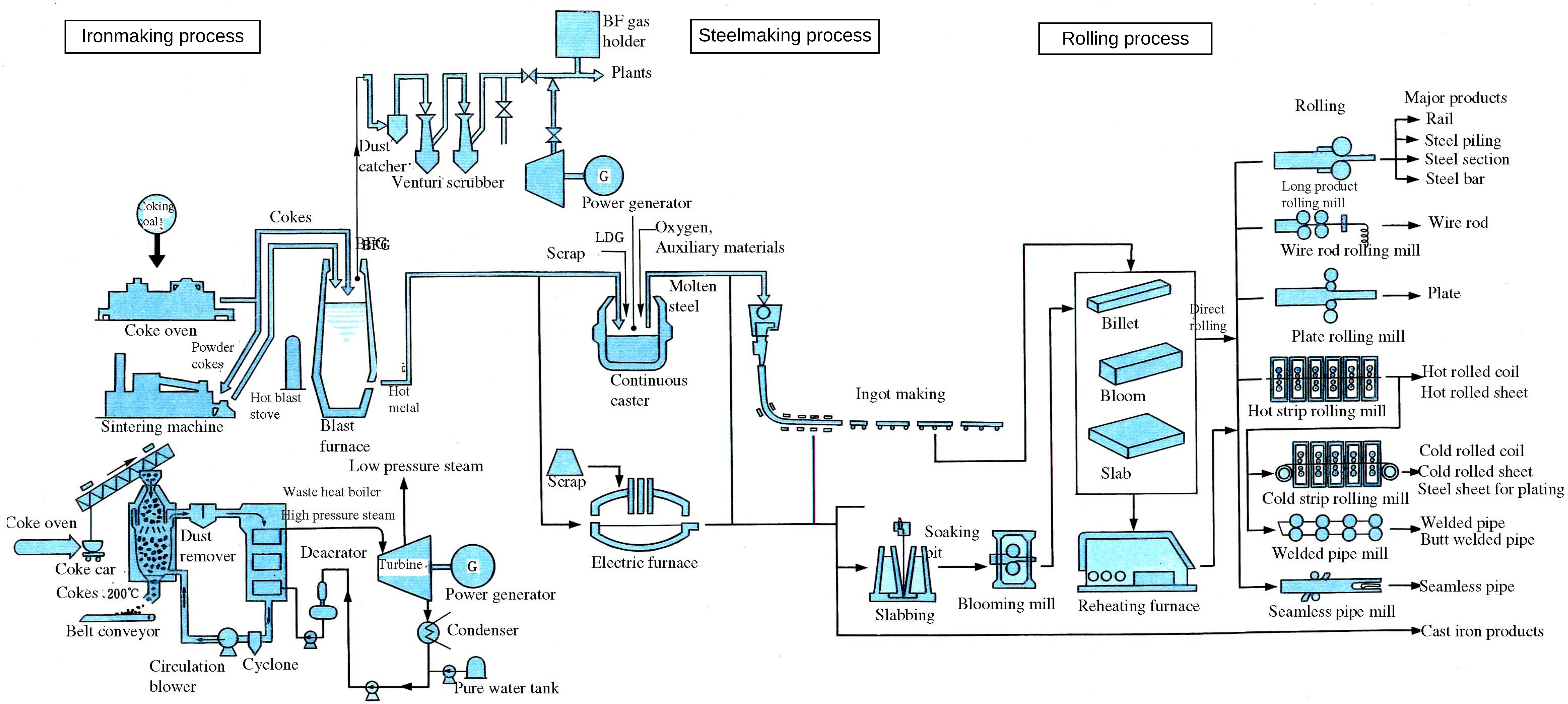
Section 1 :
Iron & Steel Industry

Process Flow
Data Sheets

Iron & Steel : Production Process and Energy Saving Technology



Item No.	Technology Item/Title
IS-PE-1	Improvement in segregated charging of sintering materials
IS-ME-1	Coal drying and moisture control equipment for coke oven
IS-ME-2	Coke dry quenching
IS-ME-3	Exhaust heat recovery system for sintered ore cooling equipment
IS-ME-4	Sensible heat recovery from main exhaust gas of sintering machine
IS-OM-1	Automatic combustion control of coke oven
IS-OM-2	Blast furnace operation control system
IS-OM-3	Blast furnace hot blast valve control system
IS-OM-4	Blast furnace burden distribution control

Item No.	Technology Item/Title
IS-PE-2	Pulverized coal injection for blast furnace
IS-PE-3	BF top-pressure recovery turbine

Item No.	Technology Item/Title
IS-PE-4	DC arc furnace with water cooled furnace wall
IS-PE-5	Continuous casting machine
IS-PE-10	High frequency melting furnace
IS-PE-11	Channel induction furnace for cast iron melting
IS-PE-12	Ferroalloy furnace for effective energy utilization
IS-ME-5	Hot stove exhaust heat recovery equipment
IS-ME-6	BOF exhaust gas recovery device (including sealed BOF)
IS-ME-7	BOF gas sensible heat recovery apparatus
IS-ME-8	Raw material preheater for electric arc furnace
IS-ME-9	Heating furnace with regenerative burners
IS-ME-10	Ladle heating apparatus with regenerative burners
IS-OM-5	Energy saving operation of electric arc furnace

Item No.	Technology Item/Title
IS-PE-6	Hot charging and direct rolling mill
IS-PE-11	Channel induction furnace for cast iron melting
IS-PE-12	Ferroalloy furnace for effective energy utilization
IS-ME-9	Heating furnace with regenerative burners
IS-ME-11	High performance heating furnace
IS-ME-12	Recovery of sensible heat from skid cooling water in heating furnace
IS-ME-13	Descaling pump (conversion to plunger pump)
IS-OM-6	Operation improvement of heat treatment furnace

Item No.	Technology Item/Title
IS-PE-7	Continuous annealing line
IS-PE-8	Convection heating type heat treatment furnace for wire rod coil
IS-PE-9	Low temperature forge welded pipe production method

IS-ME-14	High efficiency gas separation apparatus
IS-OM-7	Centralized energy management (Energy center)

IS-PE-1	Energy Conservation Directory	
[Industry Classification] Iron & Steel [Technology Classification] Production Equipment	Improvement in segregated charging of sintering materials	[Energy Source] Coke [Practical Use] 1990's

Outline

This is an improvement of the charging device in the sintering process. By uniformly charging the materials along the width of the sinter bed and optimizing the size segregation along the height, the yield and quality are improved, resulting in energy saving.

Principle & Mechanism

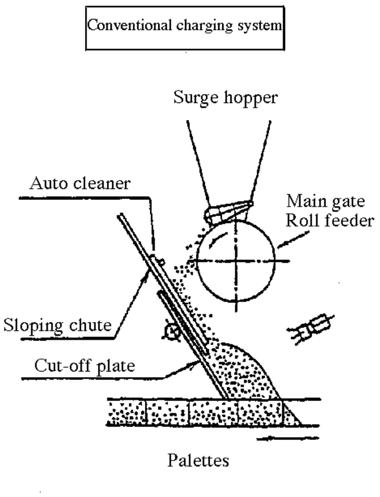
The improvement of segregated charging is to optimize the size distribution along the height of the sinter bed By this, the permeability increases, and the quality of the sintered ores in the upper layer is improved, resulting in the overall yield improvement.
Further, the return ores are reduced. Accordingly, the coke consumption is reduced and the energy saving effect is achieved.

[Description]

Structure explanation, Shapes, and/or System diagram

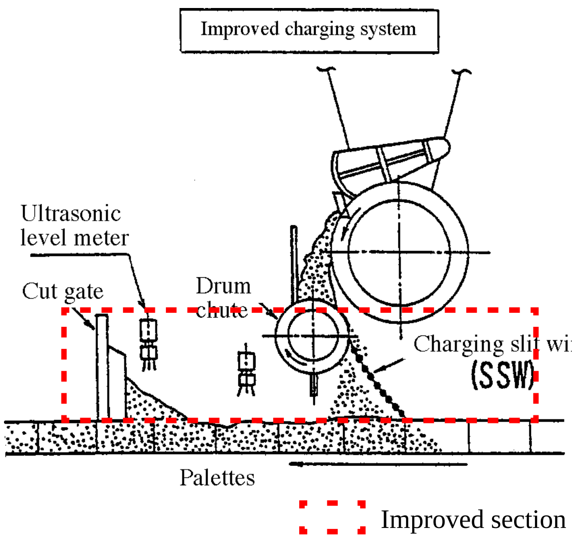
Before improvement

The roll feeder feeds the sinter raw mix onto the palettes through the chute. Due to the inappropriate size segregation of the sinter mix, the permeability of the sinter mix on the palettes is low, and the return ore rate is high.



After improvement

The roll feeder feeds the sinter raw mix onto the drum chute in order to decrease the falling height. Then, the mix is fed through the segregated slit wires onto the palettes. Thus, the segregation of the raw mix becomes appropriate.



Energy saving effects

Table. 1 Energy saving by the improvement

	Before improvement	After improvement	Crude oil equivalent
Specific coke consumption (kg/T-sinter)	Base	(-) 2.8	6,600 kL/y
Coal addition rate (%)	Base	(-) 0.54	1,200 kL/y

(Note) The crude oil equivalent was calculated assuming the annual production of 3 million tons, and the coke's calorific value of 7,100 Kcal/Kg.

[Economics] Equipment cost

Investment amount: 150 -200 million yen
Improvement effect: 1 million yen/year
Investment payback: 2 years

Remarks

[Example sites]

There are many similar examples.

[References]

Materials of the 86th Ironmaking Sectional Meeting of the Iron amd Steel Federation
Ironmking section 86-19-common subject (1996)

[Inquiry]

ECCJ (JIEC)

IS-PE-2

Energy Conservation Directory

[Industry Classification] Iron & Steel	Pulverized coal injection for blast furnace	[Energy Source] Coke
[Technology Classification] Production Equipment		[Practical Use] around 1980

Outline

This is a technology to inject pulverized coal directly into a blast furnace through tuyeres in place of using cokes. Energy to produce cokes (coking energy) is reduced.

Principle & Mechanism

- Pulverized coal is injected into a blast furnace through tuyeres by a pulverized coal injection device.
- The type, size, etc. of pulverized coal injected differs by injection device and blast furnace.
- By improving the equipment and operation technology, injection of 50-200 kg/t-pig is now possible, resulting in a large energy saving.

[Description]

Structure explanation, Shapes, and/or System diagram

Pulverized coal injection (PCI) system

The PCI system is composed of equipment for coal receiving, crushing and drying, injection, instrumentation, etc.

1) Pulverized coal is directly injected into a blast furnace through tuyeres.
2) Raw material used for pulverizing is non-coking economical coal, which substitutes for coking coal.
3) Non-coking coal is pulverized by a crusher into the 200-mesh (74m), 75-80% pass.
4) The crusher has drying and sorting functions, and automatically controls the flow of pulverized coal so that it is evenly distributed when injected into the tuyeres.
5) Inert gas is used to prevent the coal dust explosion at the time of crushing.

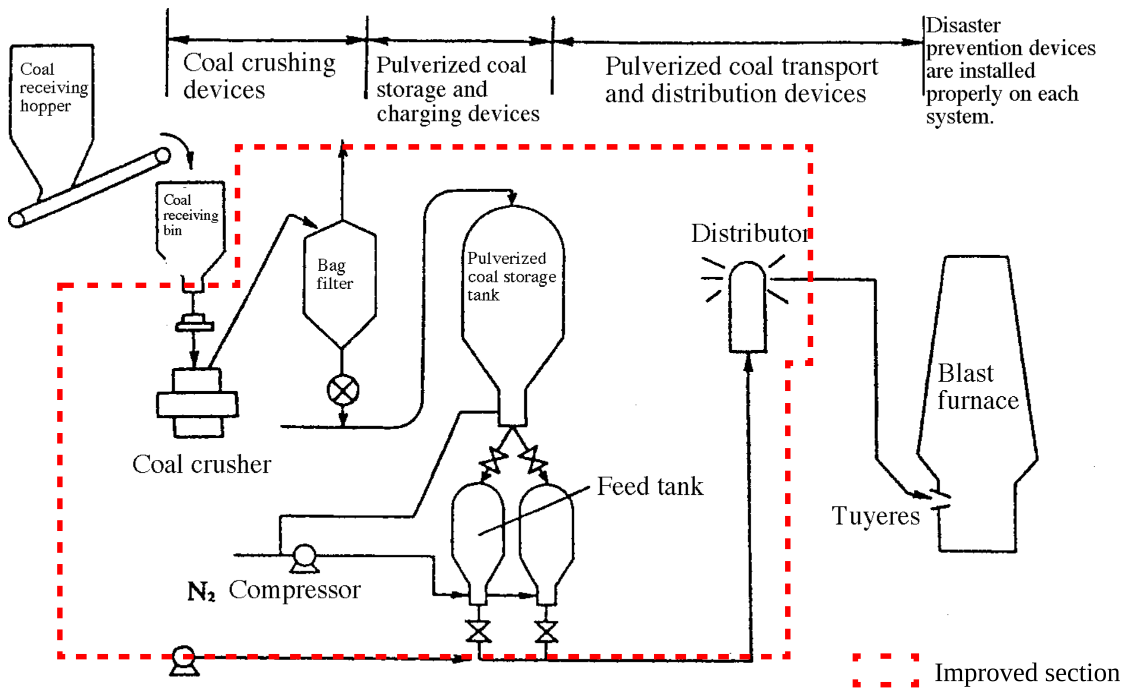


Fig. 1 Diagram of pulverized coal injection

Energy saving effects

At the pig production of 3,000 kt/year,
Reduction in crude oil equivalent: 19,460 kL/year at pulverized coal injection of 100 kg/t-pig, plus longer coke-oven life.
Reduction of energy consumption per ton of pulverized coal: 600,000 kcal/t-coal, coal injection 300,000 t-coal/year

[Economics] Equipment cost

Investment amount: 3,000 million yen
Improvement effect : 1,000 million yen/year
Investment payback: 3 - 4 years

Remarks

The load to coke ovens decreases and the investment for their renovation is suppressed.

[Example sites]	[References]	[Inquiry]
Adopted by almost all blast furnaces in Japan.	Topics in the History of Iron and Steel Technology in 20th Century, 1995 Iron & Steel (Vol. 81, No. 4, 1995, p. 8-10, 25-27)	ECCJ (JIEC)

IS-PE-3	Energy Conservation Directory

[Industry Classification] Iron & Steel	BF top-pressure recovery turbine	[Energy Source] B gas
[Technology Classification] Production Equipment		[Practical Use] around 1975

Outline

A device which utilizes the furnace top gas pressure of a high pressure blast furnace for generating electric power by driving gas turbine.

Principle & Mechanism

The pressure of the BF gas (B gas) generated in a blast furnace is 2-3kg/cm^2 at the furnace top in high-pressure operation. In order to effectively utilize this gas in the downstream processes, conventionally its pressure was reduced by the septum valve after the dust was removed.
A top-pressure recovery turbine (TRT) utilizes this pressure and temperature, and recovers them as electricity by a gas turbine. As it recently became possible to remove the dust by a dry method and increase the turbine inlet temperature, it is expected that more electricity will be recovered.

[Description] Structure explanation, Shapes, and/or System diagram

The wet-type and dry-type BF top-pressure recovery turbines are schematically shown below.
As the dry type has less pressure drop and gas temperature higher by 50˚C compared with the wet type, some dry types can generate 1.6 times as much electricity.

1) Wet-type BF top-pressure recovery turbine

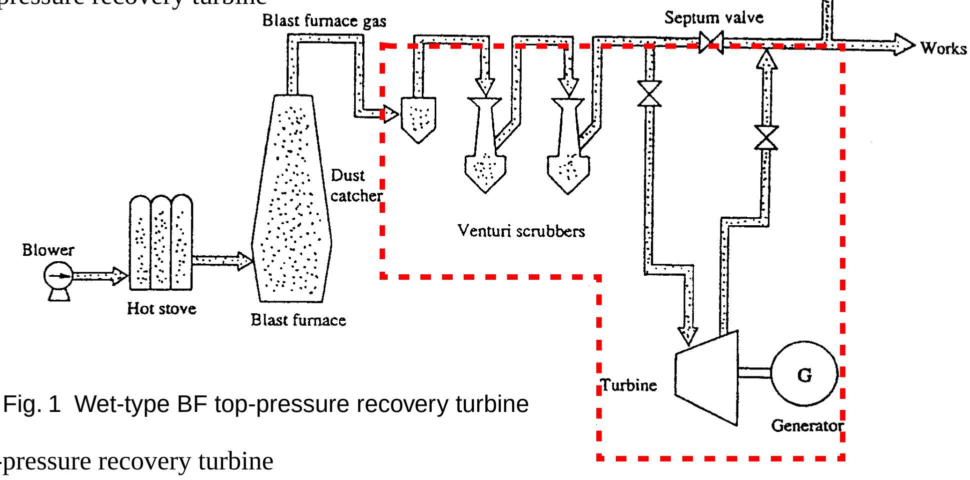


Fig. 1 Wet-type BF top-pressure recovery turbine

2) Dry-type BF top-pressure recovery turbine

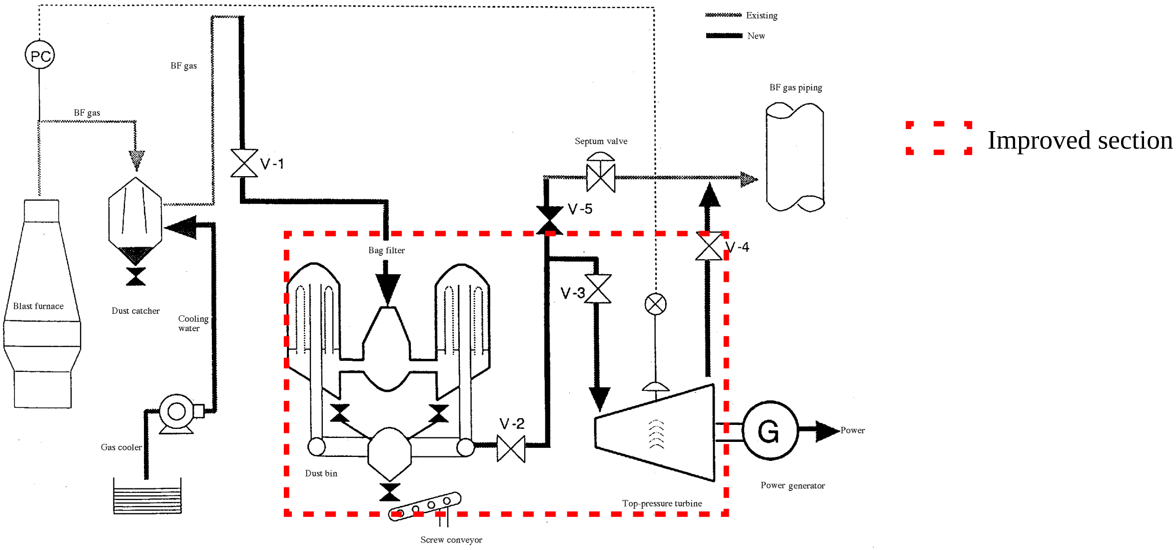


Fig. 2 Dry-type BF top-pressure recovery turbine

Energy saving effects

Reduction in crude oil equivalent::
29,000 - 39,000 kL/y at power generation of 18,000 kW and hot metal production of 3,000 kt/y, wet type.

[Economics] Equipment cost

Investment amount: 1,500 million yen
Improvement effect: 900 million yen/year
Investment payback: 1.7 years

Remarks

This technology was adopted in NEDO's model project for the BF top-pressure recovery turbine at Panzhihua Iron & Steel Group Corporation in Sichuan Province of China (finished in March 1998).

[Example sites]	[References]	[Inquiry]
Adopted 100% at high-pressure BFs.	"Earth-Friendly Steel Making," the Japan Iron and Steel Federation, 1990, p. 16,"Recent Development and Future of Ironmaking Technology," p. 159, NEDO's technical documents	ECCJ (JIEC)

IS-PE-4

Energy Conservation Directory

[Industry Classification] Iron & Steel	DC arc furnace with water cooled furnace wall	[Energy Source] Electricity
[Technology Classification] Production Equipment		[Practical Use] around 1990

Outline

Large energy saving is achieved in an arc furnace which melts and refines ferrous materials such as steel scrap by changing its power source from the conventional 3-phase alternating current (AC) to the direct current (DC).

Principle & Mechanism

1) The largest advantage of the DC arc furnace over the 3-phase AC arc furnace is that it can melt the materials uniformly.
2) In the DC arc furnace, the metal is melted and agitated by the electric current flowing through it and the magnetic field.
3) By adopting the water-cooled furnace wall, high-efficiency operation is achievable.

[Description]

Structure explanation, Shapes, and/or System diagram

[Before improvement]

The following structural diagram shows an AC arc furnace.

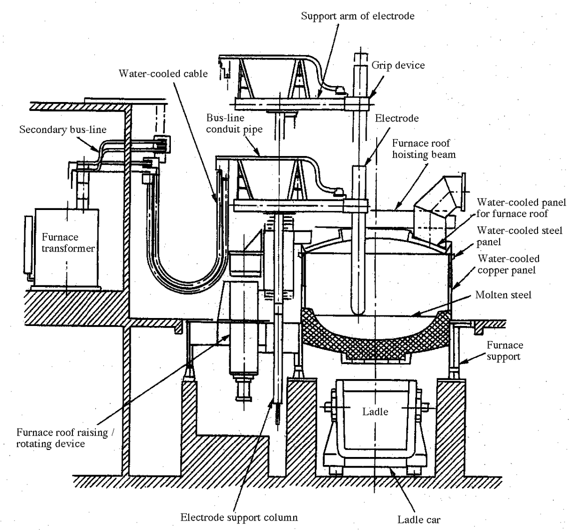


Fig. 1 AC arc furnace

[After improvement]

[Features of DC arc furnace]

- Its arc jet is stable. As the scrap is always placed in contact with the anode, where the energy consumption by arc is large, the temperature-raising efficiency is high.
- The molten metal is aggressively agitated by the electro-magnetic force.
- As flicker generation is reduced by half, large power equipment can be employed.
- As the scrap is melted uniformly, hot spots and cold spots are not easily generated.
- As it has only one moving electrode above the furnace, the superstructure becomes simple.

Shown below is the outline of a DC arc furnace.

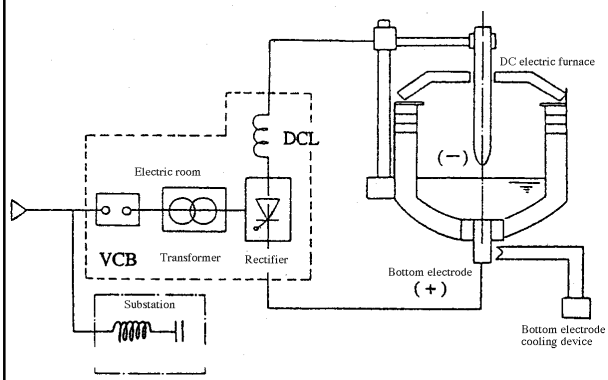


Fig. 2 Structure of DC arc furnace

Energy saving effects

1) Specific power consumption is reduced by 5-10%.
2) Furnace maintenance materials are reduced.
3) Specific electrode consumption is reduced by 40-50%.

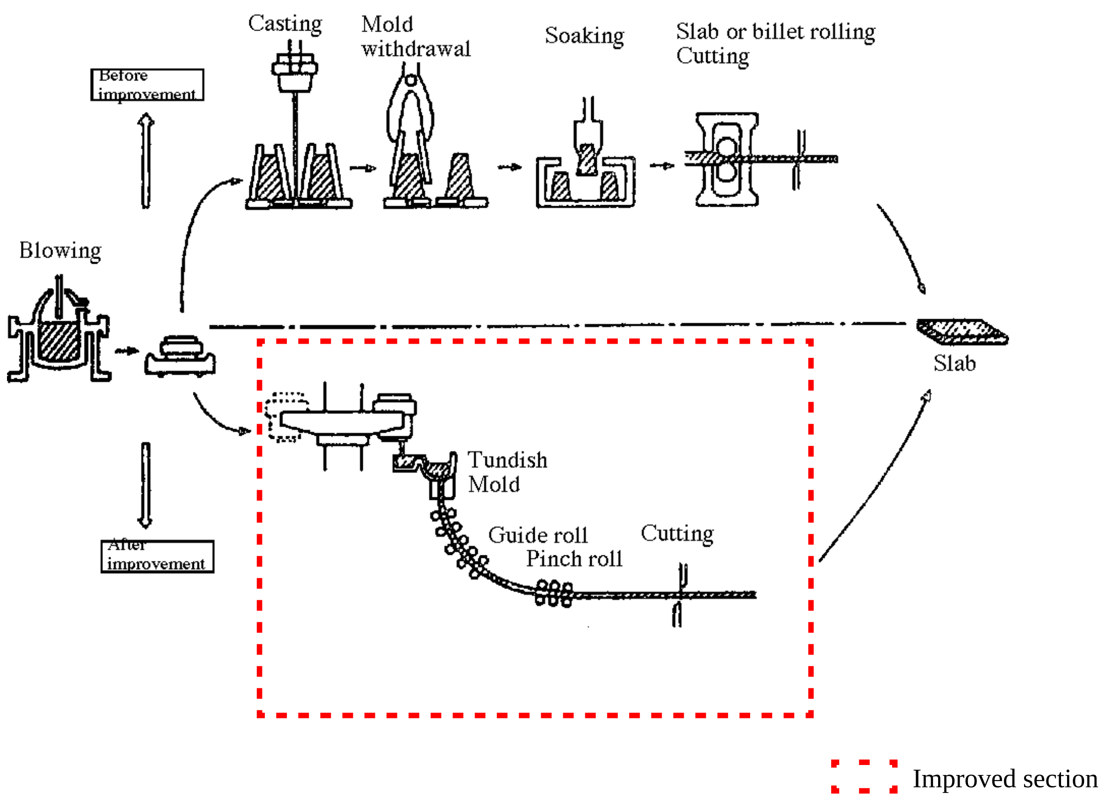
[Economics] Equipment cost

Investment amount: 1,000 million yen
Improvement effect: 250 million yen/year
Investment payback: 4 - 5 years

Remarks

[Example sites]	[References]	[Inquiry]
	Explanation of the energy investment tax credit system Industrial Furnace Handbook	ECCJ (JIEC)

IS-PE-5	Energy Conservation Directory	
[Industry Classification] Iron & Steel [Technology Classification] Production Equipment	Continuous casting machine	[Energy Source] Fuel, electricity [Practical Use] around 1980

Outline	Molten steel discharged from a converter (BOF) or electric furnace (EF) is continuously cast into semi-finished steel materials (semis) such as slabs and blooms by a mold. This continuous casting machine achieves large energy saving by eliminating some of the process steps.
Principle & Mechanism	Molten steel is continuously charged into the mold. It is control-cooled from outside, and withdrawn as it is solidified from the surface and formed into semis. This machine eliminates the ingot casting, soaking, and slab or billet rolling, and achieves large reduction in fuel and power consumption.
[Description] Structure explanation, Shapes, and/or System diagram	In a conventional process, molten steel from a BOF or EF is poured into ingot molds, and solidified. After cooled down, the ingot is withdrawn from the mold, heated up again in a soaking pit, and sent to a slab or billet rolling mill. Continuous casting eliminates these process steps, and directly produces semis by continuously pouring the molten steel into a mold. 
Energy saving effects	Reduction in crude oil equivalent: 25,940 kL/y Reduction of 200,000 kL/t-steel at production of 1,200,000 t/year
[Economics] Equipment cost	Investment amount: 70 - 80 million yen for casting capacity of 1,200,000 t/year Improvement effect: 500 million yen by energy saving, 2,000 million yen by yield improvement Investment payback: 3 years
Remarks	

[Example sites]	[References]	[Inquiry]
Adopted almost 100% at integrated steel mills in Japan	"Collection of Energy Conservation Cases 1997 ," ECCJ	ECCJ (JIEC)

IS-PE-6

Energy Conservation Directory

[Industry Classification] Iron & Steel	Hot charging and direct rolling mill	[Energy Source] Fuel
[Technology Classification] Production Equipment		[Practical Use] around 1970

Outline	High-temperature semi-finished materials (slab, bloom, or billet) just after continuous casting (CC) is charged into the heating furnace with the temperature maintained as high as possible, thus reducing the fuel consumption at the heating furnace. Further, by improving the measures for preventing the temperature drop of the semis after CC, the semis are directly sent to the rolling mill without going through the heating furnace, eliminating the heating process and substantially reducing the fuel consumption.
Principle & Mechanism	The temperature drop of the semis is prevented by various measures: optimal temperature control in CC, hot surface defect inspection, shortened transportation and handling time, strengthened heat-retaining, etc. By the hot charging into the heating furnace and direct rolling made possible by these measures, the fuel for the heating furnace is saved.

[Description]

Structure explanation, Shapes, and/or System diagram

In order to charge the high-temperature semis into the heating furnace with the temperature maintained as high as possible, various measures were incorporated as follows.
1) To shorten the time for transportation and handling.
2) To strengthen the heat-retaining measures.
3) To expand the flawless casting.
4) To synchronize the CC process and the hot-rolling process through appropriate scheduling.
5) To make the temperature of the semis as high as possible.

In order to perform direct rolling, following measures are required in addition to the above: strengthened heat-retaining measures at CC, higher CC speed, higher rolling speed, low-temperature rolling, etc.
Low-temperature rolling is a technology to roll at a temperature as low as possible. One such technology put into practice is an in-line edge-heater.

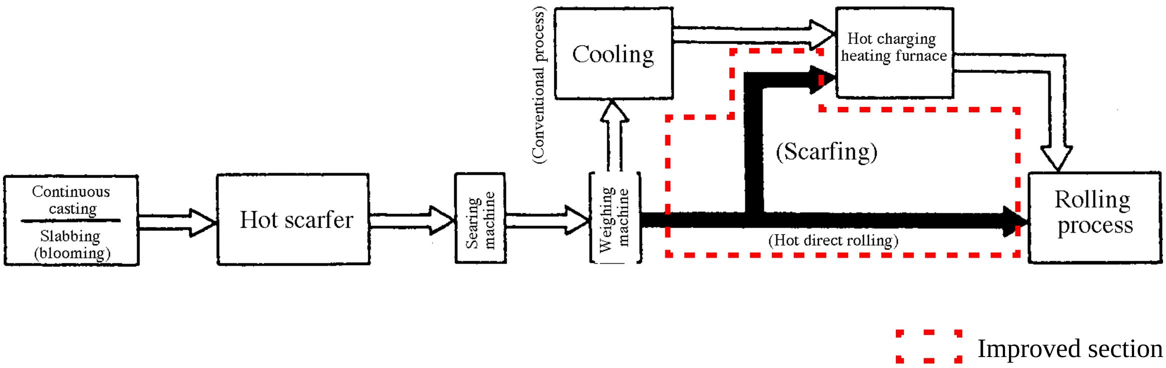


Fig. 1 Hot direct rolling flow diagram

Energy saving effects	Reduction in crude oil equivalent: 16,200kL/t Reduction of 50x103 kcal/t by coupling direct rolling with hot charging at rolling of 3,000 kt/y.
[Economics] Equipment cost	Investment amount: 500 million yen Improvement effect: 200 - 300 million yen/year Investment payback: 3 years
Remarks	

[Example sites]	[References]	[Inquiry]
Hot charging is adopted almost 100%.		ECCJ (JIEC)

IS-PE-7	Energy Conservation Directory	
[Industry Classification] Iron & Steel; [Technology Classification] Production Equipment	Continuous annealing line	[Energy Source] Fuel, electricity; [Practical Use] around 1972

Outline	Electrolytic cleaning, annealing, cooling, temper rolling, and recoiling in a cold-rolling process are integrated into one line.
Principle & Mechanism	Annealing is carried out for the purpose of heat-treating and softening steel sheets which is work-hardened by cold rolling. Workability of the steel sheets is thus improved. Formerly, annealing was carried out by a non-continuous system such as a batch-type annealing furnace. A continuous annealing line was developed in order to save energy, to improve the productivity, and to reduce variations in sheet quality by directly connecting the various processes
[Description] Structure explanation, Shapes, and/or System diagram	1) The material is charged from the one end of the furnace, sent forward mechanically while being heated gradually, and soaked up to a determined temperature (about 700°C). Afterwards, it is cooled down at a certain cooling speed in the cooling zone, and discharged from the other end of the furnace. 2) This system is also applied to the production of material coils for tin plates, stainless steel sheets, etc. 3) The ratio of continuously annealed sheets in cold rolled sheet production has been increasing gradually to about 50%.

[Before improvement]

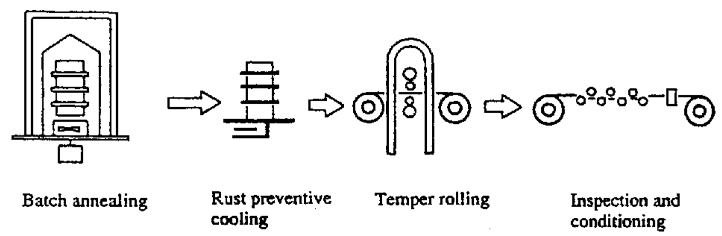


Fig. 1 Batch annealing process flow

[After improvement]

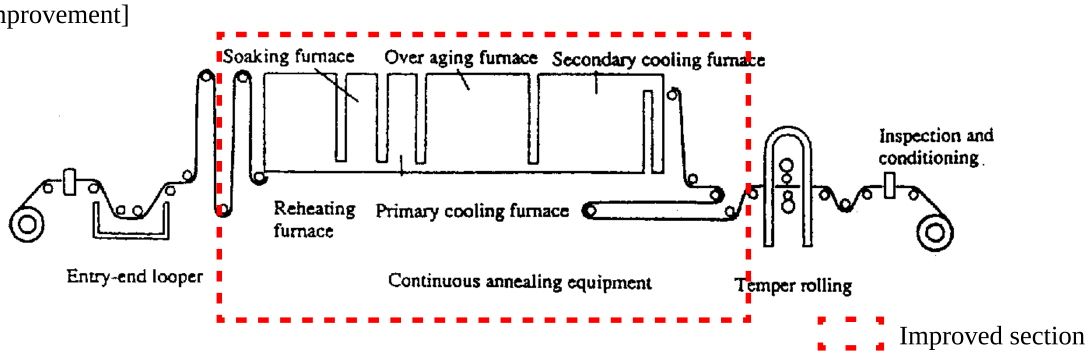
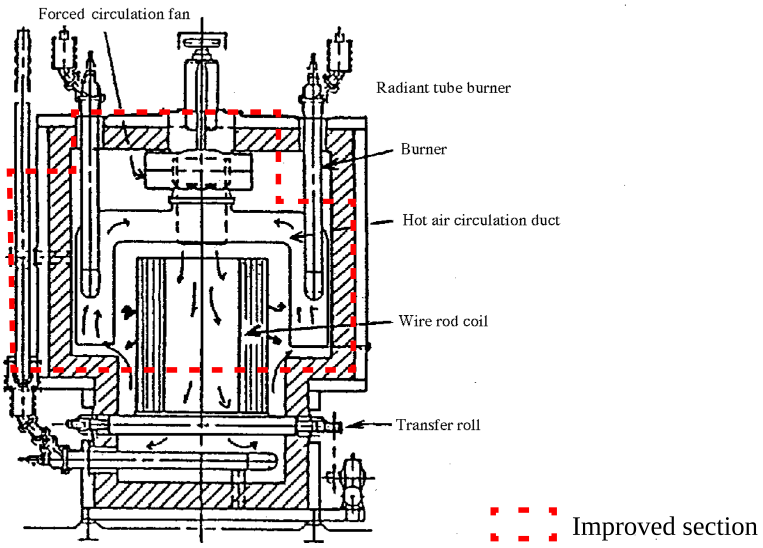


Fig. 2 Continuous annealing process flow

Energy saving effects	Reduction in crude oil equivalent: 10,400 kL/y Reduction of 100,000 kcal/t at production of 960 kt/month
[Economics] Equipment cost	Investment amount: 20,000 - 25,000 million yen Improvement effect: Energy saving and productivity improvement Investment payback: years
Remarks	

[Example sites]	[References]	[Inquiry]
Adopted at many sites for steel sheet production.	Earth-friendly ironmaking, the Japan Iron and Steel Federation, 1990, p. 14 Iron & Steel (Vol. 81, No. 4, 1995, p. 206) Iron & Steel World Report (No. 1296, 1983.5.1, No. 1471, 1989.3.21) Iron & Steel World (No. 1471, 1471, 1989. 3.21)	ECCJ (JIEC)

IS-PE-8	Energy Conservation Directory	
[Industry Classification] Iron & Steel [Technology Classification] Production Equipment	Convection heating type heat treatment furnace for wire rod coil	[Energy Source] Fuel [Practical Use] around 1985

Outline	In order to shorten the time required for spheroidizing annealing of wire rod coils, a forced circulation fan was installed, which blows a large amount of hot air into the coils from inside, and performs forced convection heat transfer cooling, which improves the heat transfer efficiency and shortens the treatment time.
Principle & Mechanism	The outside of the wire rod coils is heated by the radiation from the radiant tube heat source as well as by the convection heat transfer by the forced circulation fan installed at the top cover. Hot air is forced into the inside of the coils by the fan. It passes through among the individual strands of the coils, and heats up the coils. Forced convection heat transfer by the fan improves the heat transfer efficiency, shortens the treatment time, and saves energy. At the time of cooling, an indirect gas cooler is employed for rapid cooling, instead of the radiant tubes.
[Description] Structure explanation, Shapes, and/or System diagram	In a conventional heat treatment of wire rod coils, a heat source is installed along the outer periphery of the coils, and the outside of the coils is kept at a designated temperature. Fig. 1 shows the cross section of a heat treatment furnace equipped with a rapid heating device. Hot air is forced into the inside of the coils by the forced circulation fan installed at the top cover. It rapidly passes through among the individual strands of the coils, and heats up the coils. The hot air which exchanged its heat with the coils passes through the hot air circulation duct equipped with radiant tubes, is given the required heat, and returns to the forced circulation fan. Thus, the coils are rapidly heated by the forced convection heat transfer within the coils. At the time of forced cooling, an indirect gas cooler is employed for rapid cooling, instead of the radiant tubes.  Fig. 1 Structure of a rapid heating furnace
Energy saving effects	The rapid heat treatment furnace saves approx. 5.5 hours compared to the conventional heating furnace, requiring only 14.5 hours for annealing. Heating time Reduced by approx. 2.5 hours Cooling time Reduced by approx. 3 hours Therefore, approx. 25% of fuel can be saved for heat treatment.
[Economics] Equipment cost	Investment amount: 200 million yen Improvement effect: 40 - 50 million yen/year Investment payback: 4 - 5 years
Remarks	

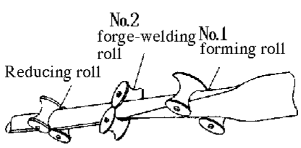
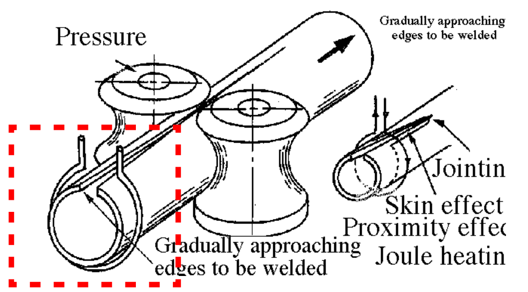
[Example sites]	[References]	[Inquiry]
	Electric Steel Making "Recent Technical Development in Heat Treatment equipment," p. 313-315, Oct. 1994	ECCJ (JIEC)

IS-PE-9	Energy Conservation Directory	
[Industry Classification] Iron & Steel [Technology Classification] Production Equipment	Low temperature forge welded pipe production method	[Energy Source] Fuel [Practical Use] around 1979

Outline	Electro-magnetic induction heating (an edge heater) was introduced in forge-welded pipe production, and the temperature of steel hoops at the exit of a continuous heating furnace was reduced from the previous high temperature (1300˚C) to 1200˚C, the edge being locally heated. Accordingly, specific fuel consumption of the heating furnace was reduced.
Principle & Mechanism	1) The automatic control system is introduced to control the edge to the constant temperature (an electro-magnetic induction heating method). 2) A seam cooling device is installed to eliminate the temperature difference in the circumference direction of pipes. The prevention of beading and bending is made possible. 3) The forge welding roll in the mill has a motor driven screw down mechanism to control the forge welding stress.

[Description]

Structure explanation, Shapes, and/or System diagram

		New process	Conventional process
Equipment		-	At the heating furnace exit, the electro-magnetic induction heater (including a set of 650kW elec power source) is required.
Production method		Control of heating conditions of the heating furnace only.	A control of forge welding stress is possible. An accuracy of forge welding temperature control is improved. A seam cooling method is adopted. The heating temperature of steel hoops is reduced.
Raw materials		Steel hoop	Steel hoop
Specific consumption	Fuel	491.6 x 10^3 kcal/ton	361.9 x 10^3 kcal/ton
	Electric power		6.6 kWh/ton
Product quality		Quality control is difficult to be achieved by heating conditions only.	An improved accuracy of forge welding stress is possible.
Remark		1300˚ C heating	Low heating temperature reduces the loss by scale generation. (1200C heating)
		 The hoop is heated in the heating furnace, and forge-welded into a pipe shape.	

Improved section

Energy saving effects	Reduction in crude oil equivalent: 7,500 kL/y Reduction of energy consumption: 115 x 103 kcal/t at the production of 50,000t/m.
[Economics] Equipment cost	Investment amount: 12,500 million yen Improvement effect: 200 million yen/year by energy saving and 200 million yen by improvement productivity Investment payback: 3.5 years
Remarks	

[Example sites]	[References]	[Inquiry]
Hot charging is adopted almost 100%.	Energy & Resources (Vol. 4, No. 5, 1983, p. 427) Iron & Steel (Vol. 81, No. 4, 1995, p. 52, 97) Iron & Steel World (1990. 7, p. 23)	ECCJ (JIEC)

IS-PE-10

Energy Conservation Directory

[Industry Classification] Iron & Steel	High frequency melting furnace	[Energy Source] Electricity
[Technology Classification] Production Equipment		[Practical Use] around 1979

Outline

A melting furnace for steel (such as stainless steel, cast steel, nickel and other alloy steel: direct melting method), and copper, brass, aluminum, noble metal and other nonferrous metals (carbon or metallic crucibles are used: indirect melting method).

Principle & Mechanism

1) Frequency and power are selected, and the high frequency induction current, with enhanced current density which is 2 ~ 5 times higher than that of the low frequency method, is generated. This current generates heat by internal resistance of the material, and performs melting.
2) Steel and alloy steel are melted by the resistant heat generated by the induction current that flows in the steel itself.
3) Nonferrous metals and nonmetals are heated and melted by the conduction heat from the induction heating element such as graphite and metallic crucibles.

[Description] Structure explanation, Shapes, and/or System diagram

The table below compares a high-frequency melting furnace with a low-frequency melting furnace.

Low-frequency melting furnace	High-frequency melting furnace
1) It can not perform rapid melting because the electric current density needs to be maintained low in view of the agitating force. As it is difficult to inject electric power to small-sized materials, melting takes longer time. 2) Batch-type intermittent operation needs a starting block or heel. 3) The equipment cost is lower than that of a high-frequency furnace.	1) It can rapidly melt small-sized? materials. This is because high-frequency current can penetrate deeper, and eddy current is generated even in the small-sized materials. 2) With high-frequency current, larger electric power can be applied, and rapid melting is possible. As radiation heat loss is small, energy is saved. 3) Batch-type intermittent operation is possible. A starting block or heel is not needed. 4) As it needs a high-frequency power source, the equipment cost is higher than that of a low-frequency furnace.

Energy saving effects

Table 1 Comparison of High-frequency and low-frequency melting furnaces

Furnace capacity: 3t	Low-frequency melting furnace	High-frequency melting furnace	Energy-saving effect
Specific consumption (kWh/t)	719	630	12.3%
Melting speed (kg/h)	910	1550	Total production of a plant: Increase by 19.5%
Electricity (kW)	750	1500	Electricity savings: 840,000 yen/month

[Economics] Equipment cost

Investment amount: 100 million yen
Improvement effect: 10 million yen/year by energy saving and 20 million yen by quality improvement
Investment payback: 3 - 4 years

Remarks

[Example sites]	[References]	[Inquiry]
	"Industrial Electric Heating," ECCJ	ECCJ (JIEC)

IS-PE-11	Energy Conservation Directory	
[Industry Classification] Iron & Steel [Technology Classification] Production Equipment	Channel induction furnace for cast iron melting	[Energy Source] Electricity [Practical Use] around 1980

Outline	Induction furnaces have two types: crucible type and channel type. Recently the channel type is more widely used because of its higher overall heat efficiency.
Principle & Mechanism	A crucible-type furnace was conventionally used for melting cast iron, using coke or low-frequency non-iron-core induction as a heat source. The current trend is to perform continuous operation using a channel-type low-frequency induction furnace and save energy.

[Description]

Structure explanation, Shapes, and/or System diagram

Crucible-type induction furnace

A crucible-type induction furnace has a crucible-type melting chamber made of refractory which is set inside of a cylindrical water-cooled induction coil. Materials are charged in it and melted. Yokes are attached around the induction coil as return circuits of magnetic flux for preventing the structural members of the furnace from being heated.

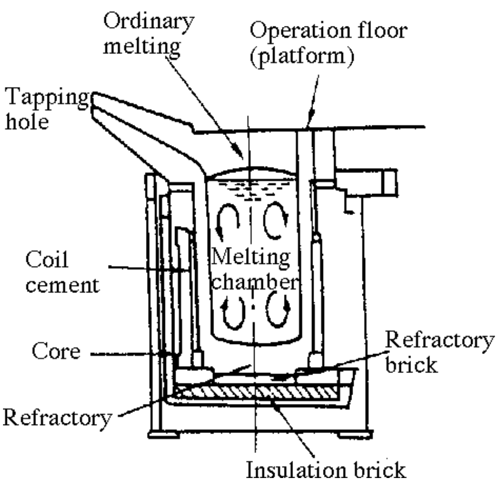


Fig. 1 Crucible-type induction furnace

Channel-type induction furnace

A channel-type induction furnace has a primary coil wound around a closed-circuit core, which is surrounded by the refractory acting as a secondary coil. The refractory is shaped into a channel, which holds molten metal. The molten metal acts as a secondary circuit, through which secondary short-circuit current flows and heats the molten metal. As the channel section (heat-generating section) is structurally small, electric power able to be injected is limited. Therefore its melting capacity is small. As molten metal always needs to be maintained in the channel section, it is mainly used as a retaining furnace.

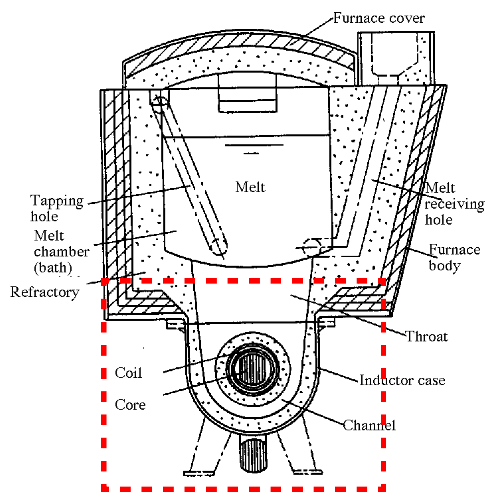


Fig. 2 Channel-type induction furnace

Energy saving effects

	Before improvement (crucible-type)	After improvement (channel-type)
1. Power efficiency	60% - 80%	95% - 97%
2. Overall efficiency	55% - 65%	75% - 85%
3. Specific power consumption	High	Low
4. Need of heel	Not needed	Needed
5. Intermittent operation	Arbitrarily possible	Principally 2 shifts or continuous operation

[Economics] Equipment cost

Investment amount: 100 million yen
Improvement effect: 10 million yen/year by energy saving and 20 million yen by yield improvement
Investment payback: 4 years

Remarks

[Example sites]

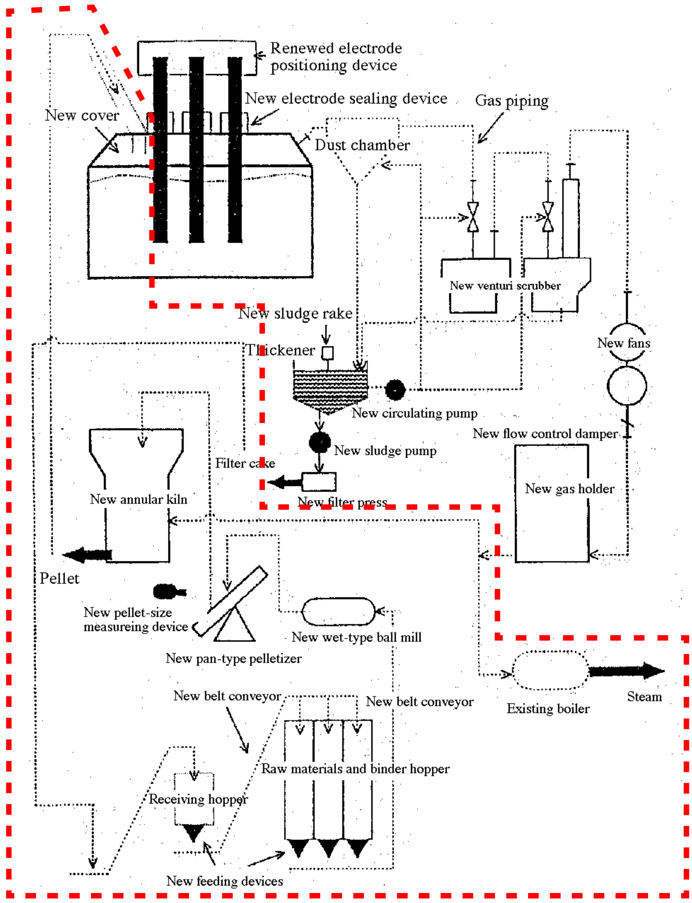
[References]

The Agency of Natural Resources and Energy, “Energy Conservation Equipment Directory,” p. 266, the Energy Conservation Center, Japan, 1982

[Inquiry]

ECCJ (JIEC)

IS-PE-12	Energy Conservation Directory	
[Industry Classification] Iron & Steel	Ferroalloy furnace for effective energy utilization	[Energy Source] Electricity, others
[Technology Classification] Production Equipment		[Practical Use] 1970’s

Outline	The electric furnace for smelting HC-FeCr (high-carbon ferrochromium) refines chromium ore using coke as a reducing agent. However, as the ratio of fine chromium ore increased in recent years, permeability in the electric furnace decreased, and specific consumption of electric power and coke increased. The system described here reduces energy consumption for producing HC-FeCr, and recovers the combustible exhaust gas.
Principle & Mechanism	When fine chromium ore is agglomerated and calcined into pellets by the annular furnace and the pellets are charged to the electric furnace in place of fine chromium ore, permeability in the furnace increases, which increases the heat exchange rate among charged materials, and decreases specific power consumption. Exhaust gas from the furnace is used as a fuel of the burner for pellet calcination. Excess gas is converted into steam, and steam purchase from outside is reduced.
[Description] Structure explanation, Shapes, and/or System diagram	As pellets are charged to the electric furnace in place of fine chromium ore, permeability of gas generated in the furnace increases, which increases the heat exchange rate among charged materials, and decreases specific power consumption.  Improved section Fig. 1 Flow diagram of ferroalloy furnace for effective energy utilization
Energy saving effects	Energy saving: Electric power, etc. Reduction in crude oil equivalent is 12,570 tons/y. When applied to 7 electric furnaces of more than 10,000 KVA each, reduction in crude oil equivalent is 80,000 tons/y.
[Economics] Equipment cost	Investment amount: 1,000 million yen Improvement effect: 200 - 300 million yen/year Investment payback: 4 - 5 years
Remarks	1) Combustible gas recovery by installing a cover on an electric furnace is applicable to the production of HC-FeMn, SiMn, etc. as well as HC-FeCr. 2) This technology is planned to be adopted in NEDO’s model project of the ferroalloy furnace for effective energy utilization at Liaoyang Metal Group Corporation in Liaoning Province of China (planned to be finished in March 2001).

[Example sites]	[References]	[Inquiry]
Adopted at many sites.	Steel makers’ in-house information	ECCJ (JIEC)

IS-ME-1	Energy Conservation Directory	
[Industry Classification] Iron & Steel	Coal drying and humidity control equipment for coke oven	[Energy Source] Coal
[Technology Classification] Machinery & Equipment		[Practical Use] around 1983

Outline

Equipment which reduces the humidity in the coal to be charged into a coke oven by heating in order to reduce fuel consumption in the coke oven. The equipment is being introduced actively in order to reduce the heat consumption for carbonization and to utilize a large amount of non-coking coal.

Principle & Mechanism

Fuel consumption in the coke oven is reduced by heating the coal and reducing the humidity. The water content in coal is generally 7 - 11%, which is reduced to about 6%: a level which does not hinder the charging operation by generating dust.
Mainly, steam is used for heating coal.
Coal humidity control equipment is installed in the middle of the transportation path from the coal blending bed to each of the coal bins for the coke ovens.
When the water content in coal is reduced too much, dust is generated during transportation and the resistance in coke Åépushing operation increases.

[Description] Structure explanation, Shapes, and/or System diagram

The conceptual diagram of the coal drying and humidity control equipment for a coke oven is illustrated below.

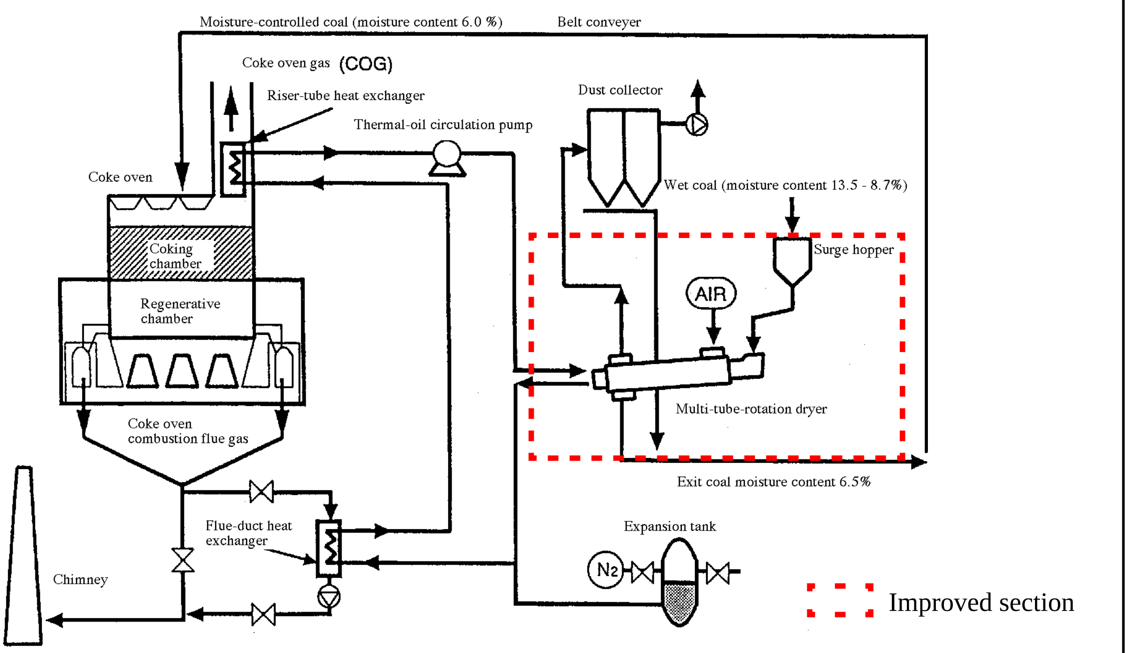


Fig. 1 The coal drying and humidity control equipment for a coke oven

Energy saving effects

Energy saving: 40,000-80,000 kcal/t-coal (18,000 kcal/t-coal per 1% of water-content reduction)
The charging amount of coal in a coke chamber is increased, and coke quality is improved by the increased density of coal charging.
Productivity is increased by about 5.9% when the water content is reduced by 2.9%.

[Economics] Equipment cost

Investment amount: 2,000 million yen for charge coal of 3,200 kt/year
Improvement effect: 700 - 1,000 million yen/year
Investment payback: 3 years

Remarks

This technology was adopted in NEDO's model project for the coal drying and moisture control equipment for coke ovens at Changing Iron & Steel Company in the City of Chonging of China (finished in December 1996).

[Example sites]	[References]	[Inquiry]
10 facilities in steel plants in Japan (1993)	Recent Development and Future of Ironmaking Technology (1993, p. 10,63) Iron & Steel World Report (No. 1311, 1983.10.21) Iron & Steel (Vol. 81, No. 4,1995, p. 9) NEDO's technical documents, etc.	ECCJ (JIEC)

IS-ME-2

Energy Conservation Directory

[Industry Classification] Iron & Steel	Coke dry quenching	[Energy Source] Fuel
[Technology Classification] Machinery & Equipment		[Practical Use] around 1976

Outline

This improvement is to use equipment which cools red heat coke produced in a coke oven by exchanging heat with inert gas in a sealed vessel, and recovers the heat as steam or electricity.

Principle & Mechanism

Coke production consumes 7-8% of the whole energy consumed in an integrated steel plant. About 45% of it is the sensible heat of red heat cokes coming out of coke ovens. Conventionally the red heat cokes just after coking, which have the temperature of 1,000-1,200˚C, are cooled by water spray, and the sensible heat is dissipated into the atmosphere. Coke dry quenching is to recover this waste heat by performing heat exchange with inert gas such as combustion exhaust gas in a sealed vessel, heating the gas to about 800˚C, and generate steam by a boiler.

[Description]

Structure explanation, Shapes, and/or System diagram

[Before improvement]

Red heat cokes were cooled by water spraying.

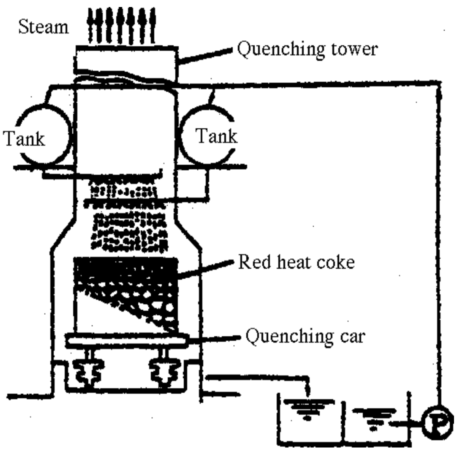


Fig. 1 Water-spraying coke quenching equipment

[After improvement]

Red heat cokes are charged into the chamber, and exchanges heat with inert gas, which generates steam in the boiler.

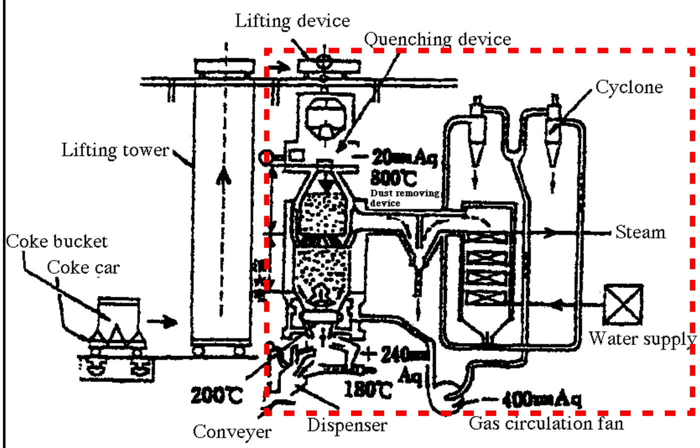


Fig. 2 Dry quenching equipment

Improved section

Energy saving effects

Table 1 Energy-saving effect

	Before improvement	After improvement
Reduction of energy consumption kcal/pig-T	Base	291 x 10^3

(Specification: Coke treating capacity 150t/h,
Coke temperature 1,200—>200˚C, boiler efficiency 80%, BF coke ratio 480kg/t-pig)

[Economics] Equipment cost

Investment amount: 5,700 million yen
Improvement effect: 2,000 million yen/year
Investment payback: 2.9 years

Effect: (Benefit) - (Incremental cost) = (Steam generation ,2600 million yen/y) - {(Electricity etc. 500 million yen/y) + (Operation & Maintenance 100 million yen/y)} = 2,000 million yen/y

Remarks

This technology was adopted in NEDO’s model project for coke dry quenching at Shougang Group Corporation in the City of Beijing of China (planned to be finished in March 2001).

[Example sites]	[References]	[Inquiry]
Mostly installed.	The Agency of Natural Resources and Energy, “Energy Conservation Equipment Directory,” p. 40 The 146th and 147th Nishiyama Memorial Technology Seminars, p. 67	ECCJ (JIEC)

IS-ME-3	Energy Conservation Directory	
[Industry Classification] Iron & Steel [Technology Classification] Machinery & Equipment	Exhaust heat recovery system for sintered ore cooling equipment	[Energy Source] Fuel [Practical Use] around 1970

Outline	Fine iron ore is mixed with fine coke, powdered limestone, etc., heated, and agglomerated into sintered ore in the sintering machine, and used as a blast furnace raw material. Red-heat sintered ore just after sintering is air-cooled in the cooler. Sensible heat of hot exhaust gas from the cooler is recovered.
Principle & Mechanism	Sintered ore discharged from the sintering machine has the temperature of 500 - 750˚C, and cannot be transported directly to the blast furnace. Therefore, the air-cooling-type cooler is installed at the exit of the sintering machine. The sensible heat of the high-temperature part (250 - 450˚C) of the cooler exhaust gas is recovered as steam. The power generation system using low-volatile flon-based medium (florinol) has been developed and put to practical use.
[Description] Structure explanation, Shapes, and/or System diagram	A conceptual diagram of steam recovery from a sintered ore cooler is illustrated below.

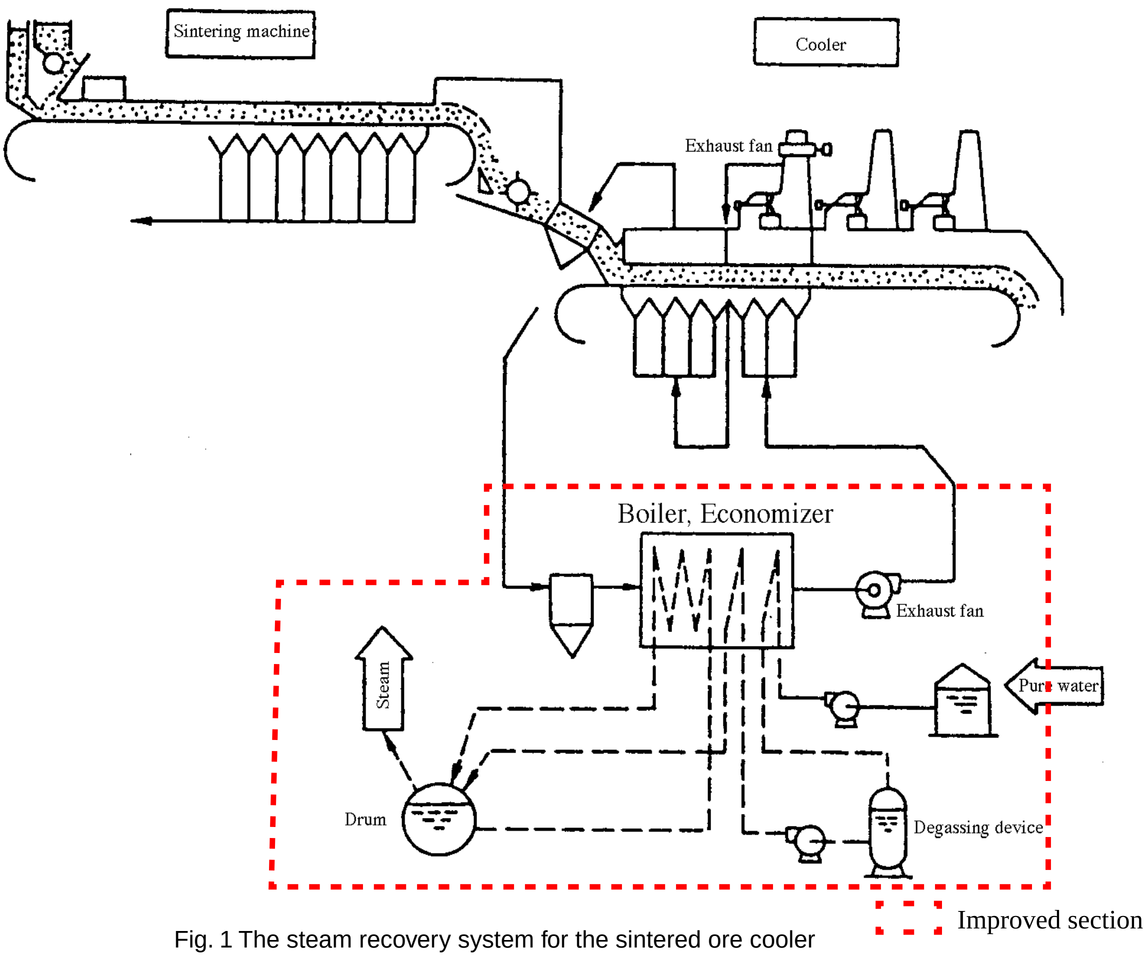


Fig. 1 The steam recovery system for the sintered ore cooler

Energy saving effects	Reduction in crude oil equivalent: 3,500 kL/y Reduction in calorific value: 60,000 kcal/t-sinter
[Economics] Equipment cost	Investment amount: 2,000 million yen Improvement effect: million yen/year Investment payback: years
Remarks	This technology was adopted in NEDO's model project for the exhaust heat recovery system for the sintered ore cooling equipment at Taiyuan Iron & Steel Group Company in Shanxi Province of China (finished in March 1998).

[Example sites]	[References]	[Inquiry]
Adopted 53% (1992)	Iron & Steel World Report(No. 1248, 1981.10.21, No. 1280, 1982. 10.21) NKK Technical Review (No. 84, 1980, p. 25) Sumitomo Metal (Vol. 84, 1980, p. 25)	ECCJ (JIEC)

IS-ME-4	Energy Conservation Directory	
[Industry Classification] Iron & Steel [Technology Classification] Machinery & Equipment	Sensible heat recovery from main exhaust gas of sintering machine	[Energy Source] [Practical Use] 1977

Outline	In a sintering machine, fine iron ore is mixed with fine coke, powdered limestone, etc., heated, and agglomerated into sintered ore, which is used as a blast furnace raw material. In this improvement, the main exhaust gas heat recovery and circulation process was adopted in addition to the cooler exhaust heat recovery. The main exhaust gas, which was previously dissipated into the atmosphere once its heat was recovered, is now returned back to the sintering machine, further enhancing the heat recovery efficiency.
Principle & Mechanism	In this process, using the waste heat boiler, the heat is recovered from the gas of the temperature of about 380˚C exhausted from the sintering machine, and then the gas is returned back to the sintering machine. By this method, the heat recovery is increased by about 30% and at the same time, emission of NOx, SOx, etc., into the atmosphere is reduced.
[Description] Structure explanation, Shapes, and/or System diagram	The following diagram shows steam recovery from main exhaust gas of a sintering machine.

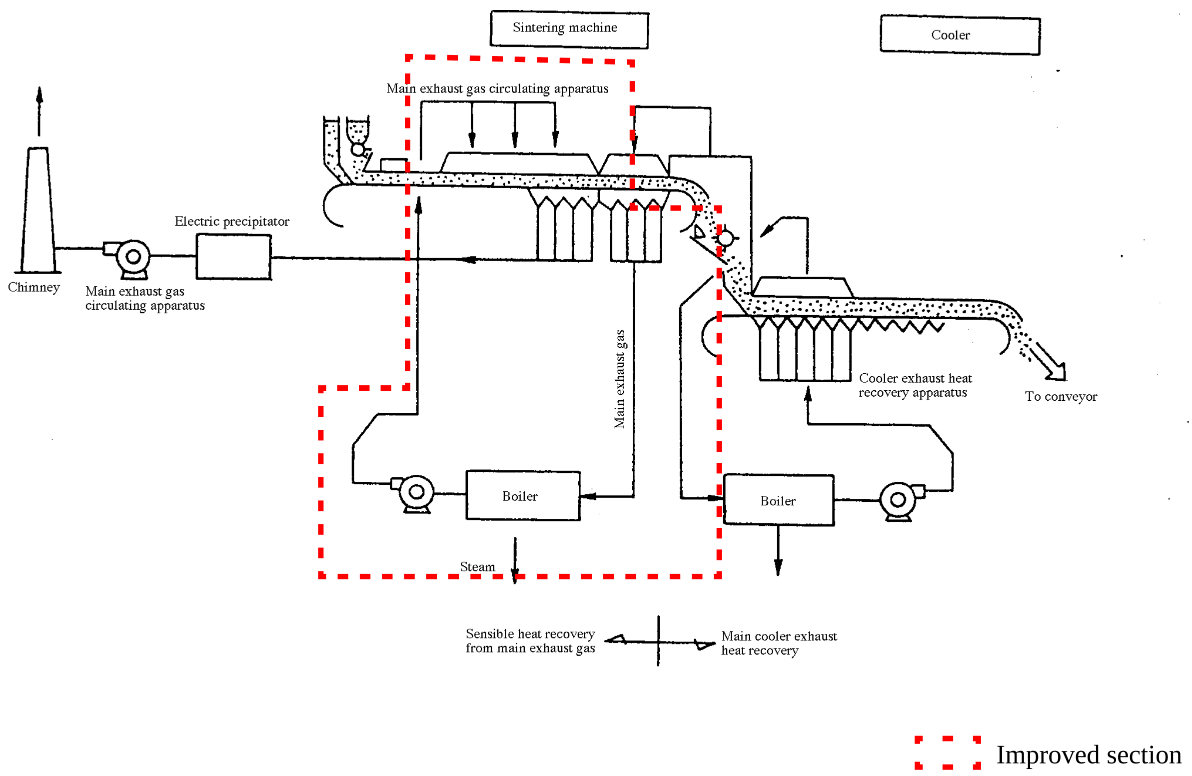


Fig. 1 Steam recovery from main exhaust gas of a sintering machine

Energy saving effects	Reduction in crude oil equivalent: 8,430 kL/y Reduction of 30,000 kcal/t-sinter at sinter production of 2,600,000 t/year
[Economics] Equipment cost	Investment amount: 400 million yen Improvement effect: 150 yen/year Investment payback: 3 years Steam generation from a boiler is 10 t/h.
Remarks	

[Example sites]	[References]	[Inquiry]
Adopted 40%	Recent Development and Future of Ironmaking Technology (p. 17), Materials and Process (Vol. 4,1991, p. 1136) , Power (Vol. 34, No. 169, 1985, p. 20), Ironmaking Research (No. 313, 1984, p. 55), Iron & Steel World Report (No. 1280, 1982.10.12), Sumitomo Metal (Vol. 34, No. 3, 1982, p. 534), Iron & Steel (Vol. 81, No. 4,1995, p. 10,11)	ECCJ (JIEC)

IS-ME-5

Energy Conservation Directory

[Industry Classification] Iron & Steel

[Technology Classification] Machinery & Equipment

Hot stove exhaust heat recovery equipment

[Energy Source] Exhaust gas

[Practical Use] around 1970

Outline

This is the equipment which improves the combustion heat efficiency and saves energy by preheating combustion air and fuel gas for a blast-furnace hot stove by utilizing the sensible heat of combustion waste gas exhausted from the hot stove.

Principle & Mechanism

1) There are two types: one has separate heat exchangers for heat receiving and heat radiating, and heat medium is forced to circulate between the two; the other uses a regenerative heat exchanger and directly preheats combustion air.
2) When preheating fuel gas, the type which has the heat exchangers completely separated is advantageous in view of safety, because fuel gas does not come in contact with high-temperature gas, and there is no danger of explosion.

[Description] Structure explanation, Shapes, and/or System diagram

1) The flow chart and external appearance of the equipment are shown below.
2) Inlet temperature of the exhaust gas: 350˚C or under, estimated temperature of air and fuel gas: approx. 220˚C

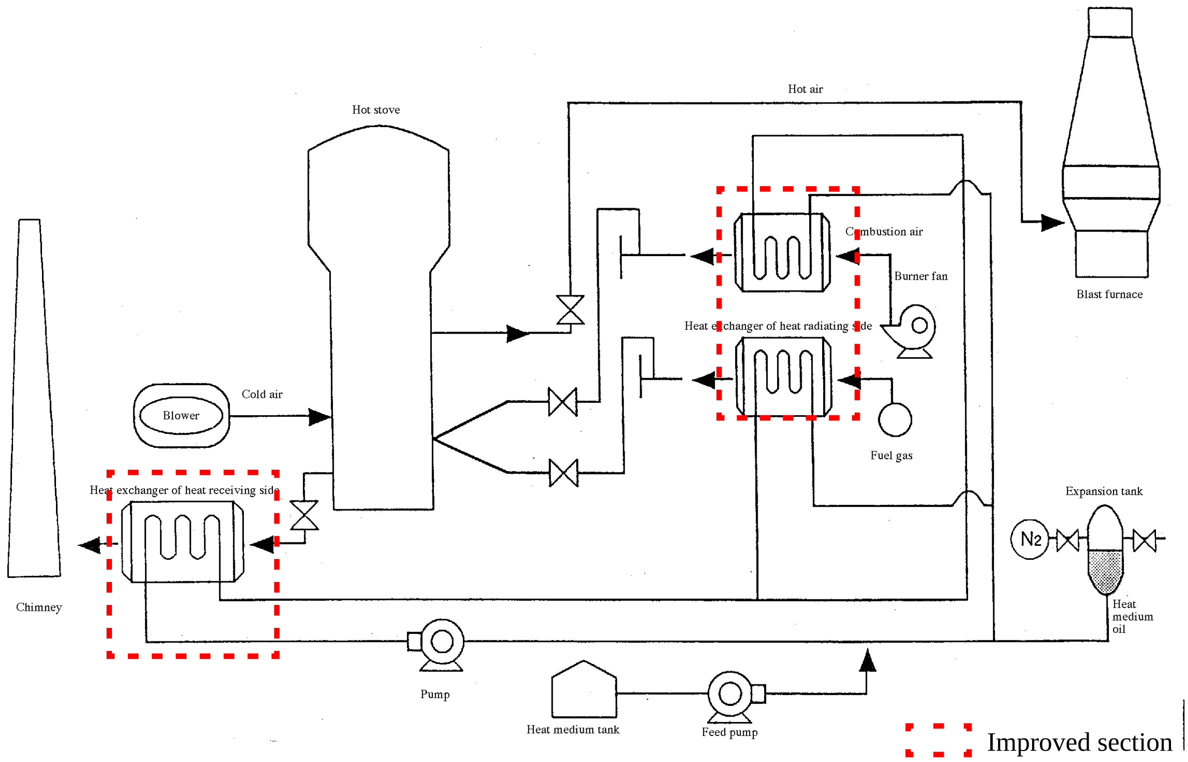


Fig. 1 Flow of heat medium type hot stove exhaust heat recovery

Energy saving effects

Reduction in crude oil equivalent: 9,700 kL/y
Reduction of 30,000 kcal/s-t at crude steel production of 3,000 kt/y
40 - 50% of the sensible heat of waste gas is recovered.

[Economics] Equipment cost

Investment amount: 500 million yen
Improvement effect: 200 - 300 million yen/year
Investment payback: 3 years

Remarks

This technology was adopted in NEDO's model project for the hot stove exhaust heat recovery equipment at Laiwu Iron & Steel Company in Shandong Province of China (finished in March 1998). It is also planned to be adopted in the NEDO project at Gangdar Iron & Steel Company in Hebei Province.

[Example sites]

[References]

The Agency of Natural Resources and Energy, "Energy Conservation Equipment Directory," p. 406, ECCJ

[Inquiry]

ECCJ (JIEC)

IS-ME-6

Energy Conservation Directory

[Industry Classification] Iron & Steel

[Technology Classification] Machinery & Equipment

BOF exhaust gas recovery device (including sealed BOF)

[Energy Source]

[Practical Use] 1962

Outline

Exhaust gas generated during a BOF (Basic Oxygen Furnace) refining process is high-temperature gas containing mainly CO. Much dust is included as well. A large volume of gas is generated intermittently. Energy of BOF exhaust gas is recovered and utilized.

Principle & Mechanism

1) For cooling and dust removing of BOF gas, there are two types of systems: combustion type (full-boiler type, half-boiler type) and non-combustion type (OG type). In the past, the combustion-type gas recovery system was the mainstream, but at present, the non-combustion-type recovery system (OG type) is mainly used due to the fact that small-sized facilities can cope with BOFs which are getting larger and it can collect the combustion gas as well.
2) The recovered gas has the CO content of more than 60% and the heating value of about 2,000 kcal/Nm^3. It can be used as the fuel for boilers, rolling mills, and power generation plants.
3) Recently, the sealed-type OG method has been developed and is getting widely used, where the section between the furnace throat and the skirt is sealed during refining in order to reduce the recovery loss of BOF gas.

[Description] Structure explanation, Shapes, and/or System diagram

The following diagram shows the BOF exhaust gas recovery system.

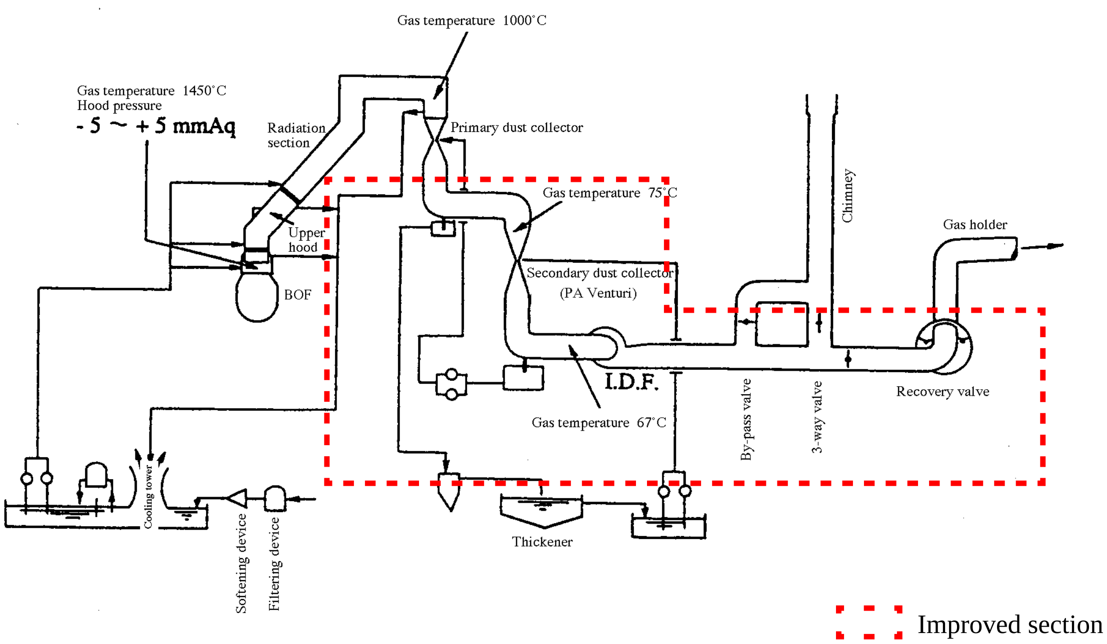


Fig. 1 The BOF exhaust gas recovery system

Energy saving effects

Recovered energy from BOF exhaust gas is 200,000 - 270,000 kcal per ton of crude steel.
The increased amount of BOF exhaust gas recovery by the sealed-type OG method is about 20,000 kcal per ton of crude steel.
It has following advantages compared with the combustion-type exhaust gas treatment method.
1) It is compact.
2) The construction cost is low.
3) The operation cost is low.
4) The efficiency of dust collection from the exhaust gas is high.
5) Recovered gas can be used as a clean fuel of a negligible sulfur content.

[Economics] Equipment cost

Specification: BOF capacity 250 t/h
Investment amount: 2,000 million yen
The investment per unit BOF capacity (t/charge) is 6 - 10 million yen.

Remarks

This technology was adopted in NEDO's model project for the hot stove exhaust heat recovery equipment at Ma'anshan Iron & Steel Company in Anhui Province of China (planned to be finished in March 2002).

[Example sites]

[References]

Iron & Steel (Vol. 81, No. 4, 1995, p. 49)
Ironmaking Research (Vol. 15, No. 2, 1993, p. 40)
Kawasaki Steel Technical Review (Vol. 15, No. 2, 1983, p. 462)
Iron and Steel Handbook (Iron and Steel Making) Version 3, 1982, p. 462

[Inquiry] ECCJ (JIEC)

IS-ME-7

Energy Conservation Directory

[Industry Classification]	BOF gas sensible heat recovery apparatus	[Energy Source]
Iron & Steel		Fuel
[Technology Classification]		[Practical Use]
Machinery & Equipment		around 1979

Outline	When recovering BOF exhaust gas, the gas is first cooled down in the flue duct, its heat being taken away by cooling water, and the cooling water is turned into hot water. This hot water is used to heat the heat-medium liquid, which is used to generate steam. The steam is effectively utilized as process steam in the plant or used to generate electricity by a steam turbine.
Principle & Mechanism	The BOF gas has the temperature of 1,300-1,700Åé at the throat of the BOF. Its sensible heat is recovered as steam by installing a boiler in the gas recovery system. Previously, heat was recovered only at the radiation section. Now, heat is recovered at the BOF throat, etc.

[Description]

Structure explanation, Shapes, and/or System diagram

The following diagram shows the sensible heat recovery apparatus for BOF gas.

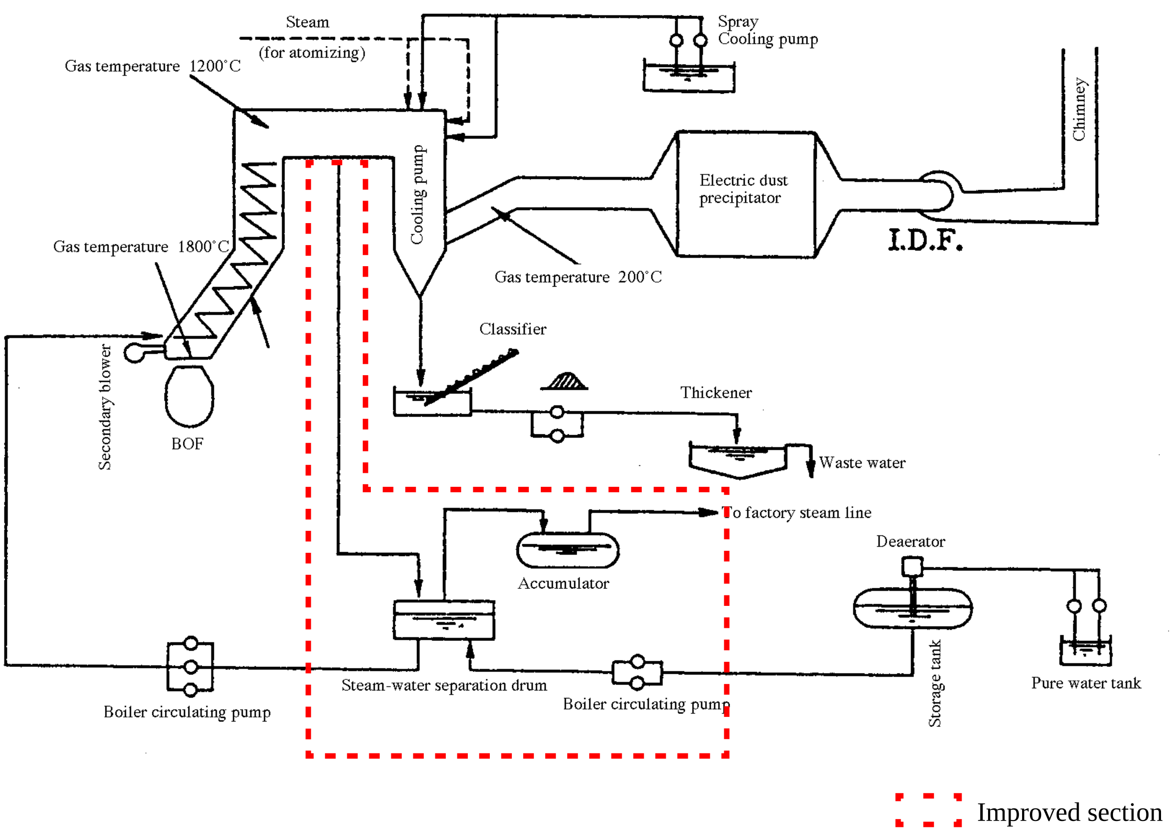


Fig. 1 The sensible heat recovery apparatus for BOF gas

Energy saving effects	Energy saving in crude oil equivalent : 9,700 kL/t Reduction of 30,000 kcal/t-s at the crude-steel production of 3,000 kt/year
[Economics] Equipment cost	Investment amount : 1,500 million yen Improvement effect: 200 yen/year Investment payback: 7 - 8 years in the case of a 250t/charge furnace
Remarks	

[Example sites]	[References]	[Inquiry]
Adopted 56% (1992)	Sumitomo Metal (Vol. 32, No. 4, 1980, p. 424) Kawasaki Steel Technical Review (Vol. 15, No. 2, 1983, p. 40)	ECCJ (JIEC)

IS-ME-8	Energy Conservation Directory	
[Industry Classification] Iron & Steel [Technology Classification] Machinery & Equipment	Raw material preheater for electric arc furnace	[Energy Source] Electricity [Practical Use] around 1981

Outline	The heat efficiency of the electric arc furnace is improved, hence its electric power consumption is reduced, by utilizing the sensible heat of high-temperature exhaust gas from the electric furnace to preheat the scrap.
Principle & Mechanism	1) With the bucket preheating method, the exhaust gas temperature is 500-1,000˚C. It goes down to 150-400˚C after recovery. The disadvantage is that the oil attached to the scrap needs to be removed by after-burning. 2) With the 1-power-source 2-furnace method, the furnace itself is used for preheating the scrap instead of a scrap-charging bucket. While one furnace melts charged material, the other preheats the scrap. Scrap is heated to a higher temperature than by bucket preheating. 3) With the shaft-furnace method, scrap is preheated in the shaft furnace installed above the furnace.
[Description] Structure explanation, Shapes, and/or System diagram	Following diagrams show the bucket-type scrap preheating method and the 1-power-source 2-furnace method.

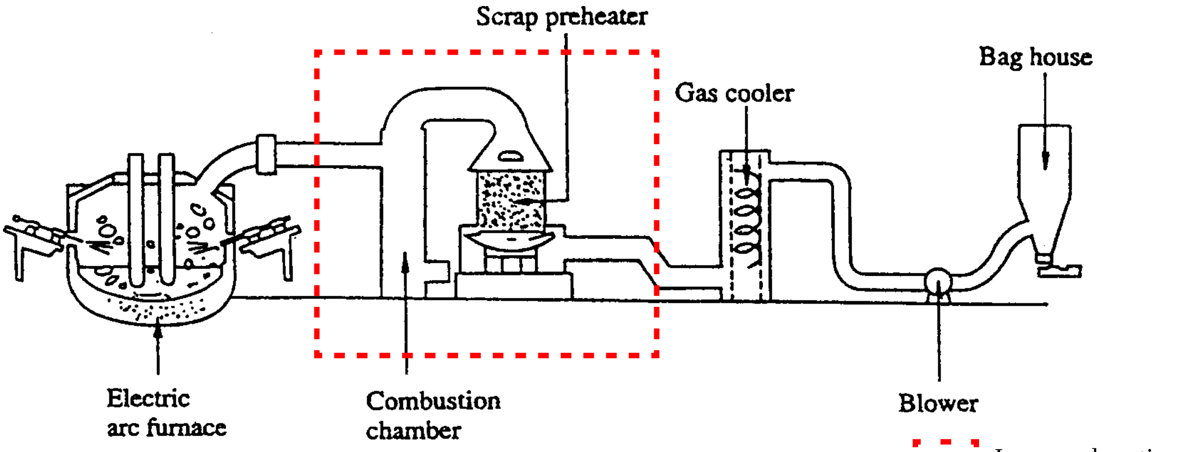


Fig. 1 The bucket-type scrap preheating method

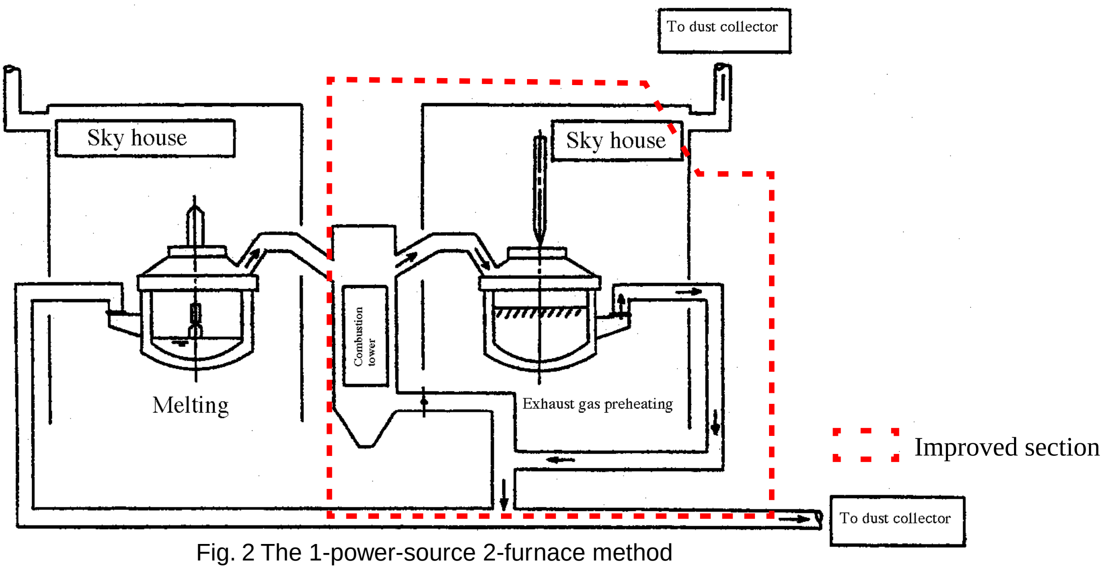


Fig. 2 The 1-power-source 2-furnace method

Energy saving effects	Reduction of specific power consumption: 60,000-80,000 kcal/t Electric power saving: 25-50 kwh/t-s 20% of the total heat of the electric-furnace exhaust gas is utilized. Shortening of the steelmaking time (5-8 min./charge)
[Economics] Equipment cost	Investment amount: 1,000 million yen Improvement effect: 200 - 300 million yen/year Investment payback: 4 - 5 years in the case of a 150t/charge furnace
Remarks	

[Example sites]	[References]	[Inquiry]
Site implemented: 42 facilities in Japan	Iron & Steel World Report, No. 1606, 1993.11.11) NKK Technical Review (No. 147, 1994, p. 9) Earth-Friendly Ironmaking, the Japan Iron and Steel Federation, 1990, p. 16	ECCJ (JIEC)

IS-ME-9

Energy Conservation Directory

[Industry Classification] Iron & Steel	Heating furnace with regenerative burners	[Energy Source] Fuel
[Technology Classification] Machinery & Equipment		[Practical Use] around 1990

Outline	A regenerative combustion system uses a pair of regenerative burners, in each of which a burner for combustion and a regenerator for heat storing are incorporated. Each of the pair is used for combustion and heat storing alternately. It is a highly efficient combustion system which can recover more than 85% of the waste heat.
Principle & Mechanism	1) The burner has a heat-storing section (regenerator) in it, and exhaust gas from the furnace and combustion air alternately pass through it in a cycle of several tens of seconds. Thus, the heat of high-temperature exhaust gas is efficiently transferred to combustion air. 2) Generally a pair of burners are installed for one furnace or one combustion zone. A system is so constructed that one burner performs combustion and the exhaust gas from the combustion is led to the opposite-side burner.

[Description]

Structure explanation, Shapes, and/or System diagram

The following diagram shows the heating furnace with regenerative burners.
When the left-side burner is performing combustion, the combustion gas is sucked into the right-side burner. As it passes through the regenerator, its sensible heat is transferred to the regenerator, and the gas temperature is sufficiently lowered before dissipated into the atmosphere. When the regenerator is sufficiently heated up after a certain period of time, the switching mechanism is activated and cold air now starts to flow through the right-side burner. As the air passes through the heated regenerator, it is preheated, and combustion is performed by the right-side burner. This time, the combustion gas is sucked into the left-side burner, and re-heats the cooled regenerator of this side. This process is repeated and the waste heat is recovered highly efficiently.

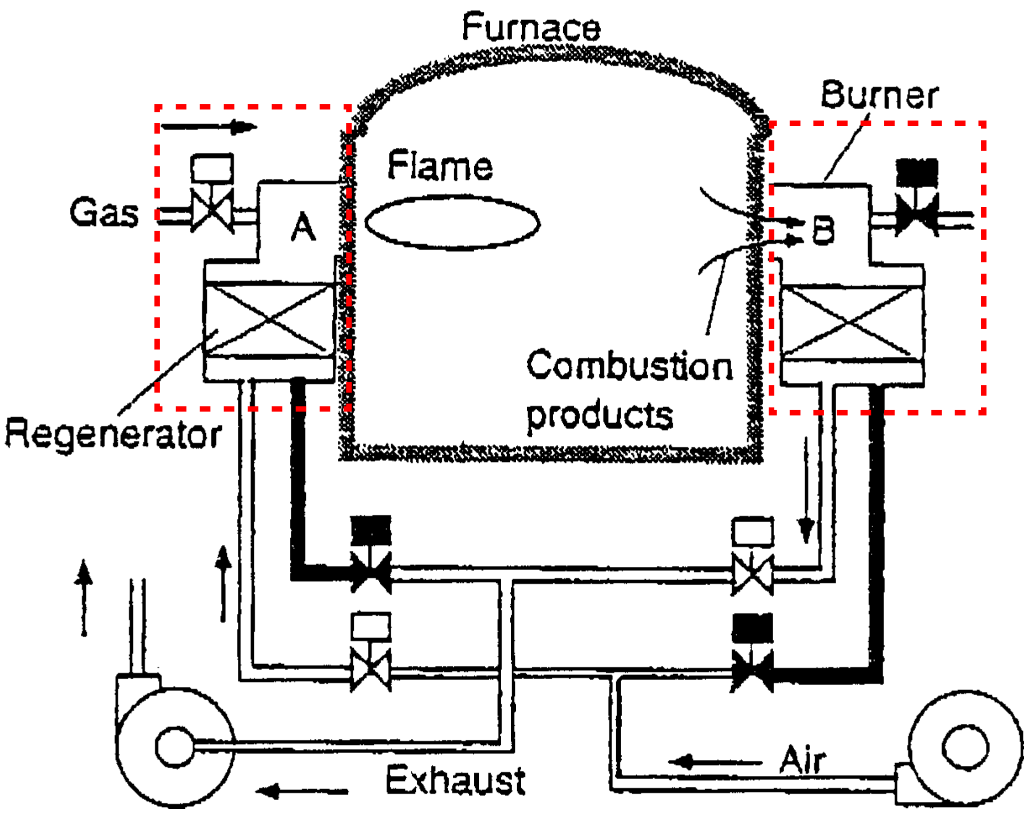


Fig.1 Concept of heating furnace with regenerative burners

Improved section

Energy saving effects	Reduction of specific fuel consumption is 10-30%.
[Economics] Equipment cost	Investment amount: 30 million yen per a pair of burners Improvement effect: 7 - 10 million yen/year Investment payback: 3 - 4 years Combustion volume: 5,000 x 10^3 kcal/piece
Remarks	

[Example sites]	[References]	[Inquiry]
	The Energy Conservation Center's High Efficiency Seminar, "The Principle of the Regenerative Combustion," Tokyo Gas Co., Ltd., Akira Yasuoka	ECCJ (JIEC)

IS-ME-10

Energy Conservation Directory

[Industry Classification] Iron & Steel	Ladle heating apparatus with regenerative burners	[Energy Source] Fuel
[Technology Classification] Machinery & Equipment		[Practical Use] 1990's

Outline

By incorporating regenerative burners into the apparatus to heat the refractories of a ladle which receives molten steel, a large energy saving is achieved. It also prolongs the life of the ladle refractories.

Principle & Mechanism

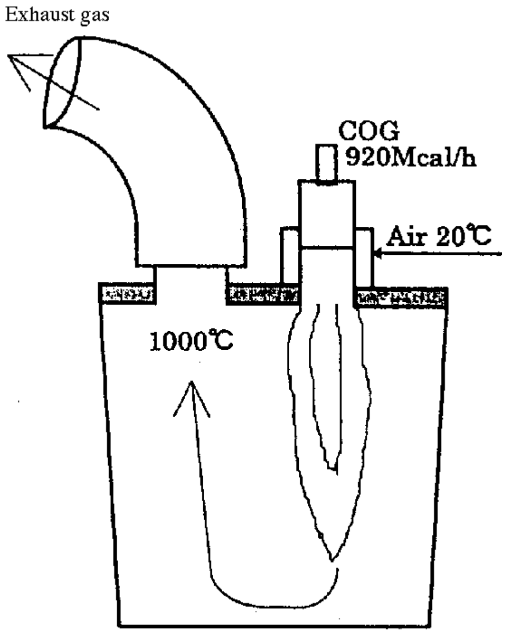
A regenerative burner system is comprised of a pair of burners which burn alternately for a determined time period and function as a exhaust duct while not burning. The heat of the high-temperature exhaust gas is stored in the regenerator installed just after the burner, and the stored heat is used for preheating the combustion air.

[Description]

Structure explanation, Shapes, and/or System diagram

Before improvement

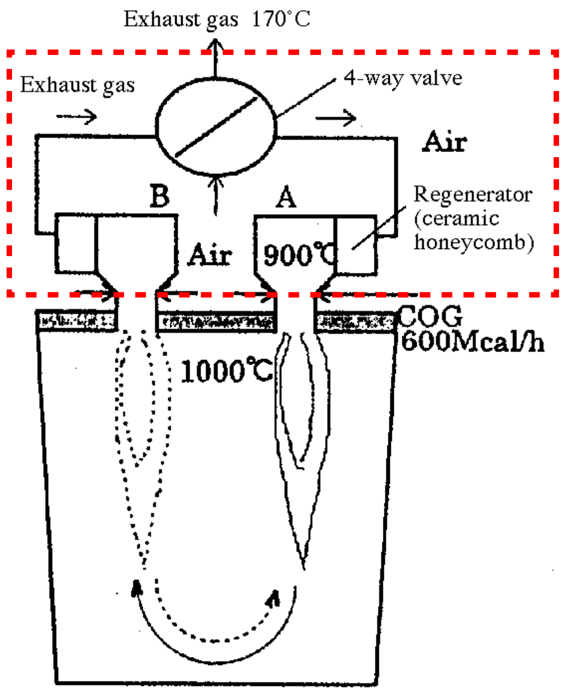
Heat efficiency is as low as about 30%, since the high-temperature exhaust gas is discharged without waste heat recovery. In addition, the temperature distribution inside the ladle is uneven.



Conventional burner

After improvement

By installing a regenerative burner system, the combustion-air temperature of about 900˚C, the exhaust-as temperature of 170˚C, and the heat efficiency of 70 % are obtained. In addition, the variation in the temperature distribution inside the ladle is improved to the level of less than about 30˚C.



Regenerative burner

Improved section

Energy saving effects

	Before improvement	After improvement	Remarks
Fuel consumption during heating (Nm^3/h)	200	120	Fuel saving of 56%
Fuel consumption during soaking (Nm^3/h)	200	7080	
Refractory life of ladles	Base case	10% extension	

Fuel saving of 56% corresponds to monthly consumption of 573 x 10^6 kcal. Increase of electric power consumption by auxiliaries is 23.9 x 10^6 kcal per month.

[Economics] Equipment cost

Investment amount: 24 million yen
Improvement effect: 10 million yen/year
Investment payback: 2 - 3 years (excluding the refractory life extension)

Remarks

As this apparatus has the automatic heating-temperature control function, fuel consumption during soaking is reduced as well.

[Example sites]	[References]	[Inquiry]
	Energy saving, Vol. 50, No. 2, p. 26-32, 1998	ECCJ (JIEC)

IS-ME-11

Energy Conservation Directory

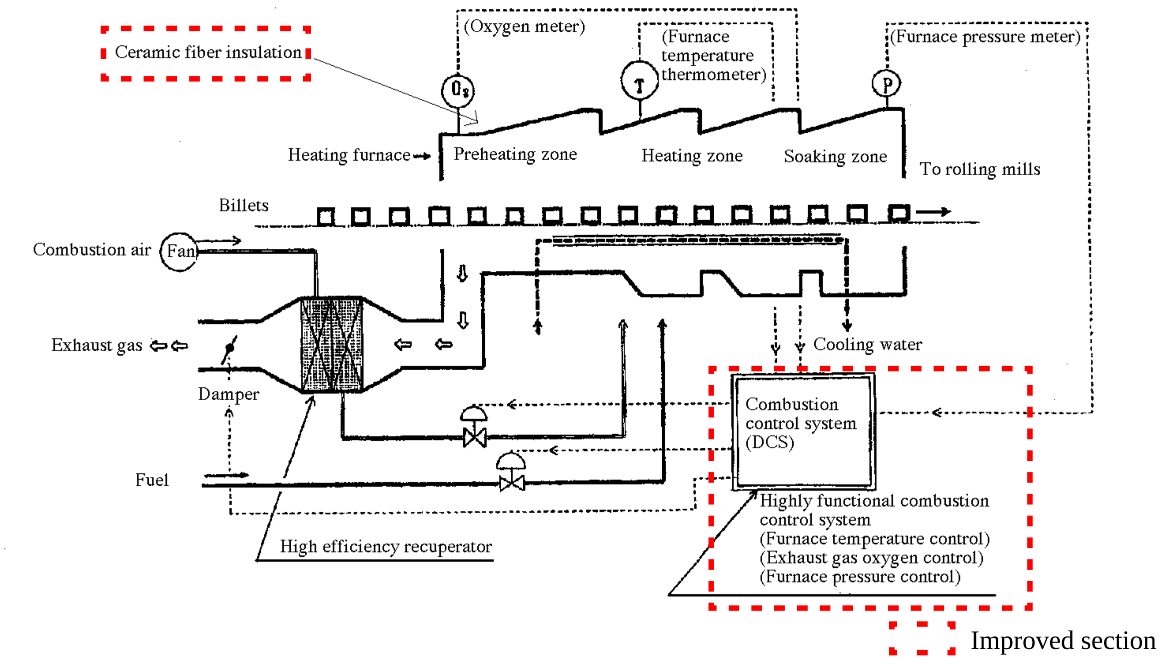
[Industry Classification] Iron & Steel	High performance heating furnace	[Energy Source] Fuel
[Technology Classification] Machinery & Equipment		[Practical Use] 1980's

Outline	A steel-product heating furnace as used in hot rolling which can heat steel products with a high heat efficiency due to strengthened exhaust-heat recovery and thermal insulation, and extremely precise combustion control.
Principle & Mechanism	In a conventional heating furnace, exhaust heat was recovered at a low temperature (for example, under 300˚C), and structural materials of the furnace wall were refractory bricks. Combustion control was carried out by simple methods. The new high-performance heating furnace are realized by: (1) waste heat recovery at a high temperature, (2) use of ceramic fibers as the structural materials of the furnace wall, and (3) adoption of extremely precise combustion control.

[Description]

Structure explanation, Shapes, and/or System diagram

1) Highly efficient waste heat recovery is realized by preheating the combustion air (and fuel) using the high-temperature exhaust gas as a heat source.
2) The temperature of the outer furnace wall, and thus the loss of heat dissipated through it, is decreased by strengthening the heat insulation using ceramic fibers as furnace-wall insulation materials. At the same time, heating response of the furnace becomes higher. (Heat loss is suppressed by increasing the heat storage capacity of the furnace wall.)
3) Exhaust-gas heat loss is reduced by optimizing the air-fuel ratio through extremely precise combustion control.



Energy saving effects

Table 1 High performance heating furnace

	Before improvement	After improvement
Energy saving (kcal/t)	-	50,000 - 200,000
Reduction in crude oil equivalent	-	-

Specification: Furnace capacity of 50-150 t/h

[Economics] Equipment cost

Investment amount: 500-1,500 million yen
Improvement effect: 50-200 million yen/year
Investment payback: 3 - 7 years

Remarks

This project is planned to be adopted in NEDO's model project for steel product heating furnace waste heat recovery at Siam Iron & Steel Company of Thailand to be operated for demonstration (planned to be finished in March 2001).

[Example sites]	[References]	[Inquiry]
Adopted at many sites.	"Collection of Energy Conservation," p. 337-347, p. 371-380	ECCJ (JIEC)

IS-ME-12

Energy Conservation Directory

[Industry Classification] Iron & Steel	Recovery of sensible heat from skid cooling water in heating furnace	[Energy Source]
[Technology Classification] Machinery & Equipment		[Practical Use]

Outline	Skid beams in a heating furnace are cooled by passing water through their insides. Previously the cooling water was sent to a cooling tower and circulated. This improvement is to supply pure water as cooling water in place of previous industrial water, and recovers the heat as steam.
Principle & Mechanism	The inner temperature of the furnace is about 1300˚C. Skid beams are used as heat transfer tubes of a boiler. A steam-water separation drum is installed outside the furnace, where steam is generated, recovering the heat.

[Description]

Structure explanation, Shapes, and/or System diagram

(Before improvement)
Skid beams were cooled by circulating industrial water. The exit temperature of cooling water was 50-60˚C.

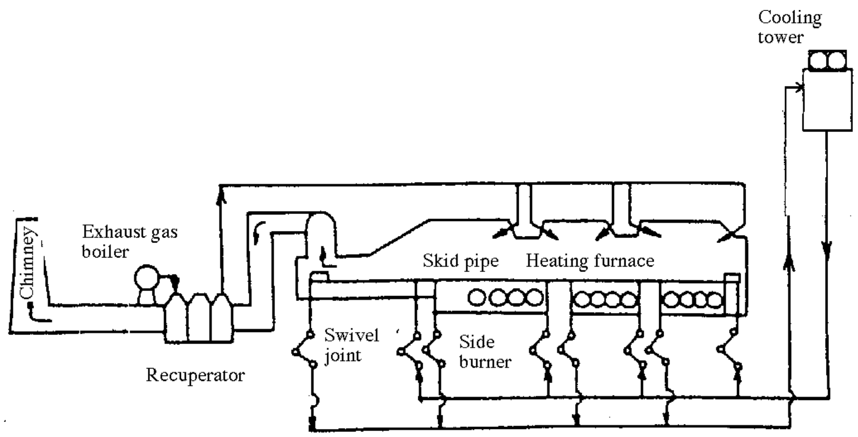


Fig. 1 Cooing water flow before improvement

(After improvement)
Industrial water was changed to pure water, and the heat is recovered as steam of the pressure of 12 kg/cm².

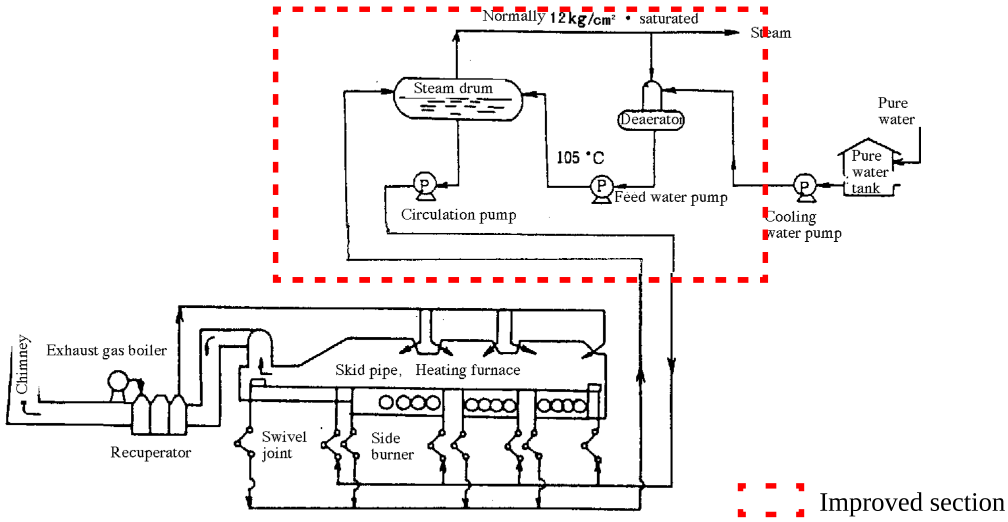


Fig. 2 Cooing water flow after improvement

Energy saving effects	Recovery amount of steam: 9 t/h x 12 kg/cm² Recovered heat in crude oil equivalent: 23,000 kL/year at operation of 7,900 hours/year
[Economics] Equipment cost	Investment amount: 1,800 million yen Improvement effect: 700 million yen/year Investment payback: 3 years
Remarks	

[Example sites]	[References]	[Inquiry]
Adopted by 1 or 2 steel companies.	Steel companies' in-house documents	ECCJ (JIEC)

IS-ME-13

Energy Conservation Directory

[Industry Classification] Iron & Steel	Descaling pump (conversion to plunger pump)	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] around 1980

Outline

A descaling pump is used to apply high-pressure water jet to remove the scale during steel rolling operation. In order to reduce power consumption, various measures were taken, such as pressure and flow rate reduction. To achieve further power saving, the turbine pump was converted to the plunger pump.

Principle & Mechanism

Since high-pressure jet is applied intermittently in short duration, a plunger pump, which can perform no-load operation at a low pressure, significantly saves power consumption during the time when high-pressure water jet is not applied.

[Description] Structure explanation, Shapes, and/or System diagram

(Example of improvement)
Out of three descaling pumps, one was converted to a plunger pump as in Fig. 1, which is operated continuously.

	Before improvement (turbine pump)	After improvement (plunger pump)
Number of pumps operated	2 sets	1 set
Flow rate	6.5 m^3/min.	5.5 m^3/min.
Pressure	170 kg/cm^2	175 kg/cm^2
Number of motors operated	2,700 kw x 2 sets	2,700 kw x 1 set

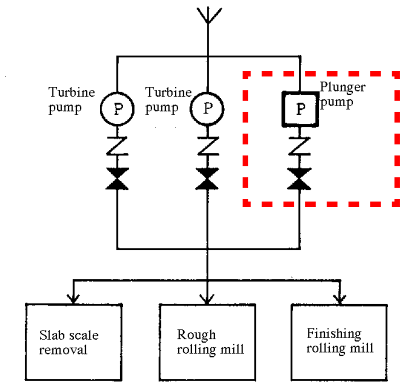


Fig. 1 Flow of descaling pump system

Before improvement

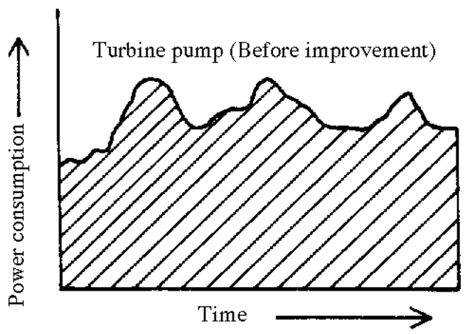


Fig. 2 Power consumption pattern of turbine pump

After improvement

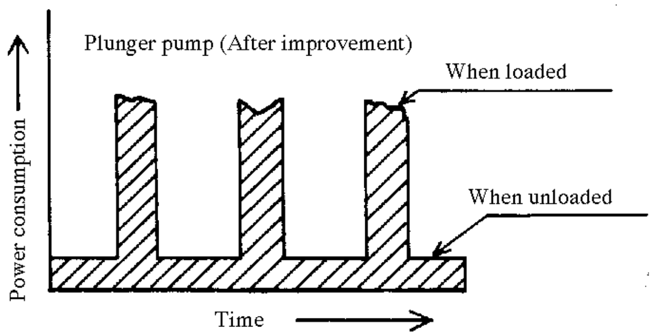


Fig. 3 Power consumption pattern of plunger pump

Energy saving effects

Table 2 Energy saving effect by plunger pump

		Before improvement	After improvement	Effect
Power consumption	Loaded	1,930 kW	1,890 kW	40 kW
	Unloaded	1,210 kW	180 kW	1,030 kW
Annual power consumption		9,456 MWh/y	3,948 MWh/y	5,508 MWh/y
Reduction in crude oil equivalent				1,338 kL/y

[Economics] Equipment cost

Investment amount: 200 million yen
Improvement effect: 80 million yen/year
Investment payback: 2.5 years at 2,750 L/min x 175 kg/cm^2 x 1 unit

Remarks

[Example sites]	[References]	[Inquiry]
Adopted at many sites.	"Collection of Improvement Cases at Excellent Energy Management Plants (1987)," p. 64	ECCJ (JIEC)

IS-ME-14	Energy Conservation Directory	
[Industry Classification] Iron & Steel [Technology Classification] Machinery & Equipment	High efficiency gas separation apparatus	[Energy Source] Electricity [Practical Use] around 1990

Outline

This is an apparatus which selectively separates and recover a gas from air, oxygen, nitrogen, hydrogen, carbon monoxide, propane, etc., in a highly efficient manner.
As for air separation, highly-efficient and energy-saving adsorption methods such as the TSA method and PSA method, and the membrane separation method are recently in use.

Principle & Mechanism

As an air separation apparatus to be used in the preliminary treatment before removing the water content and carbon dioxide from air, the adsorption method is more commonly adopted than the conventional reversible heat exchanger method. Two types of adsorption method are available: one is the TSA (Thermal Swing Adsorption) method for a larger plant which utilizes the temperature difference, and the other is the PSA (Pressure Swing Adsorption) method for a smaller plant.

[Description] Structure explanation, Shapes, and/or System diagram

Oxygen separation apparatus (Fig. 1)
A feed air compressor consumes 90% of the whole electricity consumed in a TSA-method plant. The new packed-bed-type distillation column suppresses the pressure loss per one theoretical stage to about 1/10 that of a distillation-dish type. The specific power consumption of the product oxygen is reduced by about 10% compared with the conventional type.
Comparison of product oxygen purity and specific power consumption (Fig. 2)
From Fig. 1 (a), when the product oxygen purity is less than 97%, the plant shown in Fig. 1 is more advantageous in terms of specific power consumption.

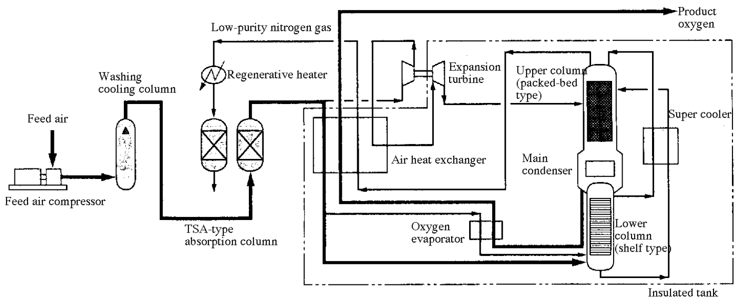


Fig. 1 Flow of TSA-type low-purity oxygen plant

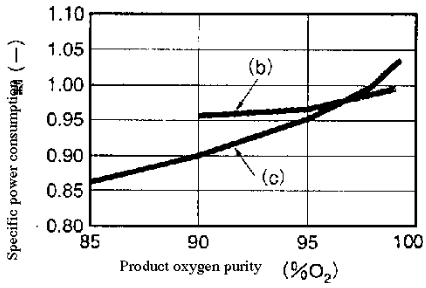


Fig. 2 Comparison of product oxygen purity and specific power consumption

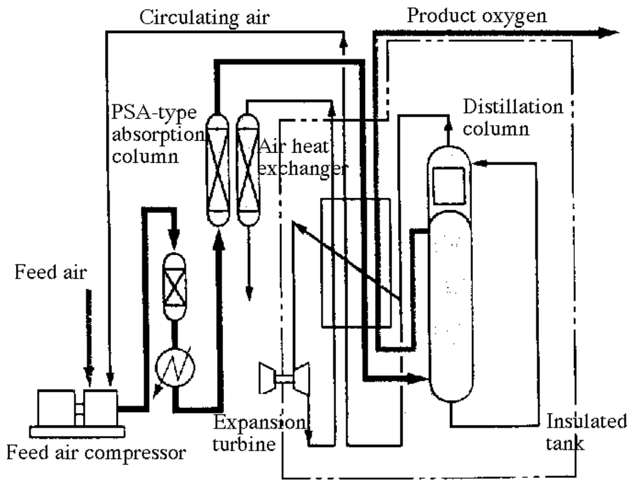


Fig. 3 Flow of air-circulation-type nitrogen separation apparatus

Energy saving effects

Specific power consumption is reduced by about 10%.

[Economics] Equipment cost

Investment amount: million yen
Improvement effect: million yen/year
Investment payback: years

Remarks

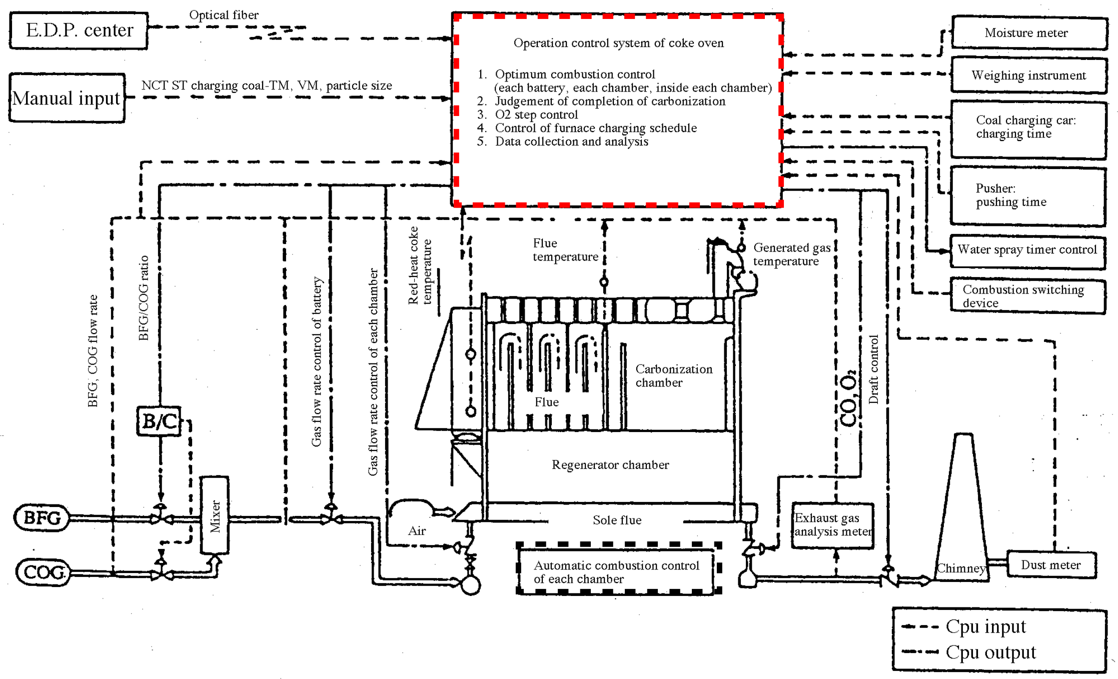
[Example sites]	[References]	[Inquiry]
	"Hitachi Review Dec. 97," p. 61	ECCJ (JIEC)

IS-OM-1

Energy Conservation Directory

[Industry Classification] Iron & Steel	Automatic combustion control of coke oven	[Energy Source] Fuel
[Technology Classification] Operation & Management		[Practical Use] around 1973

Outline	Program heating adjusts and optimizes the heating condition in each coking chamber in accordance with the state of coal carbonization. It saves energy by reducing coking energy consumption. It can improve the coke quality as well.
Principle & Mechanism	1) Measurements are carried out on the flue temperature, generated gas temperature, red-heat coke temperature, exhaust gas composition, etc. 2) Electric valve controllers are installed on each of the existing adjusting cocks at the branches of the gas and air distribution piping, and the drafting pressure regulating waist dampers. 3) Combustion in each chamber is separately controlled in accordance with the conditions of the charged coal (charged volume, moisture content, etc.) and the operation (target time to finish heating, etc.). 4) The operation control system is integrated, which covers heating pattern control, air-fuel ratio control, program heating, charge scheduling, etc.
[Description] Structure explanation, Shapes, and/or System diagram	The following figure shows a flow of automatic combustion control of a coke oven.



Improved section

Fig. 1 Flow diagram of automatic combustion control of a coke oven

Energy saving effects	Amount of carbonization energy reduced: about 40,000 kcal /t-coal at coke production of 1,500 kt/year
[Economics] Equipment cost	Investment amount: 300 - 400 million yen Improvement effect: 150 million yen/year Investment payback: 3 years
Remarks	

[Example sites]	[References]	[Inquiry]
Installed at 50% of integrated steel plants in Japan	Recent Development and Future of Ironmaking Technology (1993, p. 11, 64) Iron & Steel (Vol. 81, No. 4, 1995, p. 9) Cokes Circular (Vol. 41, No. 2 1992, p. 92)	ECCJ (JIEC)

IS-OM-2

Energy Conservation Directory

[Industry Classification] Iron & Steel	Blast furnace operation control system	[Energy Source] Fuel
[Technology Classification] Operation & Management		[Practical Use] around 1980

Outline	By the development in sensors and control technology, the system to control blast furnace operation made rapid progress. In the past, major blast furnace abnormalities were prevented by identifying operational abnormalities in early stages by sensor information and taking appropriate measures. The AI method is now adopted and expert systems are developed, which incorporate the experience and knowledge of the operators, and make possible to control the furnace condition and furnace heat.

[Description]

Structure explanation, Shapes, and/or System diagram

Blast furnace censor
Fig. 1 shows typical censors installed to a blast furnace. Various types of detectors to be inserted into a furnace and sondes were developed, which make possible to measure the temperature distribution and gas composition in the furnace. Even the direct observation inside the tuyere is now possible.

Blast furnace operation system by AI
The information obtained by these censors were effectively utilized to develop operation analysis models and operation theories, and helped to establish blast furnace operation technology that can meet various requirements.

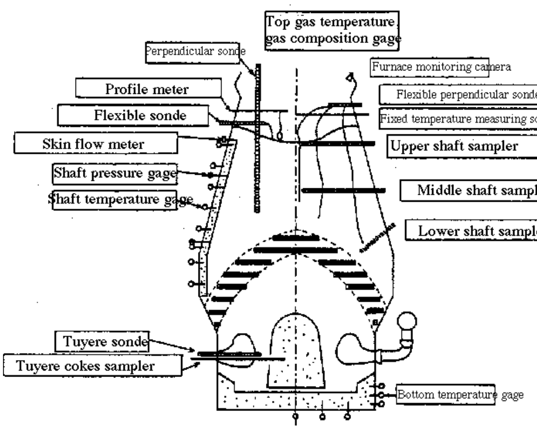


Fig. 1 Blast furnace censors

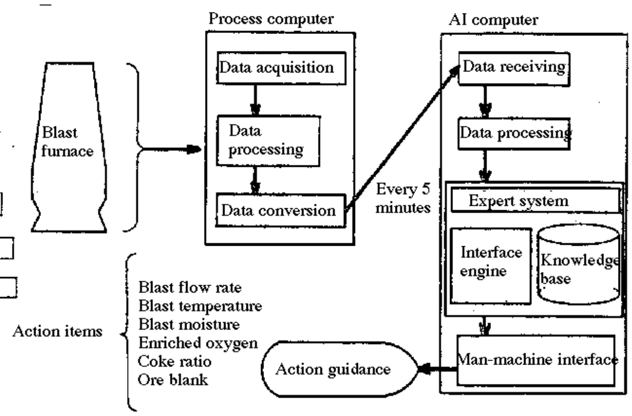


Fig. 2 Blast furnace operation system by AI

Energy saving effects	Stabilization of blast furnace operation against fuel change (heavy-oil injection, pulverized-coal injection) Optimum control of the air-fuel ratio of a hot stove
[Economics] Equipment cost	Investment amount: million yen Improvement effect: million yen/year Investment payback: years
Remarks	

[Example sites]	[References]	[Inquiry]
Adopted at many sites.	No. 146-147 Nishiyama Memorial Seminar	ECCJ (JIEC)

IS-OM-3

Energy Conservation Directory

[Industry Classification] Iron & Steel	Blast furnace hot blast valve control system	[Energy Source] Fuel
[Technology Classification] Operation & Management		[Practical Use] 1990

Outline	To improve the circumferential balance, etc., which deteriorated as blast furnaces became larger, hot blast control valves and their control system were adopted to individually control the hot blast flow rate at each of the tuyeres, hence saving energy.

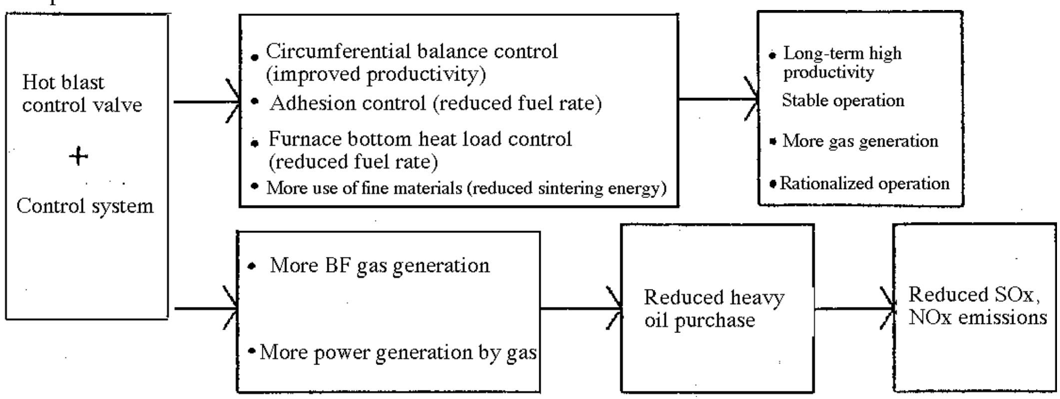
[Description]

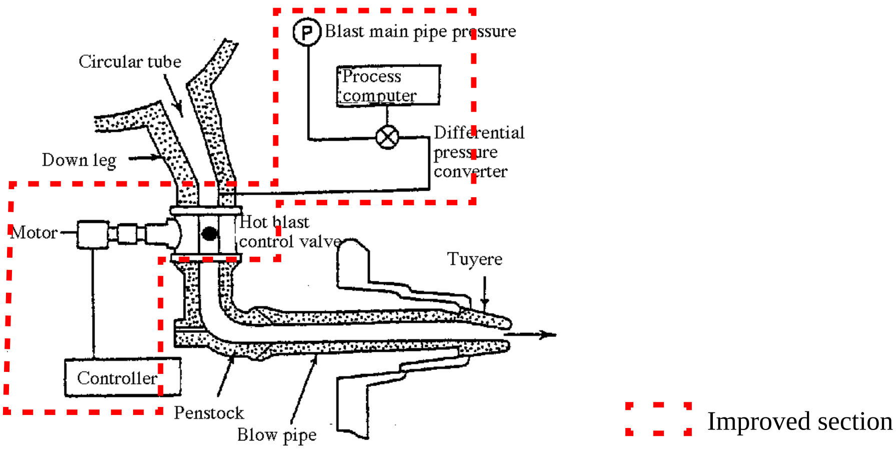
Structure explanation, Shapes, and/or System diagram

Before improvement

Control method	Problems
1. Change of tuyere diameter	• Continuous control in accordance with the furnace condition is not possible. (To change the tuyere diameter according to the production volume is essential.) • To temporarily stop the BF operation is required to change the tuyeres. (It affects the production and causes energy loss.)
2. Closing of tuyeres (clay plugging)	• Full closing of the tuyere forms the non-active zone in front of the tuyere. • Clay plugging needs to stop operation.
3. Change of the fuel injection rate at each tuyere	• Difference in the fuel injection rate at each tuyere disturbs the circumferential balance in heat input.

After improvement





Energy saving effects	Energy saving 134,000kcal/t Reduction in crude oil equivalent 4,300kL/y SOx, NOx Reduced by 47% Production 3,000kt/y
[Economics] Equipment cost	Investment amount: 200 - 300 million yen Improvement effect: 7 - 9 million yen/year Investment payback: 3 - 4 years
Remarks	

[Example sites]	[References]	[Inquiry]
	Steel companies' in-house documents	ECCJ (JIEC)

IS-OM-4

Energy Conservation Directory

[Industry Classification] Iron & Steel	Blast furnace burden distribution control	[Energy Source] Fuel
[Technology Classification] Operation & Management		[Practical Use] around 1970

Outline

This technology controls the burden distribution along the radial direction in the upper layers of the blast furnace. It is a most important means to control the inside conditions of the blast furnace. By this, heat exchange between the gas and burden in the furnace and reducing reaction are efficiently performed.

Principle & Mechanism

1) In order for the reducing reaction in the furnace to be efficiently performed, layering of the iron ores and cokes needs to be accurately controlled.
2) This is a system to charge the iron ores and cokes into the furnace with optimum distribution along the circumferential and radial directions.
3) The size distribution of the materials is 6-50 mm.

[Description] Structure explanation, Shapes, and/or System diagram

The recent bell type controls the materials falling from the both sides of the bell by moving the movable armor. In contrast, the bell-less type makes the materials fall to the designated positions by a rotating chute.
Burden distribution control is a technology to control the layering of the iron ores and cokes, which have different permeability, at the furnace top.
The movable armor controls the layering of the materials by controlling the angle of the plates with the falling materials.
The blast furnace charging system has two types: bell-armor type and bell-less type. The bell-less type is largely different from the bell-armor type in that it can continuously control the positions where charged materials falls in the furnace. It can more flexibly control the burden distribution, and is more widely used recently.

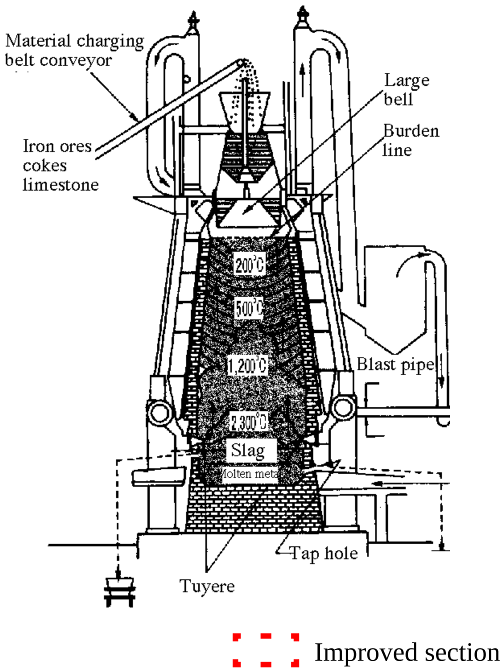


Fig. 1 Blast furnace and its auxiliary equipment

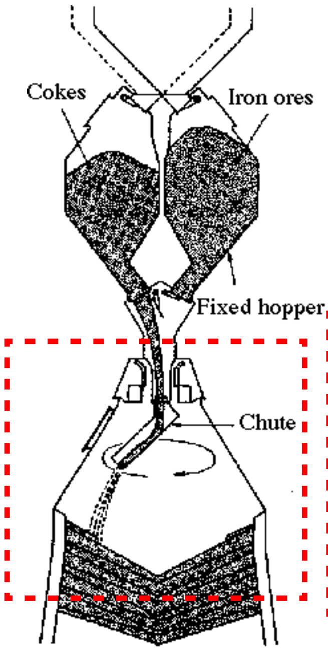


Fig. 2 Bell-less-type blast furnace

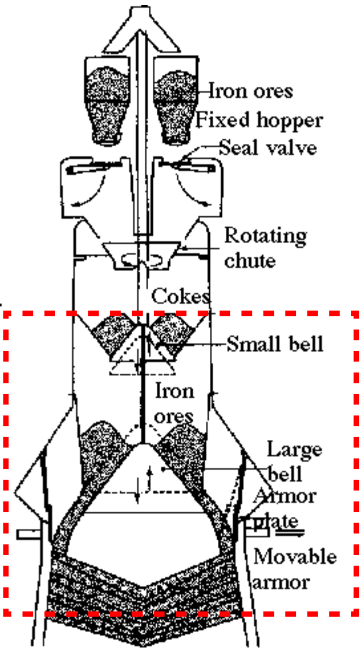


Fig. 3 Bell-type blast furnace

Energy saving effects

1) As the gas efficiency increases, the shaft efficiency increases as well.
2) As a result, the consumption of coke can be reduced by 5 ~ 15 kg/ton of pig iron.

[Economics] Equipment cost

Investment amount: 2,500 million yen
Improvement effect: 400 - 500 million yen/year
Investment payback: years

Remarks

The bell-less type is adopted when a BF is repaired on newly installed. It is cheaper and has more energy-saving effects than the bell type.

[Example sites]	[References]	[Inquiry]
	Iron amd Steel Federation "The 146th and 147th Nishiyama Memorial Technology Seminars", p. 150, etc.	ECCJ (JIEC)

IS-OM-5

Energy Conservation Directory

[Industry Classification] Iron & Steel	Energy saving operation of electric arc furnace	[Energy Source] Electricity
[Technology Classification] Operation & Management		[Practical Use] 1980

Outline

An example of the operation improvement which targets at the reduction of electric power consumption of small and medium size electric arc furnaces.

[Description]

Structure explanation, Shapes, and/or System diagram

1) Use of a basic melting furnace
- Electric arc furnaces are divided into two types by the lining refractories they use: acidic furnace (MgO-based refractories) and basic furnace (SiO_2-refractories). The acidic furnace is merits such as low power consumption and short melting time. On the other hand, it has a difficulty in removing harmful elements such as P and S, and therefore it has the limitation in the types of steel it can produce.
- One of the furnaces was remodeled to an acidic type to deal with return scrap which contains relatively smaller amounts of P and S, and power saving was achieved.

2) Shortened melting time by eliminating intermediate analysis (Fig. 2)
- Formerly in the arc furnace operation, for the purpose of checking the compositional specification, composition analyses were performed four times: at melt down, at oxidation finishing, at the intermediate time, and in the ladle. It was confirmed that the elimination of the intermediate analysis does not cause quality problems. The elimination shortened the melting time by about 5 minutes, and saved power consumption by about 20 kWh/t.

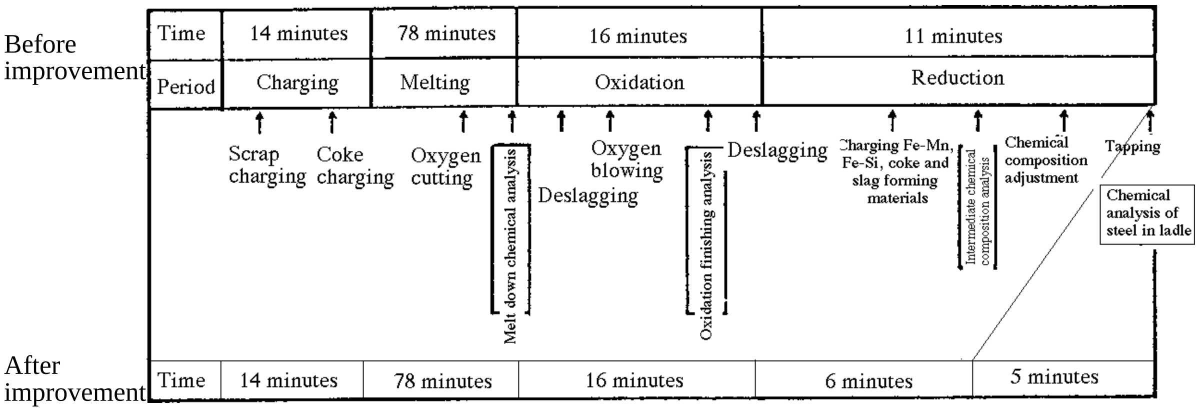


Table 1 Comparison of power consumption

Process	Before improvement	After improvement	Effect
Furnace type	Basic furnace (kWh/t)	Acidic furnace (kWh/t)	
Melting period	500	449	51
Oxidation period	75	70	5
Elimination of intermediate analysis	21	-	21
Total	596	519	77

Energy saving effects

Annual power consumption 2,460 x 10^3 kWh/year
Reduction in crude oil equivalent 600 kL/year

[Economics] Equipment cost

Investment amount: 10 - 15 million yen
Improvement effect: 10 - 15 million yen/year
Investment payback: 1 year

Remarks

[Example sites]	[References]	[Inquiry]
	The Energy Conservation Center, Japan, "Collection of Energy Conservation Cases 1981 (Vol. 1)," p. 399	ECCJ (JIEC)

IS-OM-6

Energy Conservation Directory

[Industry Classification] Iron & Steel	Operation improvement of heat treatment furnace	[Energy Source] Fuel
[Technology Classification] Operation & Management		[Practical Use] around 1980

Outline

As continuous steel coil plating equipment for mass production, conventionally an indirect heating furnace was widely used, which employed the radiant-tube heating and soaking zone. In this improvement, a continuous plating furnace which is equipped with a direct-firing reducing heating zone was introduced, and large energy saving was achieved.

[Description] Structure explanation, Shapes, and/or System diagram

Fig. 1 shows an example of the indirect heating furnace, and Fig. 2 the direct-firing heating method.

Indirect heating method (before improvement)

The furnace consists of a preheating zone, heating and soaking zone, slow cooling zone, rapid cooling zone, and adjusting cooling zone. In the preheating zone, the steel strip is preheated by the combustion gas from the heating and soaking zone to 250-300˚C, a temperature where oxidation of its surface does not start yet. Next, the strip goes into the heating and soaking zone where it is heated and soaked by the gas-firing radiant tubes in the H_2-N_2 atmosphere.

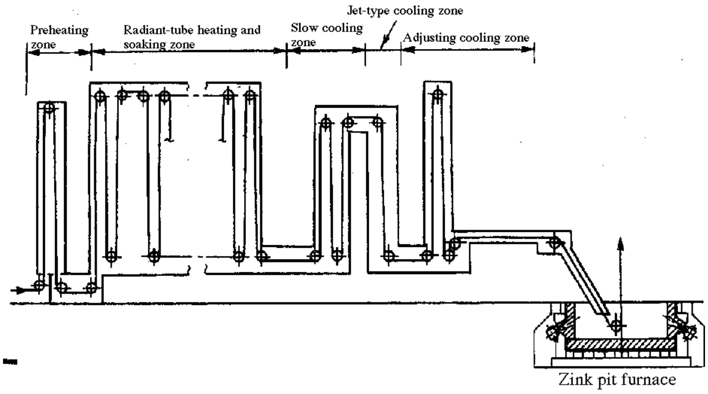


Fig. 1 Vertical-type indirect-heating continuous hot-dip galvanizing furnace

Direct-firing reducing method (after improvement)

In a direct-firing reducing furnace, as in a non-oxidation furnace, combustion is performed at the air-fuel ratio of less than unity. The CO + H_2 concentration in the combustion gas is 4-6%. The temperature difference between the strip and the flame blown to it is set to be large. The strip is heated rapidly without being oxidized to about 700˚C by the high-temperature combustion gas in the direct-firing reducing zone. Compared with the radiant tube method, it has advantages like better heat response and shorter furnace length.

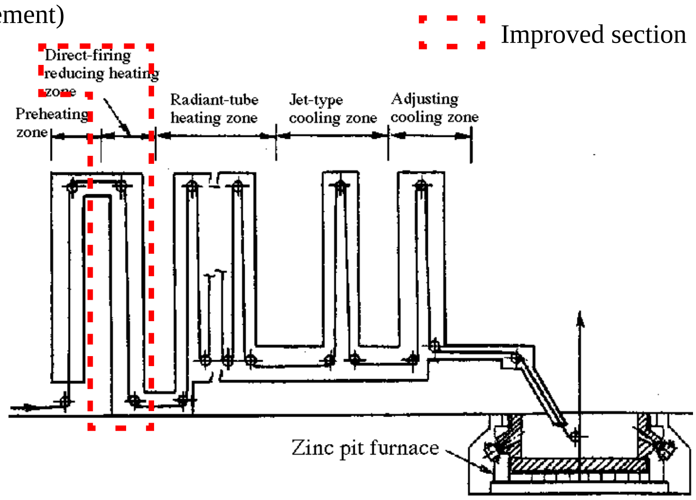


Fig. 2 Vertical-type direct-firing reducing continuous hot-dip galvanizing furnace

Energy saving effects

1) Better heat response
2) Shorter heating zone length in the furnace
3) Faster treatment speed

[Economics] Equipment cost

Investment amount: 100 million yen
Improvement effect: 30 million yen/year
Investment payback: 3 - 4 years

Remarks

[Example sites]	[References]	[Inquiry]
	Industrial Furnace Handbook	ECCJ (JIEC)

IS-OM-7	Energy Conservation Directory	
[Industry Classification] Iron & Steel [Technology Classification] Operation & Management	Centralized energy management (Energy center)	[Energy Source] Fuel, electricity, others [Practical Use] around 1980

Outline	The centralized energy management system is a system which manages the energy supply and demand in an integrated steel plant to minimize the energy cost. By this system, the energy supply and demand balance is adequately grasped in association with the operation of various processes in the plant, and such situations as excessive energy generation (causing the gas dissipation, etc.) and energy shortage (causing the increase in power purchase) are avoided, hence reducing energy costs and achieving energy saving.
Principle & Mechanism	Based on the energy utilization plans (half-yearly and monthly), - Energy forecast and utilization - Monitoring and control - Performance evaluation are performed. It has a cyclic system configuration incorporating a trend management system, allocation management system, and performance management and analysis system, and allocates the energy in an optimum manner.
[Description] Structure explanation, Shapes, and/or System diagram	The functional configuration of the system is as follows.

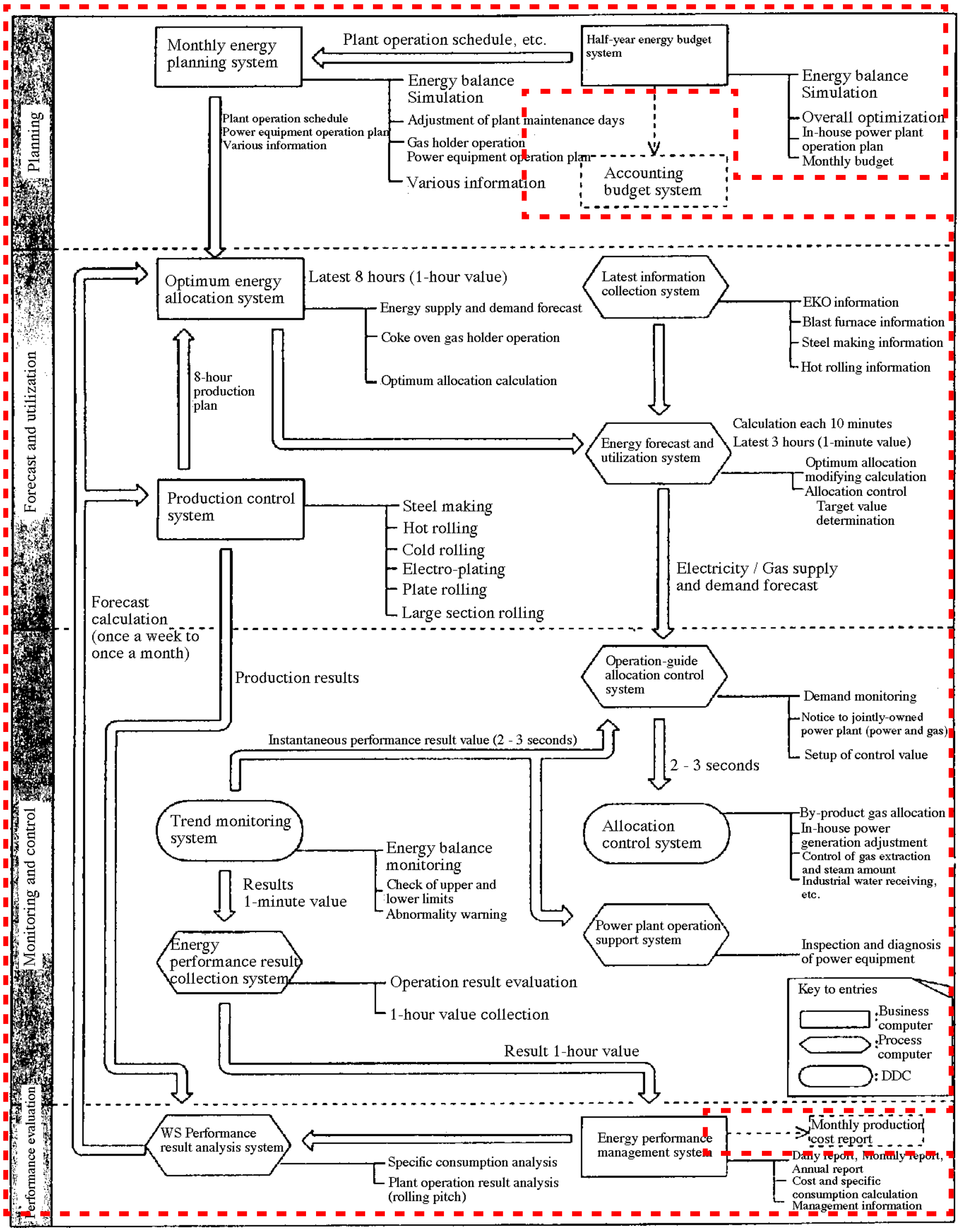


Fig. 1 Functional configuration of the energy management system

Improved section

Energy saving effects

Table 1 Effects of the energy management system

Items	Effects
1. Effects of supply and demand forecasting 1) Averaging of power load 2) Optimization of power purchase plan 3) Balancing of gas supply and demand 4) Optimization of in-house power plant operation 5) Optimization of oxygen plant operation	1) Reduction of contracted power by cutting demand peak 2) Increase of economical power purchase and optimization of contracted power 3) Prevention of gas emission, reduction of fuel purchase, and sales of high-value gas 4) Optimum use of gas and power, and supply of economical steam 5) Prevention of oxygen emission and increase of argon recovery
2. Improvement of business efficiency in planning and performance data collection, etc.	1) Reduction of required man-hours and more efficient analysis 2) Optimum energy planning such as reduction of contracted power
3. Improvement of business efficiency in long- and middle-term strategy planning, etc.	1) Optimum response to requirements such as facility upgrading, operation mode change, and energy price variation
4. Services to production divisions	1) Promotion of energy saving by voluntary management

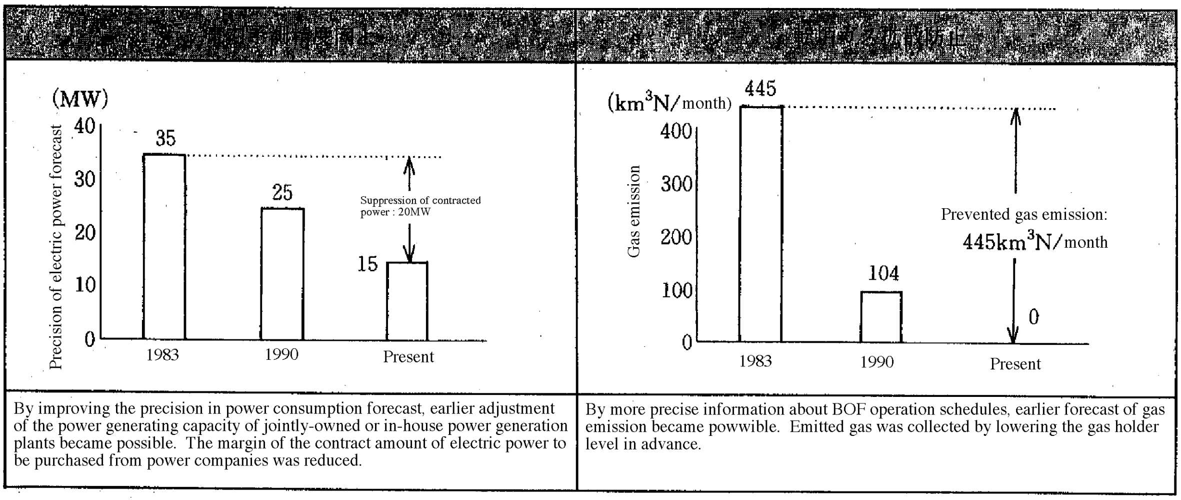


Fig. 2 Examples of effects of the energy management system

[Economics] Equipment cost

Investment amount: 700 - 1,500 million yen
Improvement effect: 300 - 400 million yen/year
Investment payback: 3 - 5 years

Remarks

[Example sites]	[References]	[Inquiry]
80% introduced.	Sumitomo Metal, Vol. 46, No. 2, 1994, p. 119, p. 125	ECCJ (JIEC)