Section 5
Ceramic Industry

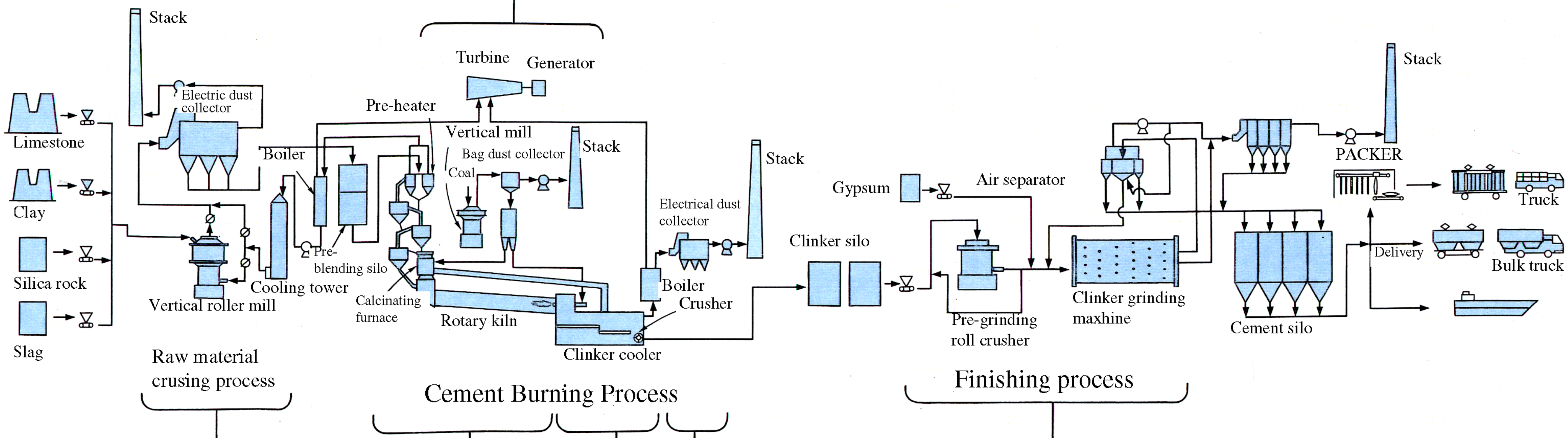
Process Flow

5-1 Cement

5-2 Glass

Ceramic (Cement) : Production Process and Energy Saving Technology

Item No.	Technology Item/Title
YC-ME-5	Cement production process: Medium-to-low-temperature flue gas power plant



Item No.	Technology Item/Title
YC-PE-5	Cement production finishing section: Introduction of pre-grinding roll crusher in the finishing section (Roller press)
YC-PE-6	Cement production finishing section: Introduction of clinker pre-grinding roll crusher (Pre-grinder)
YC-PE-7	Adoption of a high-efficiency separator in the finishing process

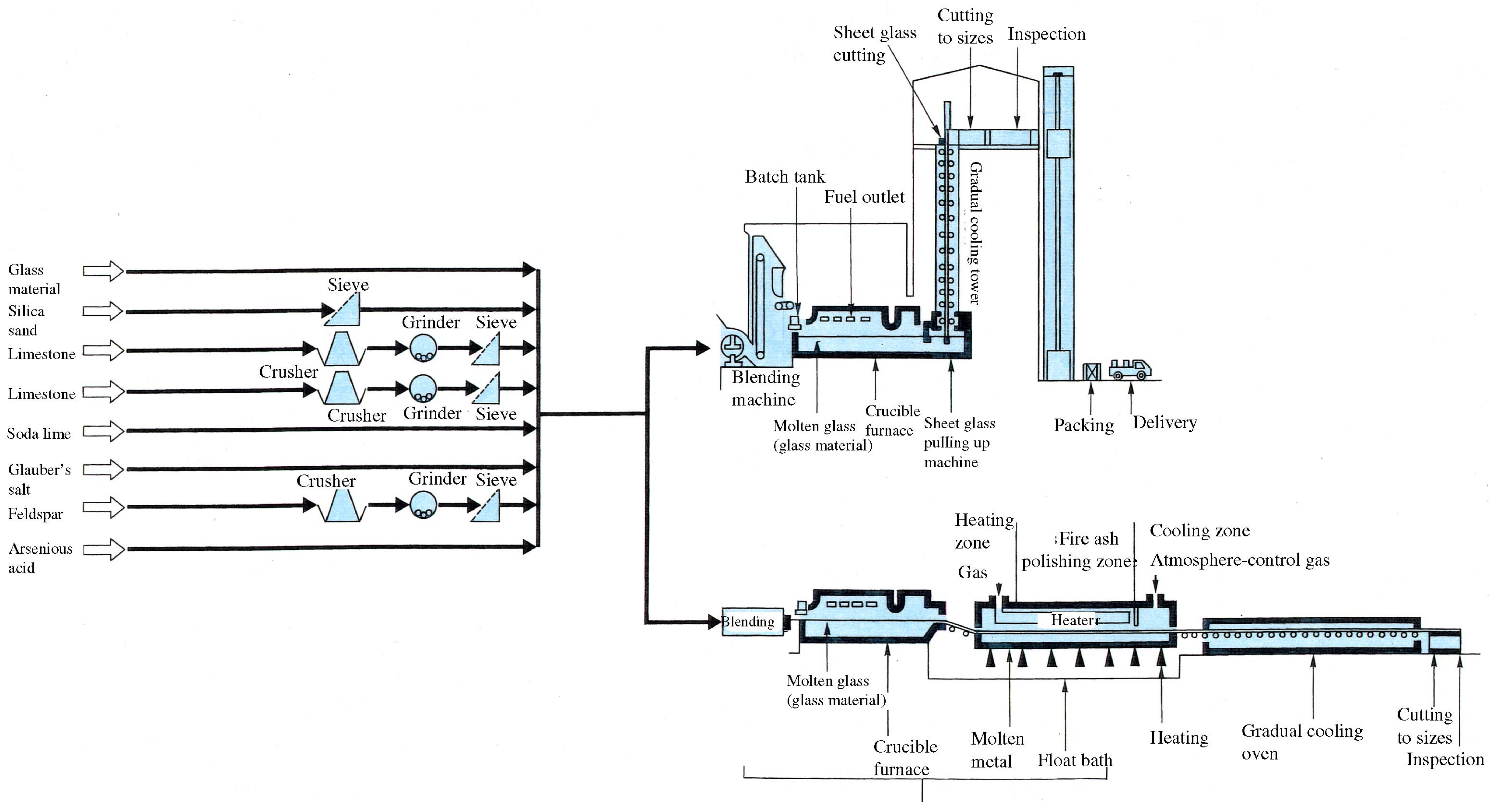
Item No.	Technology Item/Title
YC-PE-2	Cement clinker burning process: Adoption of suspension preheater (SP)
YC-PE-3	NSP-type cement calcining furnace
YC-ME-2	Cement burning process: Modification of a conventional suspension preheater to a five-stage cyclone suspension preheater
YC-ME-3	Clinker burning process: Small-pressure-drop suspension preheater
YC-ME-4	Burning of used tires as substitute fuel for cement kiln

Item No.	Technology Item/Title
YG-PE-1	Introduction of electric furnace instead of crucible furnace for melting glass
YC-ME-1	Rock crushing process: Adoption of external rock transfer system to the roller mill crusher

Item No.	Technology Item/Title
YC-PE-8	Cement clinker burning process: Adoption of high-efficiency quenching cooler

Item No.	Technology Item/Title
YC-PE-4	Cement clinker burning process: Adoption of vertical roller mill for coal crushing

Ceramic (Glass) : Production Process and Energy Saving Technology



Item No.	Technology Item/Title
YG-PE-1	Introduction of electric furnace instead of crucible furnace for melting glass
YG-PE-2	High-efficiency melting furnace and shaping system for glass

Data Sheets

5-1 Cement

5-2 Glass

YC-PE-1

Energy Conservation Directory

[Industry Classification] Ceramic : Cement	Cement raw material preparation Introduction of a large vertical roller mill for raw material crushing	[Energy Source] Electricity
[Technology Classification] Production Equipment		[Practical Use] 1970s -

Outline

Formerly, the closed system consisting of ball mills and classifiers was used for crushing cement raw materials. This vertical roller mill has a high crushing energy efficiency and requires a smaller area for installation compared with the conventional ones. Large vertical roller mills of this type were introduced in the 1970s and have been extensively adopted.

Principle & Mechanism

[Structure of the vertical roller mill] (Refer to Fig. 1.)
- The rollers are hydraulically pressed against a disc table and the feed is crushed between the rollers and the table.
- In this vertical mill is housed a classifier above the rollers.

[Description]

Structure explanation, Shape, and/or System diagram

[Characteristics of the vertical roller mill]
1) The specific power consumption is lower than that of ball-mill crushing.
2) The residence time of the raw materials in this type of crusher is much shorter than that in the ball mill; therefore, the crushing section has a good response to the needs of the raw material mixing section and hence contributes to stable quality.
3) Because of the operation being continuous, the feed may be dried by using the flue gas from the kiln.
4) The area for installation is small and the noise level is low.
5) This type of mill can crush lumps too large to be fed into the ball mill.

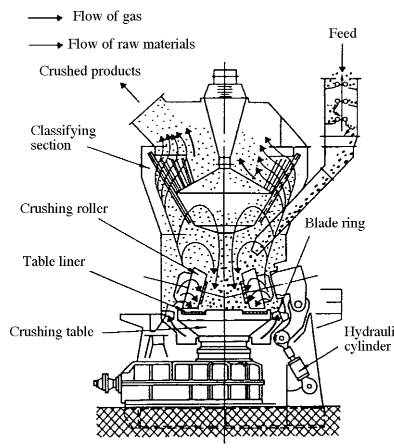


Fig. 1 Vertical roller mill

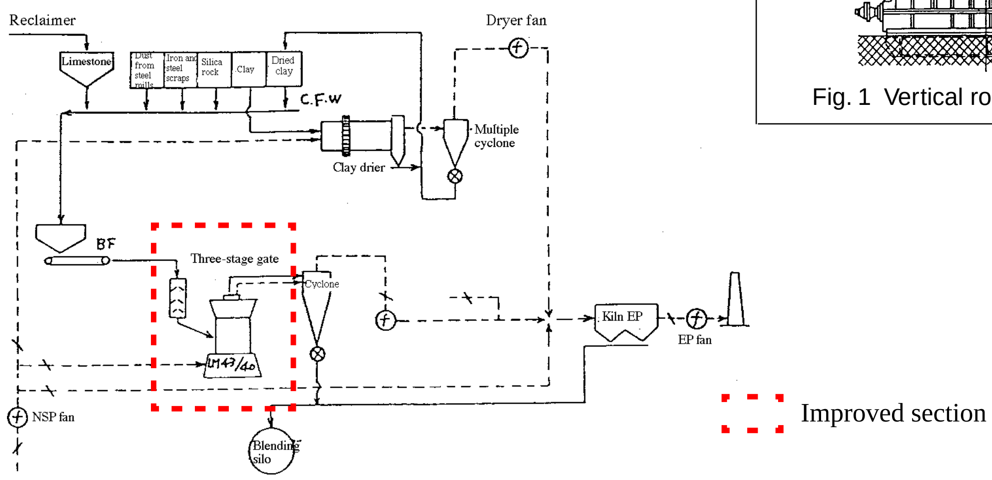


Fig. 2 Schematic process flow of vertical roller mill for raw material crushing

Energy saving effects

Table 1 Energy saving effect of the vertical roller mill

	Conventional crusher (Ball mill + Classifier)	Newly developed crusher (Vertical roller mill)	Effect
Production	100%	160 to 180%	60% to 80% (Increase)
Power consumption*	20 to 26 kWh/t	14 to 18 kWh/t	About 30% (Reduction)
Specific power consumption			2,240,000 kWh/y (Reduction)
Crude oil equivalent			544 kL/y (reduction)

Note: * Crusher capacity : 200 t/h at operation of 7,000 h/y

[Economics] Equipment cost

Cost of the facility: about 1500 million yen for a vertical roller mill of about 200 tons/hour, including associated facilities and installation cost

Remarks

[Example sites]	[References]	[Inquiry]
	37th Cement Production Technology Symposium(1980), p.6	Japan Cement Association / ECCJ(JIEC)

YC-PE-2	Energy Conservation Directory	
[Industry Classification] Ceramic : Cement	Cement clinker burning process	[Energy Source] Fuel
[Technology Classification] Production Equipment	Adoption of suspension preheater (SP)	[Practical Use] 1965

Outline

This modification represents installation of a facility to effectively dry and preheat the feed previously blended in the raw material blending section using the flue gas stream from the kiln. This improvement has achieved marked energy saving compared with the conventional wet process.

Principle & Mechanism

1) The exhaust gas from the kiln in the dry burning process is about 1,050˚C. Formerly, the sensible heat of this flue gas was partly recovered by exhaust gas boiler for power generation.
2) The new facility represents a modification which instead directly recovers the sensible heat for drying and preheating the kiln feed.

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

[Structure of suspension preheater (SP)] (Refer to Fig. 1.)
1) The structure consists of multi-stage cyclones in which kiln feed flows against the stream of flue gas.
2) The system first developed used four cyclones. The newer system is equipped with five cyclones.
3) The draft loss is from 100 to 120 mmAq. per stage; therefore, induced drafting is necessary.
4) Generally, the temperature of flue gas at the outlet of the four-stage cyclone preheater is from 350 to 380˚C.

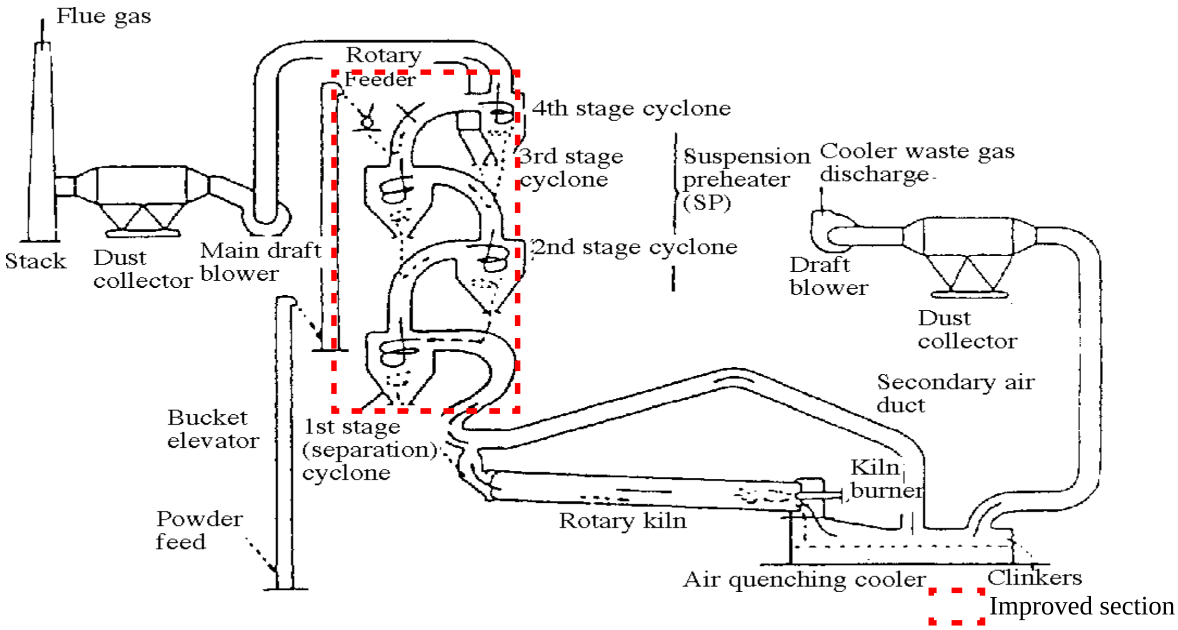


Fig. 1 Schematic flow of feed drying and preheating in the suspension preheater

Energy saving effects

1) Energy saving effect

Table 1 Energy saving effect of the suspension preheater (Production: 4,000 t/D)

	Improvement effect	Note
Specific heat recovery	400 to 500 x 10^3 kcal/(t-clinker)	Av. 450 x 10^3 kcal/(t-clinker)
Annual total heat recovery	594 x 10^9 kcal/y	Operation: 330 D/y
Crude oil equivalent	264,000 kL/y	

(2) Productivity of burning process may be improved.

[Economics] Equipment cost

Capacity of the kiln: one series of 4,000 tons/day facilities
(raw materials preparation through burning to finishing)
Cost of the facilities: 30,000 million yen

Remarks

The maintenance cost of the refractory of the rotary kiln can be reduced compared with the wet process.

[Example sites]
Employed at manyplants.

[References]
29th Cement Production Technology Symposium(1972), p.93
30th Cement Production Technology Symposium(1973), p.60
31st Cement Production Technology Symposium(1974), p.42

[Inquiry]
Japan Cement Association / ECCJ(JIEC)

YC-PE-3

Energy Conservation Directory

[Industry Classification] Ceramic : Cement	NSP-type cement calcining furnace	[Energy Source] Fuel
[Technology Classification] Production Equipment		[Practical Use] Around 1965 -

Outline

The NSP-type kiln has been developed to overcomes disadvantages of the increased size of SP-type kiln – such as wearing of firebricks in the calcining zone, increase in the maintenance cost, prolonged shutdown period and increase in heat loss. The adoption of the NSP-type kiln increases capacity and enables extended continuous operation without increasing diameter of the kiln, thus realizes significant energy saving.

Principle & Mechanism

A significant portion of the theoretical heat required to produce cement clinkers is consumed in the pyrolysis of limestone, which constitutes as much as 75 percent of the raw material, according to the reaction,

$CaCO^3$ -> $CaO + CO^2$.

[SP-type kiln]: Although the preheater, or suspension preheater, accomplishes a high rate of heat exchange between the flue gas and the feed, the pyrolysis proceeds to the extent of only about 40 percent. The rest of the pyrolysis remains to be conducted in the kiln.

[NSP-type kiln]: The NSP-type kiln integrates a combustion furnace, called calcining furnace, in the preheater of the SP-type kiln. The calcining furnace burns 1 to 1.5 times as much fuel as that burned in the main kiln to accomplish more than 90 percent of the pyrolysis before the raw material is fed into the main kiln. In this way, the NSP-type kiln enables as much as 2 to 2.5 times the fuel to be burned in the entire plant without increasing the thermal duty on the main kiln, and consequently increases the capacity of the plant.

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

Before modification (SP-type kiln)

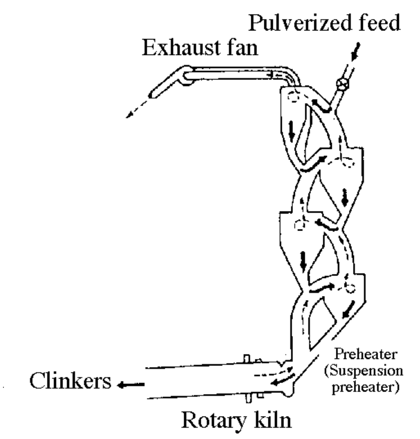


Fig. 1 Flow of SP-type kiln

After modification (NSP-type kiln)

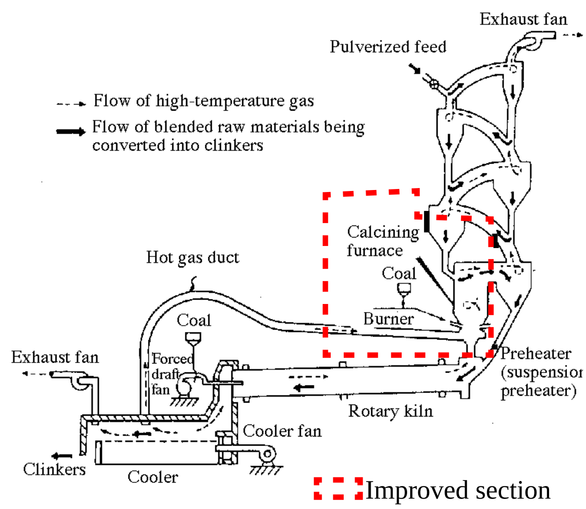


Fig. 2 Flow of NSP-type kiln

Energy saving effects

Productivity : The maximum production per unit rotary kiln has increased from a 3,000 to 4,000 ton-per-day range to a 7,000 to 10,000 ton-per-day range.

Table 1 Comparison between SP-type kiln and NSP-type kiln in thermal energy and productivity (7,000 tons/day base)

	SP-type Kiln	NSP-type Kiln	Effect
Productivity	61.8 kg/h-m^3 (100)	100.8 kg/h-m^3 (163)	
Specific energy consumption	814 kcal/kg clinker	797 kcal/kg clinker	17 kcal/kg-clinker (reduction)
Crude oil equivalent			17,453 kL/y (reduction)

[Economics] Equipment cost

Investment amount (A): million yen   Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

[Example sites]	[References]	[Inquiry]
Installed at almost all Japanese cement plants.	Energy Resourses Journal (Vol.17 No.14, 1996)	NEDO / ECCJ(JIEC)

YC-PE-4

Energy Conservation Directory

[Industry Classification] Ceramic : Cement	Cement clinker burning process	[Energy Source] Electricity
[Technology Classification] Production Equipment	Adoption of vertical roller mill for coal crushing	[Practical Use] 1980s -

Outline

Formerly, combination of a tube mill and a separator was used mainly for crushing coal. Nowadays, highly efficient vertical roller mills capable of crushing and drying coal, and classifying crushed coal have been commercialized. As a result, significant reduction of specific electric power consumption has been achieved.

Principle & Mechanism

1) Moist coal is fed either from the top or side to the rotating table of the vertical roller mill.
2) The roller mill mechanism is primarily to crush coal between the disc table and rolls which are pressed hydraulically onto the table.
3) Ground coal is fed upward to the classifier placed above by the hot air blown into the mill from below. Coal is dried while it is being brought upward by the hot air.

[Description]

Structure explanation, Shape, and/or System diagram

[Structure of roll mill for coal crushing] (Refer to Fig. 1.)

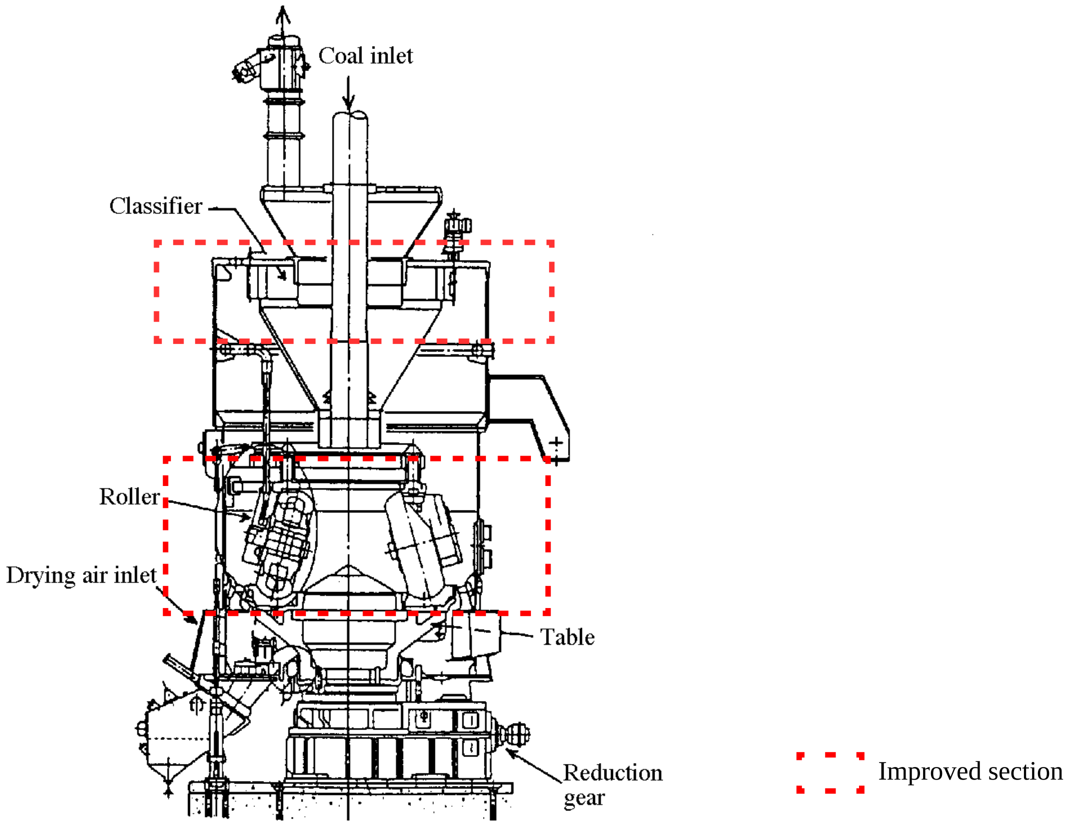


Fig. 1 Structure of vertical roller mill for crushing coal

Energy saving effects

Use of the vertical roller mill can reduce specific consumption of electric power by 20 to 25 percent compared with the conventional combination of tube mill and separator.

[Economics] Equipment cost

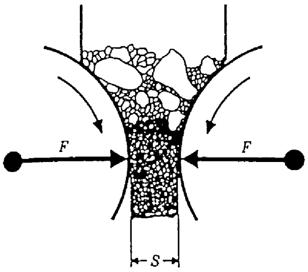
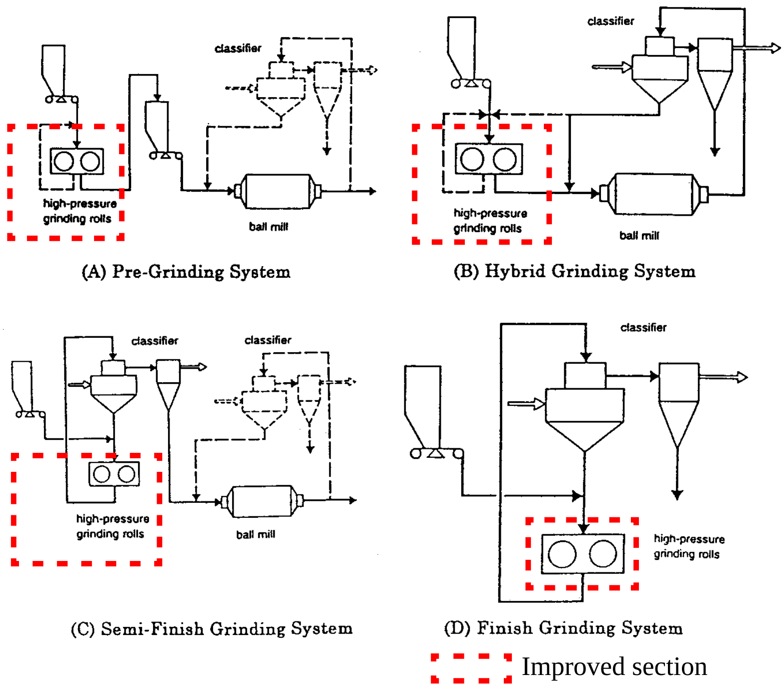
Investment amount (A): 600 million yen for 20 ton/hour size Improvement effect (B): million/year
Investment payback (A/B): years

Remarks

[Material of the major part]
Wear resisting cast steel is used for the rotating table and rolls.

[Example sites]	[References]	[Inquiry]
Installed at many plants.	Makers'in-house technical documents	Japan Cement Association / ECCJ(JIEC)

YC-PE-5	Energy Conservation Directory	
[Industry Classification] Ceramic : Cement	Cement production finishing section Introduction of pre-grinding roll crusher	[Energy Source] Electricity
[Technology Classification] Production Equipment		[Practical Use] Mid 1980s -

Outline	The burned clinkers from the kiln are quenched to about 100˚C in a quenching cooler and sent to the finishing section. This pre-grinding roll crusher grinds the clinkers to be fed to the finishing section under extremely high pressures, thereby reducing the total consumption of electric power in the cement clinker grinding section, compared with the conventional closed ball mill grinding system. This type of crushers have been extensively adopted since the mid 1980s to contribute greatly to energy saving.
Principle & Mechanism	As Fig. 1 indicates, the crusher crushes the clinkers by exerting pressures as high as 50 to 100 Kg/cm^2, on the basis of the projected area of the roll, onto the layer of clinkers passing between the two rolls. This preliminary crushing improves the total energy efficiency in the grinding operation, the subsequent closed ball mill system in particular.  Fig. 1 Conceptual diagram for mechanism of high-pressure roll press
[Description] Structure explanation, Shape, and/or System diagram	[Characteristics of Roll Crusher] 1) The roll crusher has a stationary roll and adjustable roll and controls the pressure between the rolls by adjusting the spacing between them. 2) Use of the roll crusher for preliminary crushing enables precise control of gypsum blending at 3 to 4 percent during the fine grinding stage. 3) Use of the roll crusher for preliminary crushing substantially reduces energy consumption of the subsequent fine grinding operations and at the same time improves cement productivity. 4) Fig. 2 illustrates process flows of systems in which preliminary roll crushing of clinkers is integrated.  Fig. 2 Process flows of systems including preliminary crushing of clinkers
Energy saving effects	Energy saving effect of preliminary crushing compared with the case without preliminary crushing in the closed ball mill grinding system (1)Specific power consumption of the preliminary crushing, 4 kWh/t : Crushing productivity increases by 30%, Specific electric power consumption reduces by 15%. (2)Specific power consumption of the preliminary crushing,10 kWh/t : Crushing productivity increases by 100%, Specific electric power consumption reduces by 26%.
[Economics] Equipment cost	The installation cost is about 500 million yen, which varies depending on the size of the facility.
Remarks	

[Example sites]	[References]	[Inquiry]
		Japan Cement Association / ECCJ(JIEC)

YC-PE-6	Energy Conservation Directory	
[Industry Classification] Ceramic : Cement	Cement production finishing section	[Energy Source] Electricity
[Technology Classification] Production Equipment	Introduction of clinker pre-grinding roll crusher	[Practical Use] 1987

Outline	The present case installs a vertical roll crusher of high grinding efficiency as a pre-grinding crusher in the step previous to the ball mill, the finishing grinder of cement production. By preliminarily crushing clinkers before they are fed into the ball mill of high power consumption, the efficiency of the ball mill was increased because its load was greatly reduced and the specific electric power consumption was significantly saved.
Principle & Mechanism	[Structure of the pre-grinding crusher] (vertical roller mill) A mixture of clinkers and gypsum was crushed by the compression and shear force between the table and three rollers, the latter being hydraulically pressed onto the former.
[Description] Structure explanation, Shape, and/or System diagram	[Outline of the pre-grinding crusher] (Refer to Fig. 1.) Limestone and others burned in the kiln are called clinkers. Clinkers are cooled and transported to the hopper. A weight counting feeder withdraws clinkers from the hopper and sends them to the pre-grinding crusher, a vertical roll mill, where the clinkers are preliminarily crushed. The preliminarily ground clinkers were lifted by a bucket elevator to a vibrating sieve which separates the ground clinkers into finer powders and coarser powders. The coarser powders in the sieve are sent back to the pre-grinding crusher. The finer powders are fed into the ball mill with gypsum for further grinding to produce finished cement product.

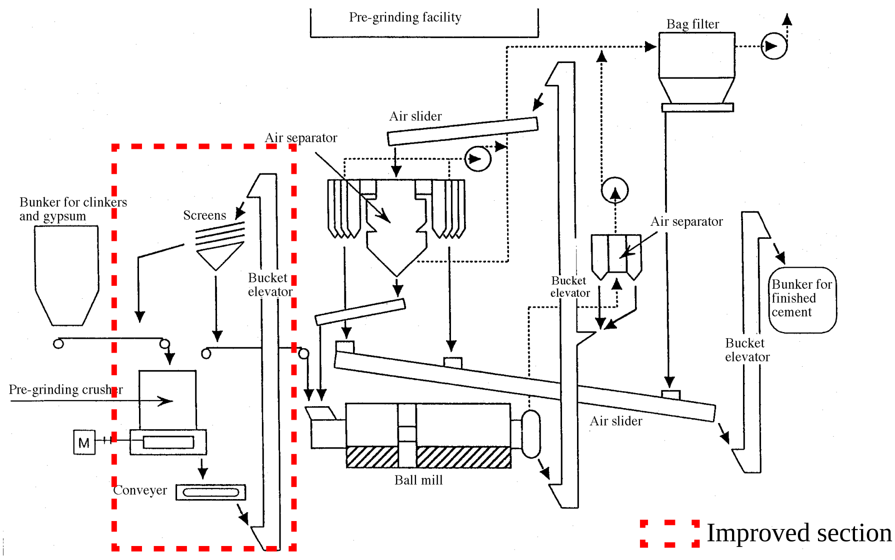


Fig. 1 Flow scheme of pre-grinding system with pre-grinding crusher for clinkers

Energy saving effects

Table 1 Effect of the pre-grinding crusher on energy saving and productivity

	Before improvement	After improvement	Improvement effect
Production capacity	107 t/hr	160 t/hr	1.5 times (increase)
Specific electric power consumption	36 kWh/t	29 kWh/t	7 kWh/t (19%reduction)
Electric power consumption*	32,400 MWh/y	26,100 MWh/y	6,300 MWh/y (reduction)
Crude oil equivalent			1,531 kL/y (reduction)

Note: * Production : 3,000 tons/day at 300 days/year operation

[Economics] Equipment cost	Investment amount (A): about 600 million yen for a 100 ton/hour grinder Improvement effect (B): million /year Investment payback (A/B): years
Remarks	This facility was used for a demonstration plant for energy saving technology at a cement plant in Indonesia as a model project of the New Energy and Industrial Technology Development Organization of Japan during the period from 1993 to 1995 and proved to effectively reduce specific electric power consumption.

[Example sites]	[References]	[Inquiry]
Installed at numerous sites. Proved effective at the Panda Cement Plant in Jawa Barat, Indonesia, for example.	44thCement Production Technology Symposium(1987), p.56 53thCement Production Technology Symposium(1996), p.36 NEDO report	Japan Cement Association / ECCJ(JIEC)

YC-PE-7

Energy Conservation Directory

[Industry Classification]	Adoption of a high-efficiency separator in the finishing process	[Energy Source]
Ceramic : Cement		Electricity
[Technology Classification]		[Practical Use]
Production Equipment		1980s -

Outline	The conventional separator based on cyclones was not very effective in separation. The modification represents development of a high-efficiency separator for grinders that produce fine particles during the finishing process.
Principle & Mechanism	1) The primary air and the secondary air flows are introduced through their respective inlets tangentially. These air flows go through the guide vanes and form a vortex. The vortexes are introduced to the classification space between the guide vanes and vortex adjusting vanes. 2) The feed charged through the inlet enters the classification space through rotating dispersion plate and impingement plate. 3) The feed is classified primarily by the whirl flow at the guide vanes and secondly by the vortex adjusting vanes. The fine particles are discharged through the collecting duct. 4) The coarse particles collected in the recovery cone, after fine particles are completely removed from the coarse particles in the tertiary air flow, are sent back to the crusher.

[Description]

Structure explanation, Shape, and/or System diagram

The structure of the high-efficiency separator and its arrangement with associated facilities are shown below.

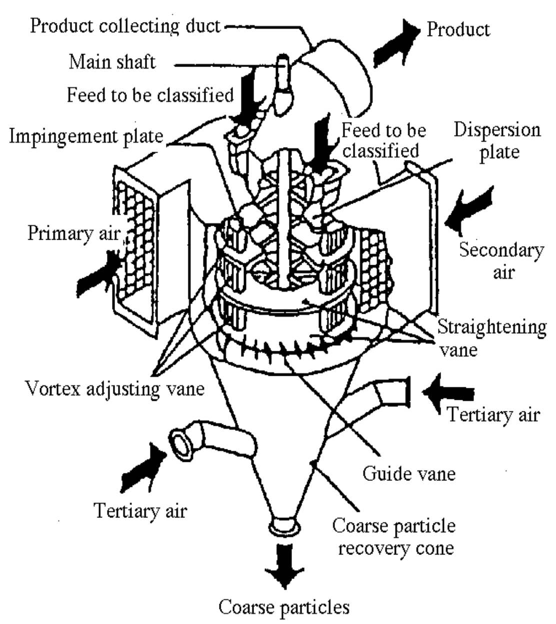


Fig. 1 Structure of high-efficiency separator

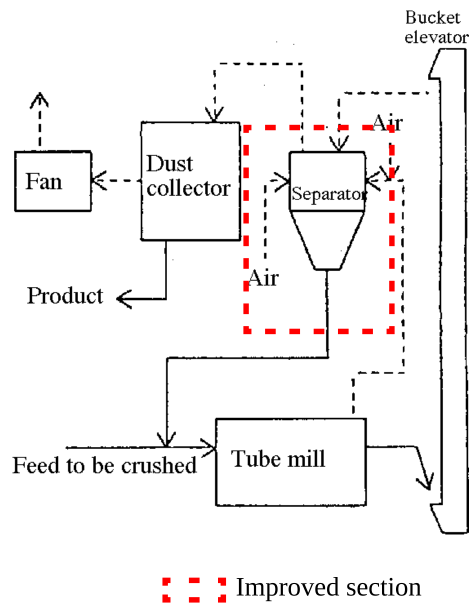


Fig. 2 Arrangement of high-efficiency separator with associated facilities

Energy saving effects	The power consumption in the finishing section of the grinding process may be reduced by about 10 percent with this high-efficiency separator.
[Economics] Equipment cost	Capacity of the facilities: One unit of classifier with dust collector corresponding to a ball mill of a 3,000 kW capacity. Cost of the facilities: About 150 million yen including installation cost
Remarks	This type of high-efficiency separators are also used in the raw material preparation section.

[Example sites]	[References]	[Inquiry]
Installed at many plants.		Japan Cement Association / ECCJ(JIEC)

YC-PE-8

Energy Conservation Directory

[Industry Classification] Ceramic : Cement	Cement clinker burning process	[Energy Source] Fuel
[Technology Classification] Production Equipment	Adoption of high-efficiency quenching cooler	[Practical Use] 1994

Outline

This modification represents adoption of a high-efficiency quenching cooler. The high-efficiency quenching cooler rapidly cools burned clinkers from the kiln by air to improve the cement quality. At the same time the air heated by the burned clinkers is used as combustion air for kiln burner to achieve energy saving.

Description of Process

[Cement burning process]

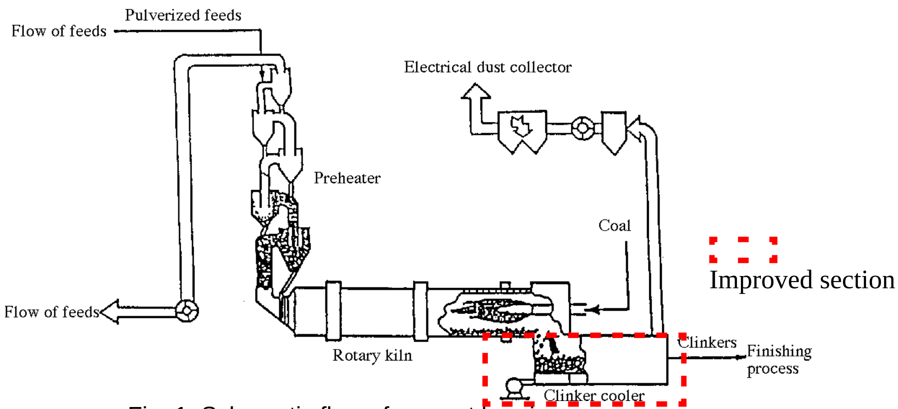


Fig. 1 Schematic flow of cement burning process

[Description]

Functions of the high-efficiency quenching cooler

1) Quenching of clinkers:
   Temperature of clinkers at the inlet of the cooler: 1,300˚C to 1,400˚C,
   Temperature of clinkers at the outlet of the cooler: 100˚C to 200˚C
   Quenching of clinkers is required to ensure the quality of clinkers.
2) Heat recovery
   About 60 % of the heat energy brought about by clinkers is recovered in the form of combustion air of about 800 ˚C.

Structure explanation, Shape, and/or System diagram

Before improvement	After improvement

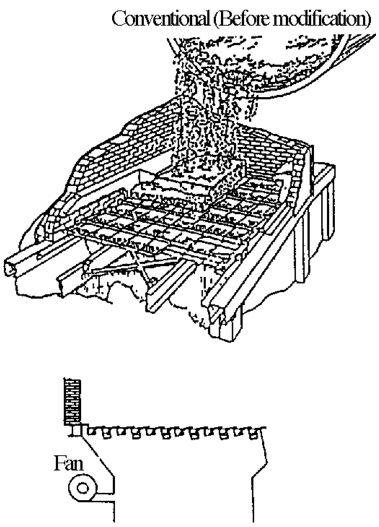
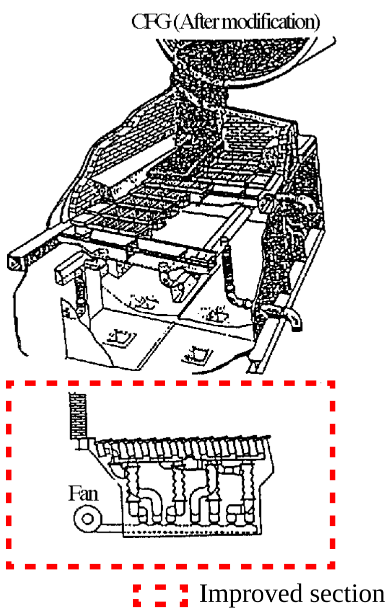

	

Fig. 2 Structure of conventional quenching cooler	Fig. 3 Structure of high-efficiency quenching cooler

	Before improvement	After improvement

[Description]

Structure explanation, Shape, and/or System diagram

Before improvement

[Cooling air chamber]

42 pieces of grate plates constitute a single large section.

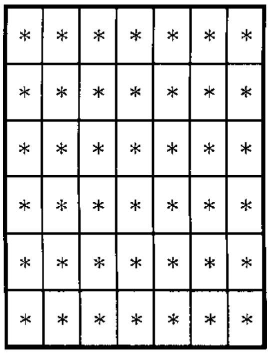


Fig. 4 Conventional cooling air chamber

[Grate plate]

A flat plate with numerous round holes opened through it.
Sealing between the plates is insufficient. The pressure loss is small.

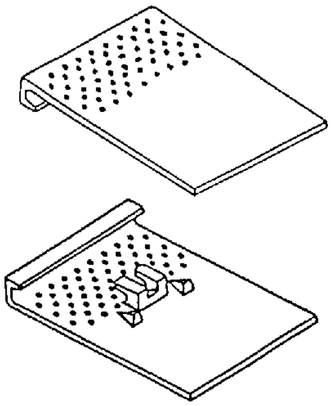


Fig. 6 Conventional grate plate

After improvement

[Cooling air chamber]

4-8 pieces of grate plates constitute one section, and the chamber is segmented into several smaller sections. In this case, one section of the conventional plate with 42 pieces is divided into 8 sections.

Improved point

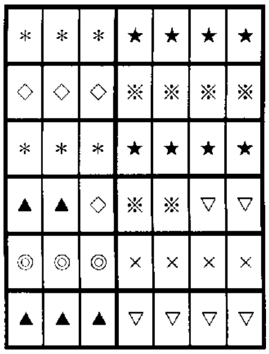


Fig. 5 Improved cooling air chamber

[Grate plate]

It has pockets (or troughs) where the clinkers are deposited. The holes on the side of the pocket are opened slightly downward.

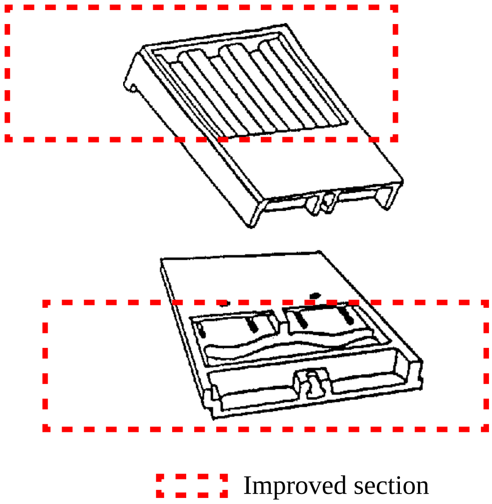


Fig. 7 Improved high-efficiency grate plate

Energy saving effects

Table 1 Energy saving efect of clinker cooler

	Improvement effect
Heat recovery rate	56.9 % to 62.3 % (Increased by 5.4%)
Specific heat consumption for cement production	2.8 % [20.5 kcal/kg-clinker](reduction)
Crude oil equivalent	approx. 2,240 kL/y (reduction)

[Economics] Equipment cost

Modification: Modification into high-efficiency cooler with the capacity of 5,000 ton/day
Equipment modification cost: 50 to 200 million yen

Remarks

With the introduction of this equipment, it is expected that the maintenance cost of the cooler grate is reduced and the operating rate of the kiln is increased due to stable cooler operation.

[Example sites]	[References]	[Inquiry]
Adopted at Mitsubishi Materials' Kurosaki Plant and some other sites.	"Collection of Energy Conservation Cases 1998," p. 499	Japan Cement Association/ECCJ(JIEC)

YC-ME-1

Energy Conservation Directory

[Industry Classification] Ceramic : Cement	Rock crushing process	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment	Adoption of external rock transfer system to the roller mill crusher	[Practical Use] 1980

Outline

The energy efficient vertical roller mills are replacing the conventional ball mills in the raw material rock crushing process. The present modification reduces the amount of the crushed rocks transferred within the roller mill and thereby reducing the power consumption of the draft fan used for transferring.

Principle & Mechanism

[External transfer type vertical roller mill]
The external rock transfer system allows a certain portion of the feed that has passed the crushing table to drop from the table and returns the portion to the inlet to the crusher using a bucket elevator. Thus, the transferring within the vertical roller crusher is reduced in this system.

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

[Conventional vertical roller mill system (before modification)] (Refer to Fig. 1.)
The conventional roller mill system transfers the crushed feed from the crushing part through the classifier. The induced fan for transferring represents about 60 percent of the total power consumption of this system.

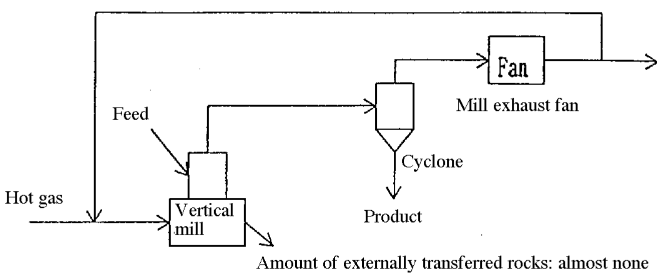


Fig. 1 System of the conventional roller mill

[External transfer type roller mill system (after modification)] (Refer to Fig. 2.)
The external transfer system returns the reject to the feed system by a bucket elevator. Therefore, the air velocity at outer periphery of the mill table is reduced and consequently the pressure drop is also reduced. This results in the lowering of specific power consumption of the induced fan.

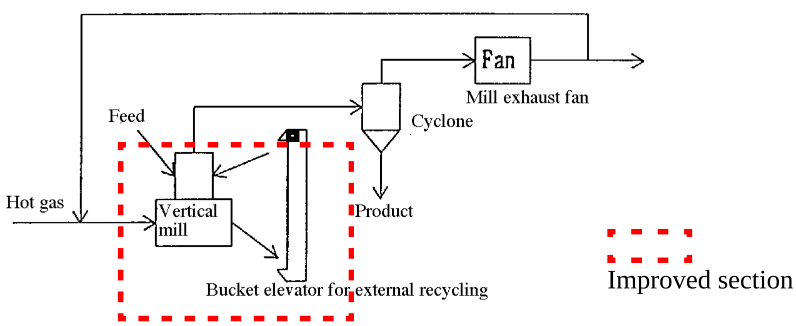


Fig. 2 Flow of the external transfer system of the roller mill

Energy saving effects

[Economics] Equipment cost

Investment amount (A): about 5 million yen Improvement effect (B): million yen/year
Investment payback (A/B): years
Installed at numerous sites.

Remarks

[Example sites]	[References]	[Inquiry]
	54th Cement Production Technology Symposium(1997), p.68 43rd Cement Production Technology Symposium(1984), p.12	Japan Cement Association / ECCJ(JIEC)

YC-ME-2

Energy Conservation Directory

[Industry Classification] Ceramic : Cement	Clinker burning process Modification of a conventional suspension preheater to a five-stage cyclone suspension preheater	[Energy Source] Fuel
[Technology Classification] Machinery & Equipment		[Practical Use] 1972 -

Outline

The NSP kiln is usually equipped with a four-stage cyclone suspension preheater. The temperature of gas at the outlet of the preheater is still as high as around 400˚C, high enough to allow further heat recovery. This case is an example of achieving energy saving by adopting a five-stage cyclone suspension preheater.

Before improvement

The exhaust gas of around 400˚C is generally used for drying raw materials. However, as the exhaust gas tends to be excessive, most of the gas is discharged after being treated for himidification though it still possesses recoverable heat energy.

[Description]

Structure explanation, Shape, and/or System diagram

[Modification to the five-stage suspension prheater]

1) The modification to the five stage preheater increases the pressure drop across the preheater and therefore increases the power consumption of the exhaust fan and decreases the throughput. It is therefore important that a low-pressure-drop axial cyclone as shown in Fig. 1 be employed. This type of cyclone is used for the upper second and third cyclones where their dust collecting ability is not adversely affected.
2) The modification to the five stage preheater may be applicable to a cement kiln of a capacity smaller than 4,000 tons per day for which exhaust gas electric power generation is not economically applicable.

[Before modification]

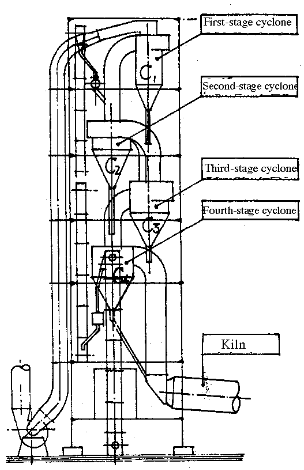


Fig. 1 Four-stage NSP suspension preheater

[After modification]

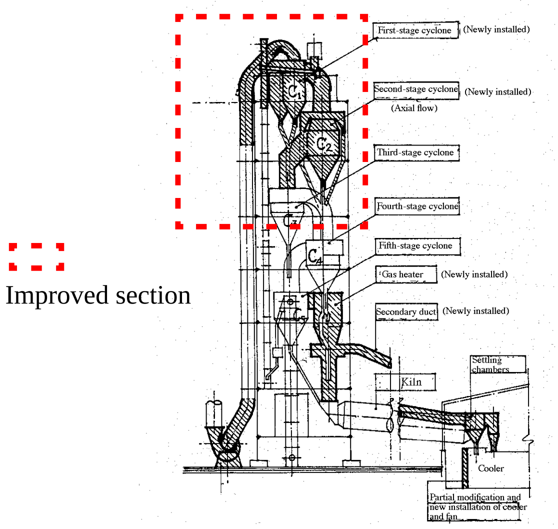


Fig. 2 Five-stage NSP suspension preheater

Energy saving effects

Table 1 Example of production capacity increase and energy saving effect by modification to five-stage cyclone

	Four-stage cyclone (before modification)	Five-stage cyclone (after modification)	Effect
Production of clinkers	1,680 t/D	2,000 t/D	320 t/D (19% increase)
Specific energy consumption	87.5 L/t (clinkers)	80.0 L/t (clinkers)	75 L/t (8.6% reduction)
Crude oil equivalent*			4,770 kL/y (reduction)

Note: * Production: 2,000 tons/day at operation of 300 days/year

[Economics] Equipment cost

Kiln capacity: One set of preheater with the capacity of 2,500 tons/day
Cost of facility: 100 to 200 million yen

Remarks

In the Japanese cement industry, the exhaust gas power generation is adopted for a number of kilns over 5,000 tons/year capacities. A number of smaller kilns have adopted five-stage cyclones.

[Example sites]	[References]	[Inquiry]
Installed at many plants.	54th Cement Production Technology Symposium(1997), p.68 38th Cement Production Technology Symposium(1981), p.12	Japan Cement Association / ECCJ(JIEC)

YC-ME-3	Energy Conservation Directory	
[Industry Classification] Ceramic : Cement	Clinker burning process	[Energy Source] Fuel
[Technology Classification] Machinery & Equipment	Small-pressure-drop suspension preheater	[Practical Use] Around 1985 -

Outline

The suspension preheater with multi-stage cyclones presents a problem of large pressure drop, resulting in increased power consumption of the exhaust blowers and leakage of air. As countermeasure to these problems, the present small-pressure-drop suspension preheater has been developed.

Principle & Mechanism

The principle of the low-pressure-drop suspension preheater is to use natural precipitation of highly concentrated dust particles in addition to the conventional separation by centrifugal force.

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

[Structure and characteristics] (Refer to Figs. 1 and 2.)

1) A trap is provided at the entrance of the cyclones to reduce the amount of the dust and reduce the linear velocity of feeds.
2) Adoption of natural precipitation of dust has enabled reduction of the inlet velocity of gas from the range of 20 to 25 meters per second to about 15 meters per second. As the velocity is reduced, the pressure drop is reduced.

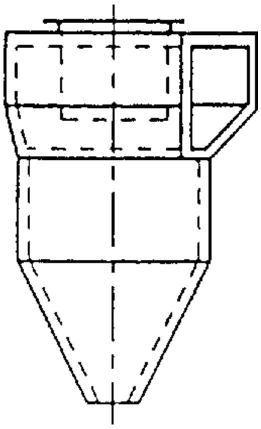


Fig. 1 Outline of small pressure drop cyclone

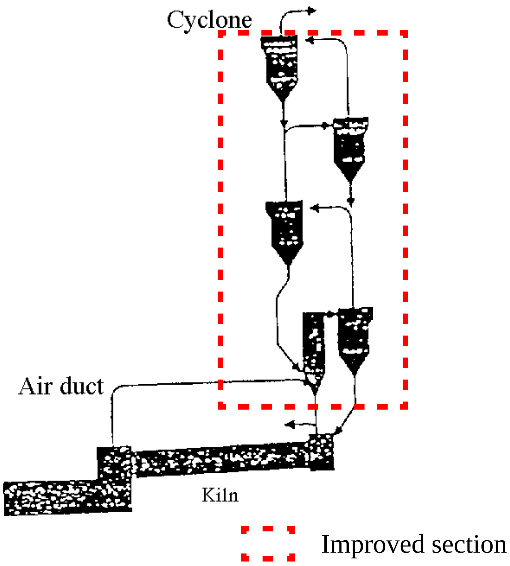


Fig. 2 Multi-stage cyclone suspension preheater

Energy saving effects

Table 1 Comparison between before and ater modification in energy saving effect

	Before modification	After modification	Effect
Pressure drop	120 to 150 mm Aq	80 to 100 mm Aq	
SP Exhaust fan power consumption	250 kW (100%)	125 kW (50%)	125 kW (50%)
Total power consumption			1,000,000 kWh/y (reduction)
Crude oil equivalent			243 kL/y (reduction)

[Economics] Equipment cost

Investment amount (A): 100 to 300 million yen Improvement effect (B) : million yen/year
Investment payback (A/B): years

Remarks

The inside walls of cyclones must be lined with fire-resistant bricks or refractory castables.

[Example sites]	[References]	[Inquiry]
Adopted at many plants.	Makers' in-house technical documents	Japan Cement Association / ECCJ(JIEC)

YC-ME-4

Energy Conservation Directory

[Industry Classification] Ceramic : Cement	Burning of used tires as substitute fuel for cement kiln	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1979

Outline

As a means of disposing of used tires, a technology has been established to utilize used tires as substitute fuel for cement kiln by burning it together with the conventional heavy oil and coal fuels. Although use of tires in the combined fuel for burning is still limited to a maximum of 10 to 13 percent, this technology certainly serves the dual purposes of waste disposal and energy saving. Accordingly, more than half the cement plants in Japan adopt this technology.

Principle & Mechanism

As Fig. 1 shows, the temperature of the combustion gas in the kiln reaches 1,800˚C At such a high temperature, the tires fed into the kiln completely burn quickly. Steel, one of the components of tires, melts and becomes iron oxide, one of cement raw materials, at this high temperature. Other components of tires also become cement raw materials as shown in Fig. 2.

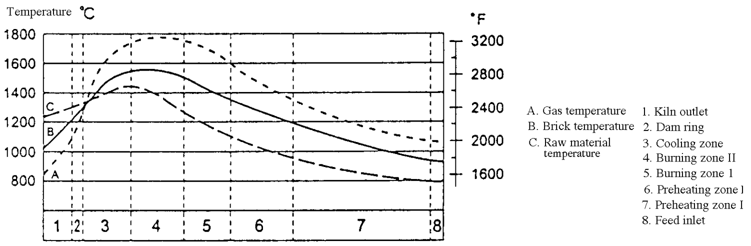


Fig. 1 Temperature distribution inside the kiln

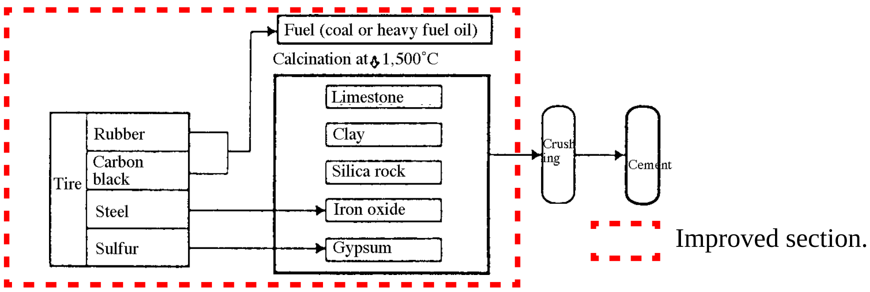


Fig. 2 Relation between components of tires and cement raw materials

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

[Structure of used tire burning facility]
(Figs 3 and 4)

- Tires are fed into the chute from the inlet of the kiln at the lower portion of the preheater. In most cases whole tires are fed without being broken.
- Fig. 4 shows the flow of the feeder.

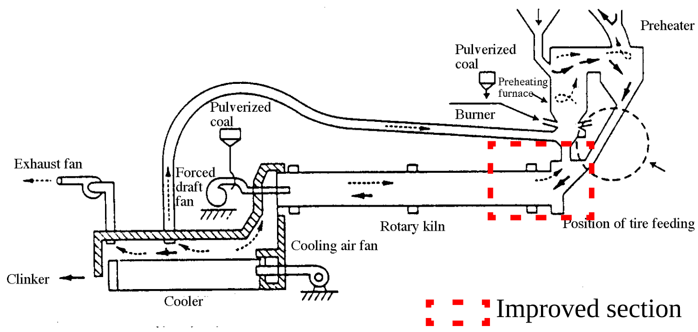


Fig. 3 Cement kiln with used tire feeding facility

Energy saving effects

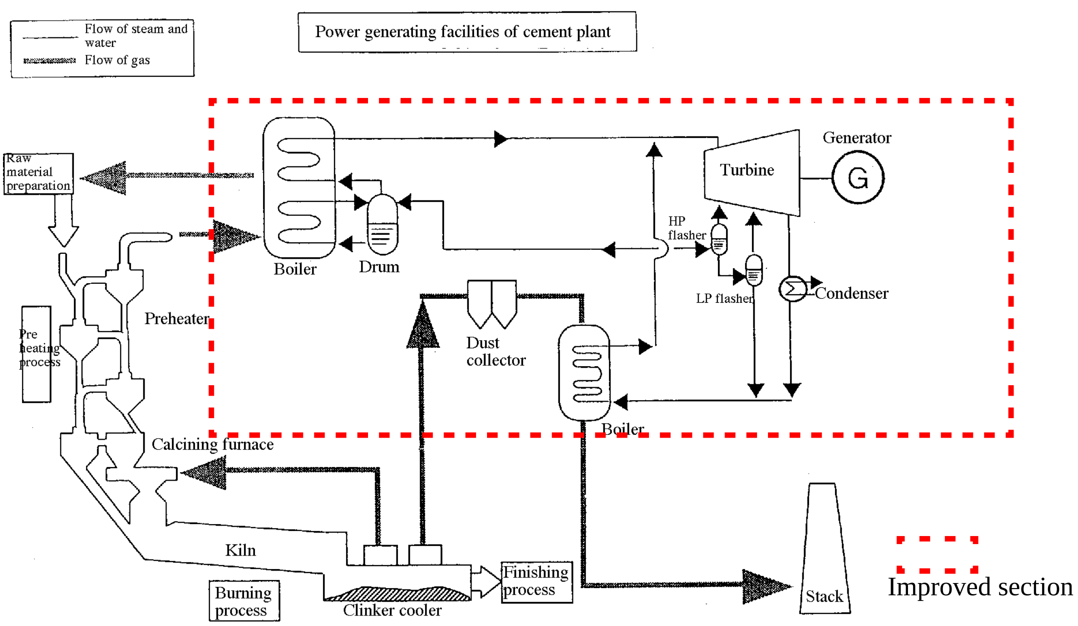
[Economics] Equipment cost

Equipment components : tire conveyer, feeder
Equipment cost : several tens million yen including installation cost
Installed at large number of cement plants.

Remarks

[Example sites]	[References]	[Inquiry]
Employed at many plants.	"Tyre Recycle Handbook (1996)" , P40, Japan Automobile Tyre Association	Japan Cement Association / ECCJ(JIEC)

YC-ME-5	Energy Conservation Directory	
[Industry Classification] Ceramic : Cement	Cement manufacturing process	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment	Medium-to-low-temperature flue gas power plant	[Practical Use] Around 1985 -

Outline	The present case saves energy by integrating electric power generation in a cement manufacturing system drawing upon the waste heat of the medium-to-low-temperature exhaust gas of the suspension preheater (SP) and the clinker cooler. Waste heat recovery boilers are installed to recover heat from these gases to generate electricity. In addition, the boiler flue gas is used to dry the cement raw material and coal. Thus, the waste heat is effectively utilized to save energy.
Before improvement	Conventionally in many cases, the waste heat of the medium-to-low-temperature exhaust gas of the suspension preheater (SP) and the clinker cooler was discharged without their heat being effectively utilized.
[Description of improvement] Structure explanation, Shape, and/or System diagram	[Power generation by the waste heat of the medium-to-low-temperature exhaust gas] (Refer to Fig. 1.) (1)The waste heat of the medium-to-low-temperature exhaust gas streams, specifically the exhaust gas of 350 to 380˚C from the suspension preheater (SP) and the exhaust gas of 200 to 250˚C from the cement clinker cooler, is recovered by waste heat recovery boilers to generate steam for driving a steam turbine to effectively generate electricity. (2)Generation of electric power is about 6,500 kW for a cement production rate of 3,000 tons per day.  Fig. 1 Concept of power generation using medium-to-low-temperature exhaust gas of cement manufacturing process
Energy saving effects	Electric power of about 6,500 kW can be generated by the cement plant of the contemplated capacity. This can save energy corresponding to 12,636 kiloliters of crude oil a year.
[Economics] Equipment cost	Investment amount (A): 5,000 to 6,000 million yen for a 23,000 KW size Improvement effect (B): million yen/year Investment payback (A/B): years
Remarks	This technology was trial-tested in fiscal 1998 by the New Energy and Industrial Technology Development Organization of Japan, at Ningguo Cement Plant in the Anhui Province of China as “Model Project for Power Generation Using Waste Heat from Cement Plant” and at the Hatenin II Cement plant in Vietnam as “Model Project for Energy Consumption Saving Using Waste Heat from Cement Burning Plant.”

[Example sites]	[References]	[Inquiry]
Adopted at many sites.	Makers’ in-house technical documents NEDO Reports	Japan Cement Association / ECCJ(JIEC)

YG-PE-1

Energy Conservation Directory

[Industry Classification] Ceramic : Glass	Introduction of electric furnace instead of crucible furnace for melting glass	[Energy Source] Electricity
[Technology Classification] Production Equipment		[Practical Use] 1984

Outline

Manufacturers of scientific equipment, medical equipment and heat-resistant chinaware normally use combined crucible furnaces for which fuels are burned. This case achieved a significant reduction of specific energy consumption and cost by introduction of an electric furnace.

Principle & Mechanism

[Principle and structure of the electric furnace] (Refer to Fig. 1.)
Glass is used as an insulator of electricity at normal temperature. At high temperatures, specific electrical resistance of glass rapidly reduces as temperature rises. In other words, electric current can flow within glass by ionic conductance in the glass body at high temperatures.

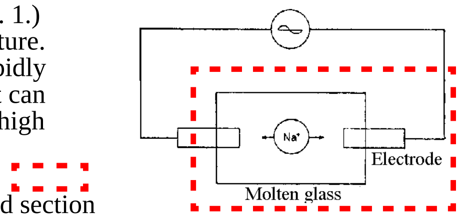


Fig. 1 Principle of electric melting

[Description]

Structure explanation, Shape, and/or System diagram

[Characteristics of electric furnace]

1. Structure of electric furnace (Refer to Fig. 2.)
   The electric furnace consists of a melting bath and an operating bath. The melting bath heats the content by direct electrical resistance heating method by using molybdenum electrodes. The operating bath heats the content by radiation from the electrical resistance heating bodies placed above.

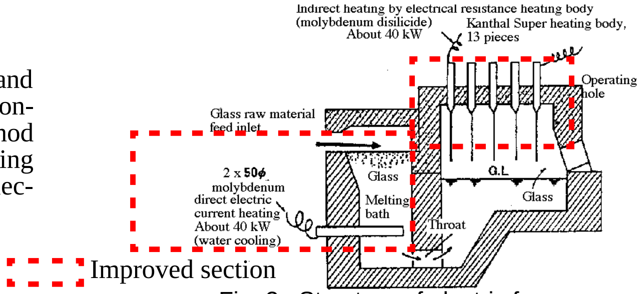


Fig. 2 Structure of electric furnace

2. Features of electric furnace
   The reasons for high thermal efficiency of electric furnace are as follows:
   1) The input energy is directly converted into thermal energy to heat glass and the glass is exoergic ; therefore, heat loss is smaller.
   2) Because of use of the direct resistance heating method, the size of the furnace can be reduced and the heat emitting surface is small. The molten glass is covered by patch, a system known as cold top; therefore, heat emission from the molten glass surface is smaller.
3. As shown in Fig. 1, the electric furnace exhibits lower specific energy consumption as compared with the combined crucible furnace. (Refer to Table 1.)

Table 1 Comparison of specific energy consumption between combined crucible furnace and electric furnace

	Electric furnace		Combined crucible furnace	
Glass production	0.7 t/D	2 t/D	1 t/D	2 t/D
Specific energy consumption	2.2 kWh/kg	1.45 kWh/kg	1 L/kg	0.8 L/kg
Specific heat energy consumption	1,892 kcal/kg	1,247 kcal/kg	9,200 kcal/kg	7,360 kcal/kg
Ratio in specific heat energy consumption (crucible furnace being 1.00)	1.00	0.66	4.86	3.89

Energy saving effects

Table 2 Comparison between combined crucible furnace and electric furnace

	Combined crucible furnace	Electric furnace	Effect
Production	7.5 t/M	10 t/M	2.5 t/m (increase)
Energy consumption	360 kL/y	716,856 kWh/y	
Energy consumption in calorific unit	3,384 x 10^6 kcal/y	1,756 x 10^6 kcal/y	1,628 x 10^6 kcal/y (reduction)
Ratio of specific energy consumption of both furnaces (crucible furnace being 1.00)	1.00	0.39	
Crude oil equivalent			176 kL/y (reduction)

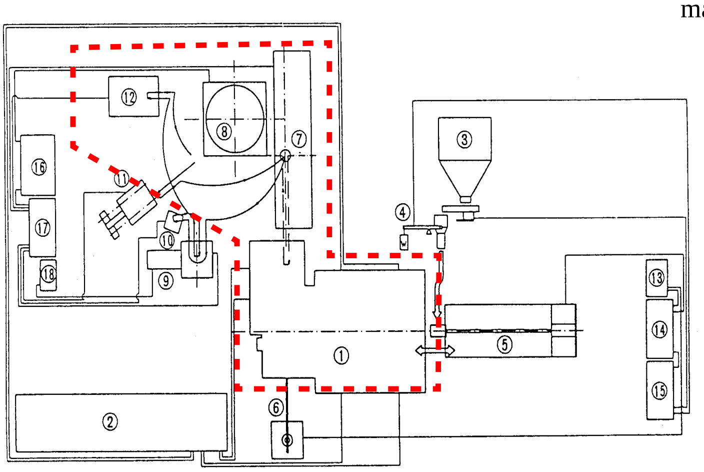
[Economics] Equipment cost

Investment amount (A): million yen   Improvement effect (B): million yen/year
Investment payback: years

Remarks

[Example sites]	[References]	[Inquiry]
Adopted at many sites.	Energy Saving Journal (Vol. 36, No. 13, 1984), P. 19	NEDO / ECCJ(JIEC)

YG-PE-2	Energy Conservation Directory	
[Industry Classification] Ceramic: Glass	High-efficiency melting furnace and shaping system for glass	[Energy Source] Electricity
[Technology Classification] Production Equipment		[Practical Use] 1989 -

Outline	This is an energy conserving system that automatically feeds raw materials into the furnace and automatically conducts shaping operation to manufacture of many products in small lots, and is applicable to manufacture of high-quality glass, both crystal glass and borosilicate glass.
Principle & Mechanism	- The electric melting furnace is of electro-conductive melting type. - A phase control thyristor system is employed for controlling. - The annealing furnace burns gas and is normally operated at 1,380˚C. Temperature is automatically controlled by a laser beam attitude control system.
[Description] Structure explanation, Shape, and/or System diagram	[Characteristics of the facilities and system] (Refer to Fig. 1.) 1)This system is capable of manufacturing crystal glass containing PbO at six percent and borosilicate glass whose thermal expansion coefficient is 50 x 10^{-7}/˚C. 2)This system adopts a direct electro-conductive electric furnace and is capable of melting two kinds of glass by using two kinds of electrodes. 3)The shaping system takes the parison from the furnace pot by a suction feeder from which the blowing tube takes the parison into the shaping machine by a robot operation. The subsequent blowing is also automatically operated. Major specifications Raw material feeding rate: 40 times/hour max. or a 200 kg max. Raw material weighing: 5 kg max. for a cycle Shaping process; glass ladling capacity: 4 kg max. for a cycle  Improved section Fig. 1 High-quality glass melting and shaping system

1	Electric melting furnace
2	Transformers
3	Raw material hopper
4	Measuring equipment
5	Raw material feeder
6	Raw material level gauge
7	Suction feeder
8	Robot
9	Annealing furnace
10	Phosphorus feeder
11	Blowpipe heater
12	Shaping machine
13	Control panel for raw material level gauge
14	Control panel for raw material feeder
15	Control panel for measuring equipment
16	Control panel for robot
17	Central control panel
18	Control panel for annealing furnace

Energy saving effects	- This system can reduce energy consumption by 30 percent compared to the present electric furnace.
[Economics] Equipment cost	Investment amount (A): million Improvement effect (B): million yen/year Investment payback (A/B): year
Remarks	

[Example sites]	[References]	[Inquiry]
Adopted at many sites.	Technical Development Series for Small or Medium-Sized Businesses NO. 126 (1990)	NEDO/ECCJ(JIEC)

YG-ME-1

Energy Conservation Directory

[Industry Classification]
Ceramic: Glass

[Technology Classification]
Machinery & Equipment

Adoption of a combustion system with oxygen burners for melting glass

[Energy Source]
Fuel

[Practical Use]
Around 1993 -

Outline

This case represents a system in which oxygen is employed instead of air for burners of the furnace to melt glass.

Principle & Mechanism

1)Combustion with the oxygen-gas burners raised the flame temperature above 2,400˚C.
2)Combustion with the oxygen-gas burners reduced formation of nitrogen oxides in the combustion gas by half.
3)Oil atomized through long-flame-type nozzles by high-pressure oxygen burns in a long flame, which produces higher level of radiation, thereby enabling high-efficiency heating.
4)This system can eliminates the need of regenerators.

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

[Specifications and structure of the oxygen burner combustion system] (Refer to Fig. 1.)
1) Major specifications of the burners
- Fuel supply pressure at burner inlet : 20 Kg/cm^2
- Oxygen supply pressure at burner inlet : 0.1 Kg/cm^2
- Length of flame at 20 L/h burner capacity: 1.2 m
  at 200 L/h burner capacity: 4.0 m

2) Process flow of oxygen burner combustion system

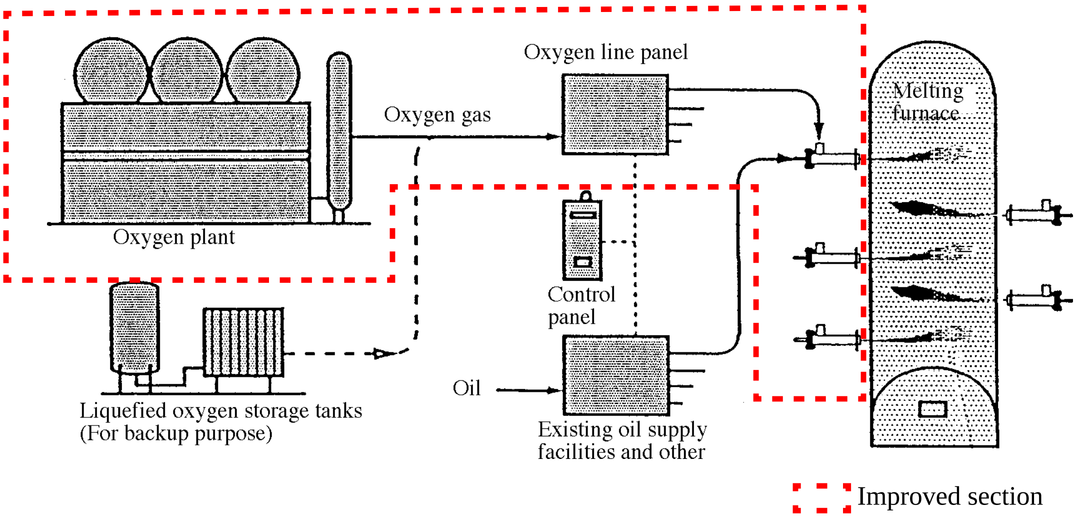


Fig. 1 Example of process flow of oxygen burner combustion burner system

Energy saving effects

Table 1 Energy saving effect of oxygen burners for glass melting furnace

	Melting furnace with air burners	Melting furnace with oxygen burners	Improvement effect
Fuel consumption	100 %	40 %	60% reduction
Crude oil equivalent			

[Additional merit]
Bubbles in the products are reduced by 75 percent.

[Economics] Equipment cost

Investment amount (A): million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

.

[Example sites]

[References]
Japan Enzyme Technical Review, No. 13 (1994), p.17

[Inquiry]
NEDO / ECCJ(JIEC)

YG-OM-1

Energy Conservation Directory

[Industry Classification] Ceramic: Glass [Technology Classification] Operation & Management	Intensified insulation of tank furnace for melting glass	[Energy Source] Fuel [Practical Use] Late 1970 -

Outline

This case improves thermal insulation of a tank furnace for E-fiberglass by changing the material of the refractory side blocks.

Principle & Mechanism

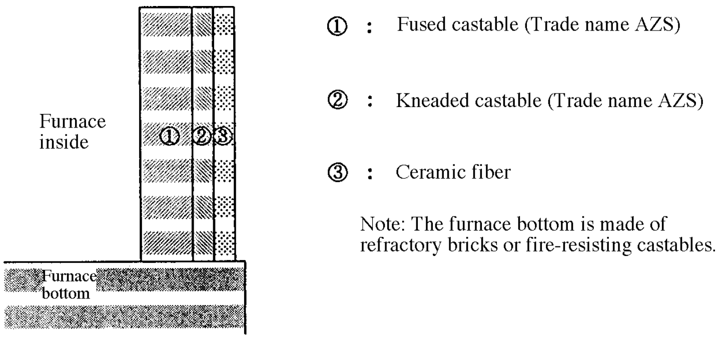


Fig. 1 Typical structure of tank furnace for melting glass

[Description]

Structure explanation, Shape, and/or System diagram

[Before improvement]

- Dense zircon was used for side blocks of the tank furnace for E-fiberglass. (Refer to Fig. 2.)

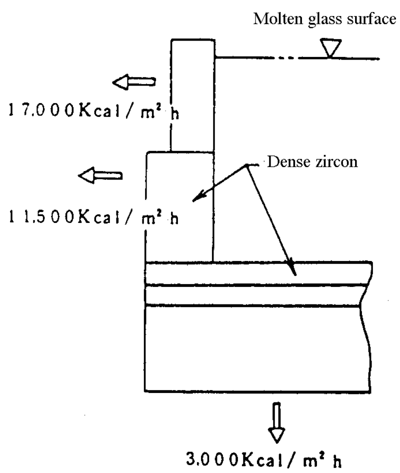


Fig. 2 Example of dense zircon used as refractory

[After improvement]

- Chromium oxide is used for side blocks and paving blocks of the furnace for melting E-fiberglass. (Refer to Fig. 3.)
- Adoption of chromium oxide cut the heat emission by half that of dense zircon, thereby reducing the fuel consumption by five percent.

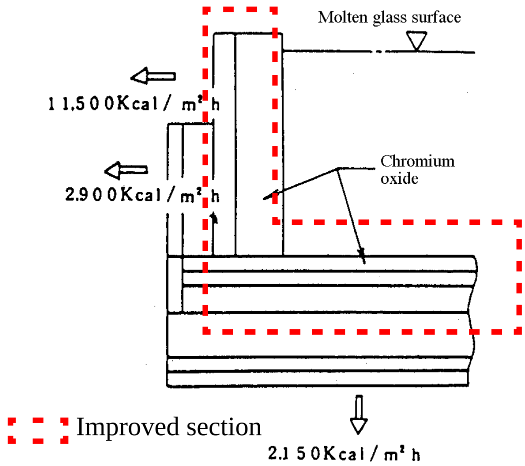


Fig. 3 Example of chromium oxide used as refractory

Energy saving effects

- This case achieved energy saving by five percent.
- Generally, modification of furnaces to optimum designs can reduce fuel consumption by 20 to 30 percent.

[Economics] Equipment cost

Investment amount (A): million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

- Depending upon selection of materials, the refractory in contact with molten glass may affect the quality of product glass and life of the furnace; therefore, care must be exercised for selection of the refractory.

[Example sites]	[References]	[Inquiry]
	Glass production makers' in-house technical documents	NEDO / ECCJ(JIEC)