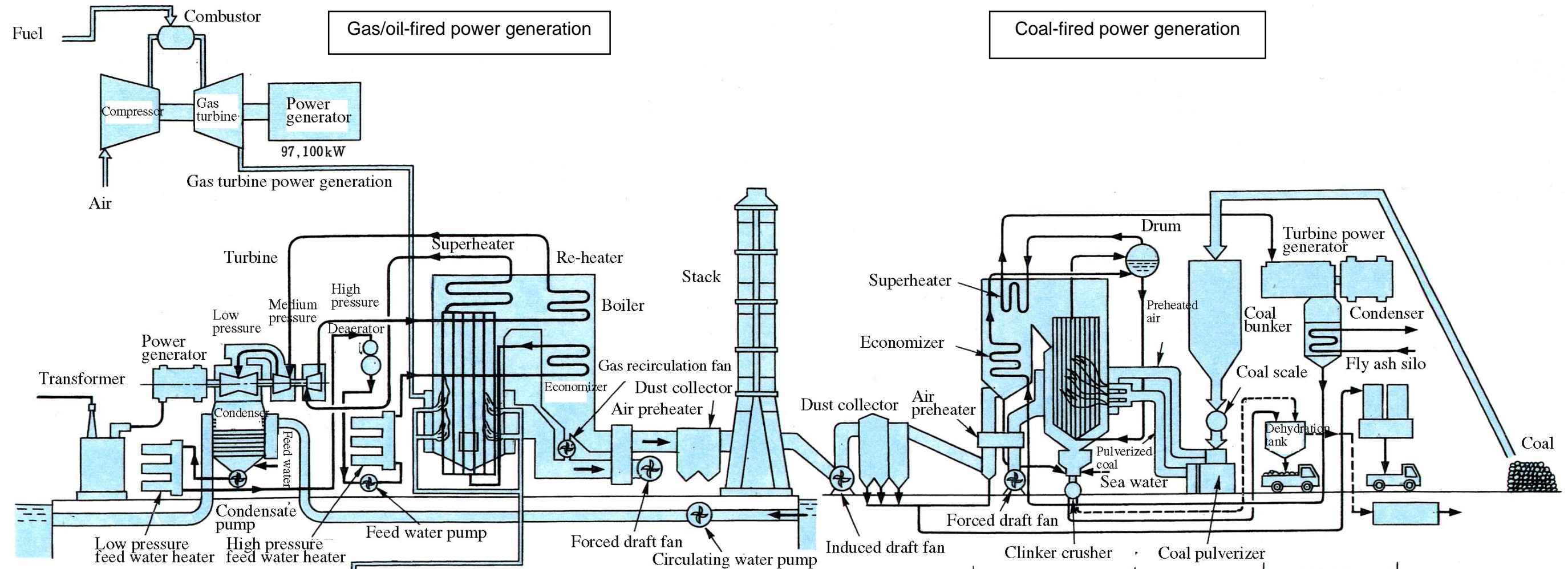


Section 9

Electricity Generation

Process Flow
Data Sheets

Electricity Generation: Power Generation Process and Energy Saving Technology



Item No.	Technology Item/Title
EG-ME-1	Rotating regenerative air preheater automatic seal gap controller
EG-ME-2	Carbon-sealed regenerative air preheater for boiler
EG-ME-3	Separate type heat pipe heat exchanger
EG-ME-6	Large sized boiler soot blower
EG-ME-9	Rotation speed control of large boiler blower and exhauster through wet type multi-plate speed reducer

Item No.	Technology Item/Title
EG-PE-5	Fluidized bed combustion coal fired boiler

Item No.	Technology Item/Title
EG-PE-6	Pressurized fluidized bed composite coal fired power plant (PFBC)

Item No.	Technology Item/Title
EG-PE-1	High efficiency steam turbine blade
EG-PE-2	Supercritical pressure power generation
EG-PE-3	Combined gas and steam turbine power generation
EG-PE-4	Waste heat recovery power generation
EG-ME-4	Removal method of scale from inside condenser tubes
EG-ME-5	Air cooler for gas turbine combustion air

Item No.	Technology Item/Title
EG-OM-1	Low-pressure operation of natural circulation boiler
EG-OM-2	Operation method of increased temperature of main steam at boiler outlet
EG-OM-3	Gas recirculating steam temperature control system
EG-OM-4	Reduction of starting-up time of cold plant

Item No.	Technology Item/Title
EG-ME-7	Repowering combined cycle system of exhaust repeat combustion type
EG-ME-8	Industrial repowering system

EG-PE-1

Energy Conservation Directory

[Industry Classification] Electricity Generation	High efficiency steam turbine blade	[Energy Source] Fuel(general)
[Technology Classification] Production Equipment		[Practical Use] 1980's~

Outline
A steam turbine that provides a high thermal efficiency by adopting the latest blade design theories, such as the laminar flow blade (Shrunked blade) with the cross-section of the blade designed to cause the least turbulence to the steam flow, a nozzle with its tip twisted in consideration of the affect of the outer and inner walls on the tip and the root of the blade (controlled vortex nozzle), and the multiple fin sealing designed to prevent steam leak from the tip of the blade.

- Principle & Mechanism**
- 1) The trailing end of the Shrunked blade is thinned, preventing turbulence of steam onthe back of the blade.
 - 2) The Shrunked blade has come to be theoretically determined due to the development of the blade design theory and the enlargement of the computer. capacity.
 - 3) As the exit speed from the nozzle is slowed down near the inner and outer walls dueto the influence by the walls, the inflow angle to the rotating blade differs from thetheoretical value.
 - 4) As a result, loss occurs near the inlet of the rotating blade (loss of attack angle).
 - 5) To solve the above problem, the tip of the nozzle is twisted in the controlled vortexnozzle, thereby making the actual steam flow match with the incidence angle of themoving blade.
 - 6) Other than the above, it has such features as the stop blade attached to the fastening plate, and the elliptically processed packings.

[Description]
The Shrunked blade, controlled vortex nozzle, multiple fin sealing, stop blade, and elliptically processed packing are illustrated below in comparison with the conventional types.

Shrunked blade
Controlled vortex nozzle
Multiple fin sealing
Stop blade
Elliptically processed packing

 Improved section

Fig. 1 Shrunked blade, controlled vortex nozzle, multiple fin sealing, stop blade, elliptically processed packing

Energy saving effects
Internal heat efficiency of a 500,000 kW-class high-technology steam turbine is 2 - 2.5% (relative value) better than the conventional type. With the utilization rate of 38%, energy saving is 3,500 kL/y in crude oil equivalent.

[Economics]
Equipment cost
 Investment amount (A): 400 million yen
 Improvement effect (B): 200 million yen/year
 Investment payback (A/B): 2 years

Remarks

[Example sites] Applied at many sites	[References] The 7th National Conference of Energy Conservation, "Collection of Energy Conservation Cases", p. 2413, the Energy Conservation Center, Japan, 1982	[Inquiry] NEDO / ECCJ (JIEC) JEMA
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EG-PE-2

Energy Conservation Directory

[Industry Classification] Electricity Generation	Supercritical pressure power generation		[Energy Source] Fuel (coal)
[Technology Classification] Production Equipment			[Practical Use] Around 1975
Outline	Supercritical pressure steam is generated in the boiler and used for driving the turbine for power generation.		
Conventional process	<ol style="list-style-type: none"> 1) Conventional steam pressure is around 170 kgf/cm². 2) From the Rankine cycle T-s diagram, it has been known that the higher steam pressure produces the higher thermal efficiency, but it has not been put into practice due to the technological limitation in designing boilers and turbines. 3) However, the steam pressure was raised from below 100 kgf/cm² to around 170 kgf/cm². 		
New process	<ol style="list-style-type: none"> 1) In the new process, the steam pressure is raised to a supercritical region (higher than 246 kgf/cm²), increasing thermal efficiency. 2) Consequently, the boiling of water to generate steam does not occur in the boiler. As the water in the liquid phase directly shifts to the vapor phase, the once-through boiler is required instead of the drum type boiler. 3) The relationship between steam conditions and the thermal efficiency of the plant is expressed by the Rankine diagram. 4) High temperature strength under high pressure was the problem confronting the designing of the superheater, reheater, main steam valve, and turbine blades, etc. However, as high-temperature materials have become available economically of late, the supercritical pressure generation has come to be often adopted. 5) When the steam pressure is excessively high (300 kgf/cm² or higher), the gross thermal efficiency does not increase much due to the increase of power consumption by the feed water pump. 		
Process comparison	Table 1 Comparison between conventional process and supercritical pressure steam generation process		
	Process	New process	Conventional process
	Steam pressure	More than 246kgf/cm ²	169kgf/cm ²
	Steam temperature	566/538° C	566/538° C
	Turbine	High pressure in 11 steps medium pressure in 6 steps	High pressure in 9 steps, medium pressure in 6 steps
	Medium pressure 1st step rotor blade	Ni-Cr-Mo-Ti heat resistant alloy steel	12% Cr-Mo-V alloy steel
	Pressure strength	Each unit of the boiler, high-pressure feed water heater, and feed water pump need to be made high-pressure resistant.	—
	Minimum load	15 - 25%	15%
	Change of load	Fast response	Ordinary response
	Frequent starts and stops	Suited	Suited
	Starting-up loss	Ordinary	Ordinary
	Start and stop	Takes a long time	Ordinary
	Thermal efficiency	1 - 2% higher	—
Facility cost	1.5 times higher for the 246 kgf/cm ² class	246 kgf/cm ² class is the standard.	
[Economics] Equipment cost	Investment amount (A): million yen Improvement effect (B): million yen Investment payback (A/B): years		
Remarks			
[Example sites] Applied at many sites	[References] Industry-owned technical materials and data of boiler makers	[Inquiry] NEDO / ECCJ (JIEC) JEMA (for equipment), FEPC (for operation)	

EG-PE-3

Energy Conservation Directory

[Industry Classification] Electricity Generation	Combined gas and steam turbine generation process	[Energy Source] Fuel (gas, light oil)
[Technology Classification] Production Equipment		[Practical Use] 1980's~

Outline In this combined generation process, power is generated by a gas turbine and a steam turbine, the latter being driven by the steam supplied from a heat recovery boiler the exhaust gas of the gas turbine.

Conventional process The previous type of gas turbine discharges the exhaust gas (about 600°C) into the atmosphere without utilizing its sensible heat.

- New process**
- 1) In this process, power is generated by the gas turbine, and the sensible heat of the exhaust gas (about 600°C) is recovered by the heat recovery steam generator (HRSG), and generated steam is used for driving the steam turbine for additional power generation.
 - 2) The exhaust gas from the gas turbine contains more than 10% of residual oxygen, which can be utilized as preheated combustion air in the industrial furnace.
 - 3) The temperature of the combustion gas at the inlet of the gas turbine is over 1070°C (over 1250°C in the latest model), and it is around 600°C at the outlet of the gas turbine.
 - 4) Illustrated below is the system diagram of the single-shaft combined power generator.

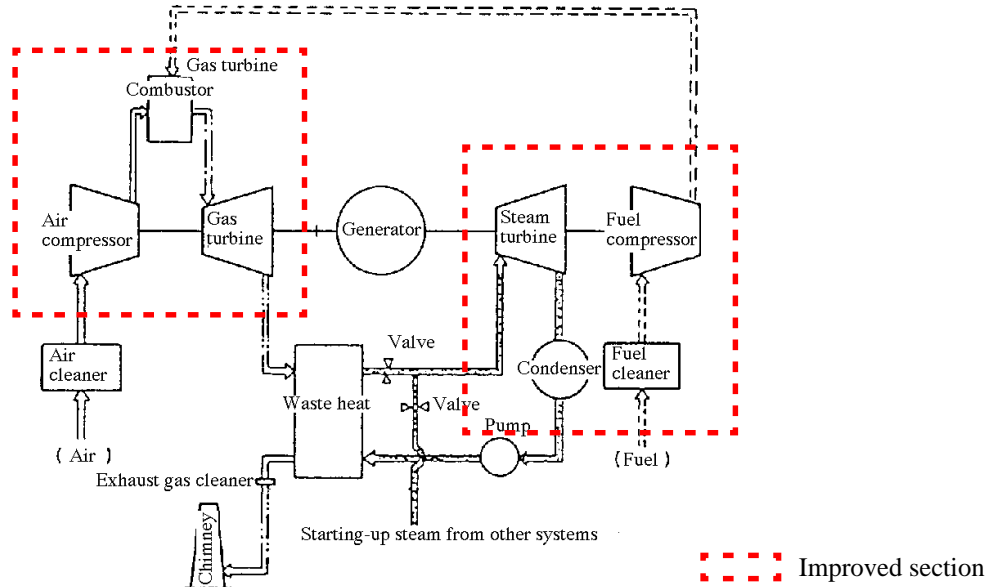


Fig.1 The system diagram of the single-shaft combined power generator

Table 1 Comparison between new and old process of combined gas and steam turbine

Process	New process	Conventional process *
Facility	Facility cost is cheap (70-80%)	Facility cost is expensive (100%)
Construction period	About one year (to be delivered to the site as a unit.)	More than 2 years (on-site assembly using delivered components)
Fuel	Gas (LNG, natural gas), light fraction oil (naphtha, kerosene, light oil)	Selectable from a wide range including heavy fraction oil, crude oil, and coal, as well as gas and light fraction oil.
Power generation efficiency	About 48% with a 150,000kW class generator (7 units for 1 million kW generation.)	About 42% for 1 million kW generation.(Single unit with a large capacity.)
Others	The multiple unit configuration alleviates reduction of generation capacity due to trouble of one unit.	Because of a single unit with a large capacity, reduction of generation is inevitably large in case of trouble. (High reliability is required.)

* Note:The conventional Process compared here is the Boiler Steam Turbine Power Generation Process.

[Example sites] Applied at many sites	[References] The Agency of Natural Resources and Energy, "1990 Energy Conservation Directory,"p.520, Research Committee at Ministry of International Trade and Industry, 1989	[Inquiry] NEDO / ECCJ (JIEC) JEMA (for equipment), FEPC (for operation)
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EG-PE-4

Energy Conservation Directory

[Industry Classification] Electricity Generation	Waste heat recovery power generation	[Energy Source] Electricity
[Technology Classification] Production Equipment		[Practical Use] 1970s~

Outline In this process, thermal energy of the high temperature exhaust gas, which was previously wasted, is recovered, being converted into steam in the waste heat boiler, and is used for driving the steam turbine to generate electrical power.

Conventional process Previously, waste heat was not utilized, and electric power was generated by driving the turbine with steam generated by the combustion of fuel in the boiler.

Illustrated in the diagram below is a new waste heat recovery generation process.

Fig.1 Diagram of the process

■ ■ ■ ■ Improved section

Table 1 Characteristic of waste heat recovery generation process

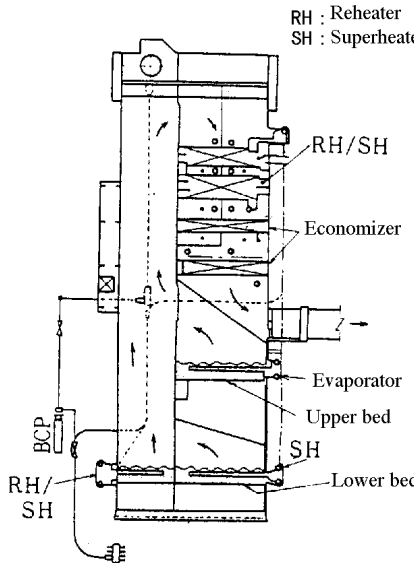
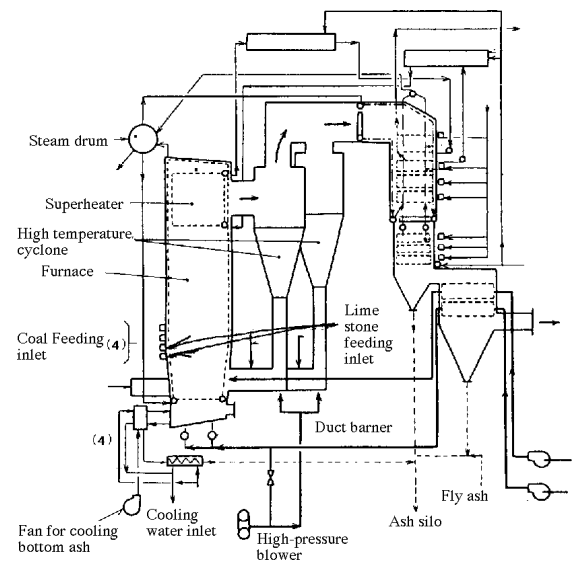
Process	New process (No corresponding conventional process)
Facility	Depending on heat volume to be recovered(steam volume), there is a wide range from a small type to a large type.
Specifications of the equipment	(1) The waste heat boiler should be flexibly adaptable to the actual installation layout. (2) The exhaust gas should involve low pressure loss, and desirably a low pressure fan should be adaptable. (3) Dust accumulation in the heat exchanger tube, and resultant deterioration of heat transfer efficiency, should be minimal. (4) In case of exhaust gas containing corrosive gases, designing should be such that the temperature of the heat exchanger tube be not in a range to cause low or high temperature corrosion. (5) For the purpose of recovering heat from the exhaust gas as much as possible, a preheater for feed water is needed. (6) For the purpose of increasing turbine efficiency, superheated steam should be used.
Fuel	Not necessary (utilization of exhaust gas heat).But in case the exhaust gas temperature is low or when the gas quantity is small, supplementary fuel is used.
Quality of the product	The electric power is used as auxiliary power, and in case of emergency, a separate power supply is needed.
Energy-saving effect	The generated electric power is considered to be a 100% energy-saving product.

[Economics]
Equipment cost
 Investment amount (A): million yen
 Improvement effect (B): million yen
 Investment payback (A/B): years

Remarks

[Example sites] Applied at many sites	[References] The Agency of Natural Resources and Energy, "Energy Conservation Facility Directory,"P436, The Energy Conservation Center, Japan, 1986	[Inquiry] NEDO / ECCJ (JIEC) JEMA
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Energy Conservation Directory

EG-PE-5	Fluidized bed combustion coal fired boiler	
[Industry Classification] Electricity Generation		[Energy Source] Fuel (coal)
[Technology Classification] Production Equipment		[Practical Use] Early 1970's
Outline	In this boiler, the gravity of particles is countervailed by the upward drag of the air, and the particles are fluidized, being handled like a fluid. The fluidized bed is composed of inactive particles like silica or desulfurizers like limestone (which are called a fluidizing medium), into which coal is injected for combustion, generating steam for power generation.	
Principle & Mechanism	<ol style="list-style-type: none"> 1) As the gravity of particles is countervailed by the upward draft of the air, fluidizing the particles, there is a correlation between the particle diameter and the air pressure, and a higher air pressure than that of the burner is required. 2) Fuel particles of coarse diameters can burn well. So, no coal pulverizer is required for this system. 3) There is no practical restriction on the stay time of the fuel. 4) As the thermal transfer between the medium and the fuel particles is rapid, the temperature quickly increases, which enables quick ignition and smokeless combustion. 5) Likewise, as the heat transfer coefficient between the heat transfer surface and the fuel particles is extremely large, the heat transfer area need not be large. 6) The fluidized bed is available in two types, the bubbling type and the circulation type. As regards inner furnace pressure, two types are available; the normal pressure type and the pressurized type. 	
[Description]	<ol style="list-style-type: none"> 1) The bubbling type is usually operated at a superficial velocity of 1 - 2 cm/sec, without carrying over the fluidizing medium out of the furnace. 2) The circulation type is operated at a superficial velocity of 4 - 10 cm/sec, carrying over the fluidizing medium and part of the fuel toward the furnace top. 3) The carried-over particles are collected with such device as a cyclone, and recirculated into the furnace. 4) The constructions of the bubbling type (left) and of the circulation type (right) are illustrated below. 	
Structure explanation, Shape, and/or System diagram	 <p style="text-align: center;">Fig.1 Bubbling type</p>	 <p style="text-align: center;">Fig.2 Circulation type</p>
Energy saving effects	Energy saving effect As coal which is not easily grinded can be used in coarse particles, a coal pulverizer is not needed, saving power consumption by the pulverizer. For example, with a 500,000 kW power generation boiler, it can dispense with 3 sets of 940 kW pulverizers (2820 kW in total).	
[Economics]	Investment amount (A): million yen	
Equipment cost	Improvement effect (B): million yen	
	Investment payback (A/B): years	
Remarks		
[Example sites]	[References]	[Inquiry]
Applied at many sites	The Japan Society of Mechanical Engineers, "Mechanical Engineers' Handbook (Advanced)," p. C7-9, Sept. 1991	NEDO / ECCJ (JIEC) JEMA

EG-PE-6

Energy Conservation Directory

[Industry Classification] Electricity Generation	Pressurized fluidized bed combustion composite coal fired power plant (PFBC)	[Energy Source] Electricity
[Technology Classification] Production Equipment		[Practical Use] 1970s~

Outline The pressurized fluidized bed combustion composite coal fired power plant (PFBC) is a highly efficient power generation plant using coal as a fuel.

Principle & Mechanism A ceramic filter is adopted to perform precision dedusting under the condition of high temperature and high pressure for the first time in the world.

[Description] The dry feed rock hopper system, a highly efficient feeding system, is adopted for fuel feeding. The fuel coal is crushed and dried, pressed together with fluidizer limestone, and is fed to the fluidized bed boiler inside the pressure vessel. After combustion and desulfurization of the fuel, the combustion gas is passed through a cyclone and a ceramic filter to be dedusted to the level of a few mg/Nm³, and then fed to the gas turbine. The steam generated from the fluidized bed boiler is fed to the steam turbine in the same way as the previous type of coal fired power generation system. Fig. 1 shows a diagram of the outline of the system.

Structure explanation, Shape, and/or System diagram

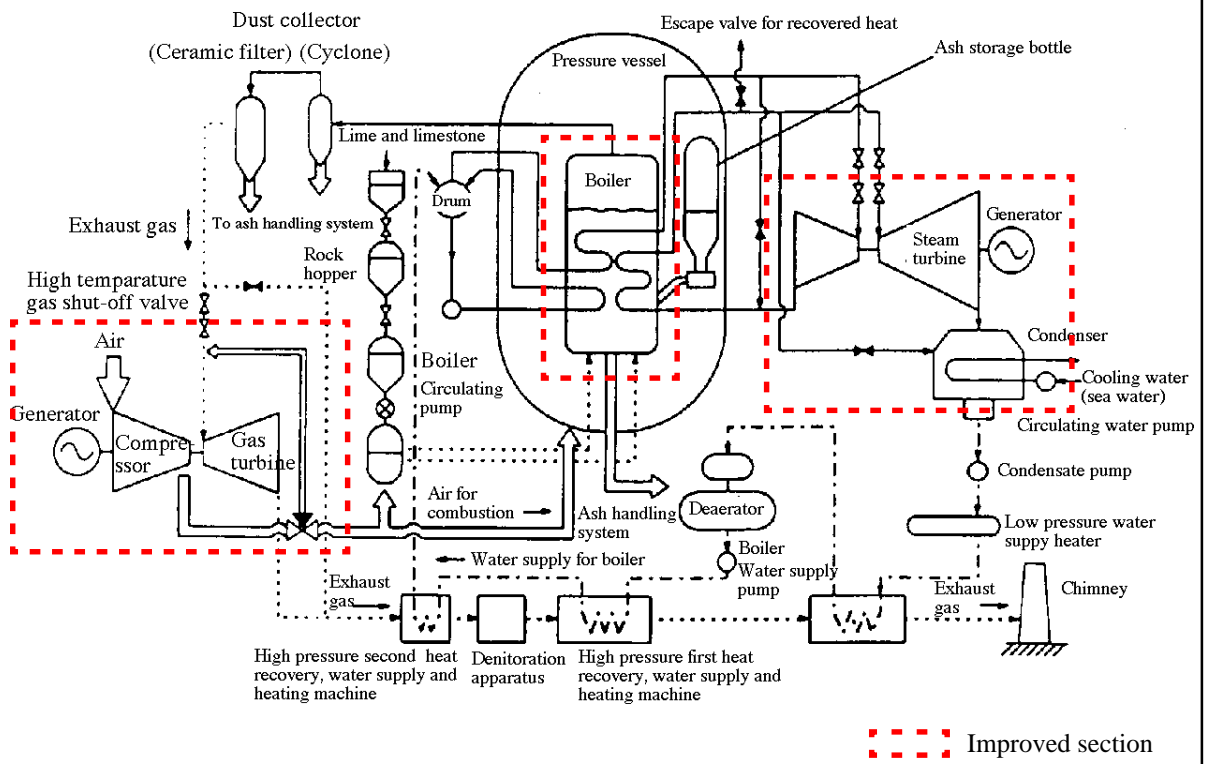


Fig. 1 Diagram of the outline of PFBC (pressurized fluidized bed combustion composite coal fired plant)

Energy saving effects The total efficiency of the plant reached the performance of more than 41% (HHV), which is equal to approximately 5% reduction in crude oil equivalent in comparison with a coal-fired power plant of the same size.

[Economics] Investment amount (A):	million yen
Equipment Improvement effect (B):	million yen
cost Investment payback (A/B):	years

Remarks

[Example sites] Applied at many sites	[References] Journal of the Japan Society of Mechanical Engineers (1998)	[Inquiry] NEDO/ECCJ (JIEC), JEMA (for equipment), FEPC (for operation)
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EG-ME-1

Energy Conservation Directory

[Industry Classification] Electricity Generation	Rotating regenerative air preheater automatic seal gap controller	[Energy Source] Fuel (general)
[Technology Classification] Machine & Equipment		[Practical Use] 1980s

Outline A device to prevent air leakage in a rotating regenerative air preheater (hereafter referred to as A/H) adopted in a medium to large capacity boiler.

Principle & Mechanism

- 1) Air leakage occurs through the gap between the rotating part and the stationary part of the A/H toward the gas side (ordinarily about 10%).
- 2) The air leakage is caused by such factors as the radial seal at the high-temperature side, radial seal at the low temperature side, and post and axial seal entrainment (residual air in the heat conductive elements).
- 3) Air leakage from the radial seal at the high temperature side is the most conspicuous, accounting for 40 - 50% of the total air leakage.

[Description]

- 1) The radial seal functions when the gap between the sector plate and the heat conductive element is kept within a designated width (1.0 - 0.2 mm).
- 2) The above gap changes in accordance with the change of such factors as the boiler load and gas temperature. In this equipment, the gap is measured by a non-contact type gap sensor and is controlled within a designated width by automatic up-and-down movement of the external end of the sector plate. The axis side can follow the expansion and contraction of the rotor, and change of gap is minimized. Illustrated at right is a concept image showing this unit attached to the A/H.

■■■■ Improved section

Fig.1 Construction of rotating regenerative air preheater automatic seal gap controller

Energy saving effects

	Air leak rate	Forced draft power	Heat recovery
Before installation	8.32 %	3,097.6kw	(Standard)
After installation	6.19 %	3,038.6kw	+903,000kcal/h
Reduction rate	2.13 %	59.3kw	96 liter/h(oil equivalent)

[Economics]

Investment amount (A): million yen

Improvement effect (B): million yen

Investment payback (A/B): years

Remarks

[Example sites] Applied at many sites	[References] The Energy Conservation Center, Japan "1981 Collection of Energy Conservation Cases (I)," p.199	[Inquiry] NEDO / ECCJ (JIEC) JEMA
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EG-ME-2

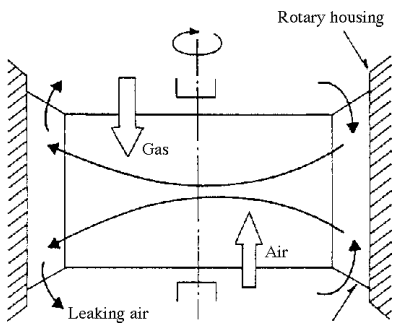
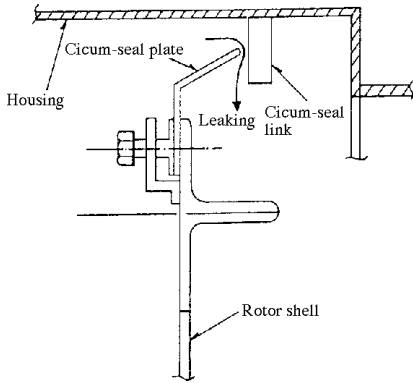
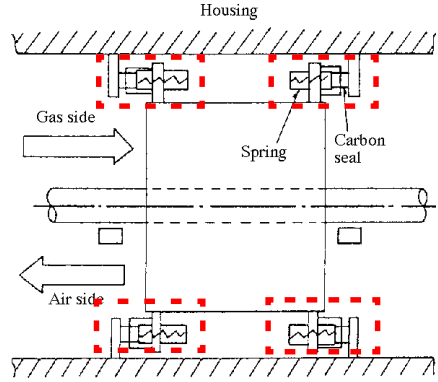
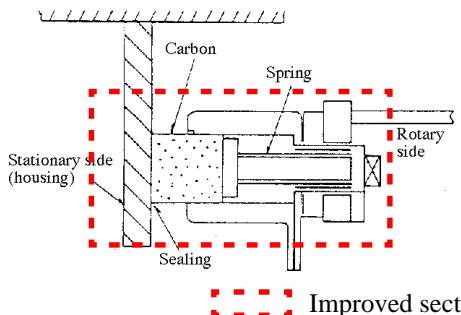
Energy Conservation Directory

[Industry Classification] Electricity Generation	Carbon-sealed regenerative air preheater for boiler	[Energy Source] Fuel (general)
[Technology Classification] Machine & Equipment		[Practical Use] 1984

Outline The regenerative air preheater for a boiler (hereafter called A/H) has intrinsic air leak due to its structure, and carbon sealing has already been adopted for a vertical type A/H below 265,000 kW in capacity. Adoption of the carbon sealing for a large capacity horizontal A/H has also been examined.

Principle & Mechanism

- 1) Leak (leak from between the circumferential area of the rotating body and the housing) from the circum-seals at the high and low temperature sides where leak occurs comparatively frequently is minimized.
- 2) Adoption of the carbon sealing for large capacity horizontal A/H characteristic of large thermal deformation of the rotating body has been examined.

[Description]	<p>[Before improvement]</p> <ul style="list-style-type: none"> The rotor is thermally deformed at the time of operation, and at the same time the circum-seal undergoes thermal deformation, generating a gap, resulting in an increase of leak.  <p>Fig. 1 Circum-seal</p>  <p>Fig. 2 Conventional circum-seal</p>	<p>[After improvement]</p> <ul style="list-style-type: none"> Inconel has been adopted for the spring since it has a characteristic of little damage by expansion and contraction, of spring.  <p>Fig. 3 Concept diagram of carbon seal attachment</p>  <p>Fig. 4 Structure of the carbon seal</p>																	
	<p>Structure explanation, Shape, and/or System diagram</p>	<p>Energy saving effects</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <caption>Table 1 Energy saving effect by the remodeling</caption> <thead> <tr> <th colspan="3">Air leak rate of the regenerative air preheater (%)</th> <th colspan="3">Converted effect by the reduction of leak (%)</th> </tr> <tr> <th>Before remodeling</th> <th>After remodeling</th> <th>Reduction.</th> <th>Boiler efficiency</th> <th>Gross thermal efficiency</th> <th>Net thermal efficiency</th> </tr> </thead> <tbody> <tr> <td>16.4</td> <td>7.8</td> <td>8.6</td> <td>0.27</td> <td>0.12</td> <td>0.14</td> </tr> </tbody> </table>	Air leak rate of the regenerative air preheater (%)			Converted effect by the reduction of leak (%)			Before remodeling	After remodeling	Reduction.	Boiler efficiency	Gross thermal efficiency	Net thermal efficiency	16.4	7.8	8.6	0.27	0.12
Air leak rate of the regenerative air preheater (%)			Converted effect by the reduction of leak (%)																
Before remodeling	After remodeling	Reduction.	Boiler efficiency	Gross thermal efficiency	Net thermal efficiency														
16.4	7.8	8.6	0.27	0.12	0.14														

[Economics]	Investment amount (A): million yen
	Improvement effect (B): million yen
	Investment payback (A/B): years

Remarks

[Example sites] Applied at many sites	[References] “Energy Saving Journal” Vol.39, No.3(1987), ECCJ	[Inquiry] NEDO / ECCJ (JIEC) JEMA
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EG-ME-3

Energy Conservation Directory

[Industry Classification] Electricity Generation	Separate type heat pipe exchanger	[Energy Source] Fuel (general)
[Technology Classification] Machine & Equipment		[Practical Use] Around 1980s

Outline When wet-type desulfurization is applied to a power generation boiler, some problems are caused such as; insufficient diffusion from the stack and occurrence of white smoke (white steam), because treated gas is discharged from the stack as moisture-saturated gas at 52 - 56°C. To solve these problems, this equipment reheats the treated exhaust gas through the heat exchange with the inlet gas to the desulfurization equipment.

Principle & Mechanism

- 1) Low-sulfur, low-dust fuel like kerosene or light oil was previously used for reheating the treated gas. They are combusted in the after-burner furnace, and generated high-temperature combustion gas was mixed with the exhaust gas, raising its temperature up to around 83°C.
- 2) This equipment is a heat exchanger utilizing heat pipes. It heats the exit gas by the inlet gas to the desulfurization equipment.
- 3) In this heat exchanger, the heating unit and the radiator unit are separated and connected via pipes.
- 4) Consequently, these two units can be installed in positions separated vertically or horizontally. This feature gives much flexibility on where to be installed along the gas flue.

The layout of the installation of this equipment is shown below.

[Description]

Structure explanation, Shape, and/or System diagram

Note :At the low temperature side, drain is the heat medium. In the case the low temperature side is located at a lower position than the hightemperature side, it is needed to install a drain pump. (In the reverse case, the drain pump is not needed.)

Fig.1 Allocation example of separate type heat pipe exchanger

Energy saving effects

- 1) Additional release of SO_x and dust is less than an after-burner system.
- 2) Low running cost and high reliability.
- 3) In comparison with the after-burner system, burner fuel cost can be saved by 20 - 35 liter/kWh.
- 4) With a 500MW class of boiler, saving of approximately 15000 kl/year is possible.

[Economics]

Equipment cost

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

Remarks

[Example sites] Applied at many sites	[References] The Agency of Natural Resources and Energy, "Thermal Power Generation Handbook," p.460, Denryokushinpousha, Feb. 1992 or other industry owned materials and data of makers.	[Inquiry] NEDO / ECCJ (JIEC) JEMA
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EG-ME-4

Energy Conservation Directory

[Industry Classification] Electricity Generation	Removal method of scale from inside condenser tubes	[Energy Source] Fuel (general)
[Technology Classification] Machine & Equipment		[Practical Use] 1989

Outline
The ball cleaning method for removing scales deposited inside the condenser tube becomes less effective as time goes by. The method introduced here is free from such deterioration, and is able to restore and maintain the heat exchanging effectiveness of the condenser as designed.

Principle & Mechanism

- 1) For removing scales deposited inside the condenser tube, cleaning with sponge balls, 26mm dia., was previously used.
- 2) Sponge balls eventually lose their surface roughness, or become deformed, and become unable to contact the inside wall closely.
- 3) Hard scales that cannot be removed by the sponge balls are gradually deposited.
- 4) Soft scales consists of silica and organic substances, and hard scales consists of manganese substances.
- 5) As a result, the vacuum of the condenser deteriorates from the original level by about 5mmHg.

[Description]

- 1) In order to make the balls contact the wall more closely, the previous balls are replaced with sponge balls of 27mm in diameter.
- 2) The previous balls are replaced with balls as below that can remove hard scales.
 - *Plastic-coat ball (G ball) This ball has a rather strong cleaning power, but not so powerful as to remove anti-corrosion coating on the inner wall.
 - *Band-shaped corborundum ball (C ball) This ball has a strong cleaning power, and may possibly remove the anti-corrosion coating on the wall. The G ball of 26mm in diameter is applied this time.
- 3) Improvement of cleaning method
Cleaning is conducted once a week, or when the vacuum deteriorates to 3mmHg. First, 27mm dia. sponge balls are used, and if the vacuum is not recovered to the original level, 26mm dia. G balls are used next time and on.
- 4) Figs 1&2 shown at right are the change of vacuum after the adoption of the above cleaning method and ball cleaning flow diagram.

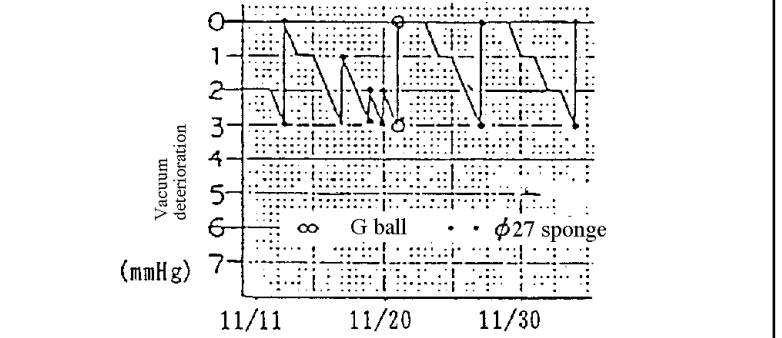


Fig.1 Change of vacuum after the adoption of the above cleaning method

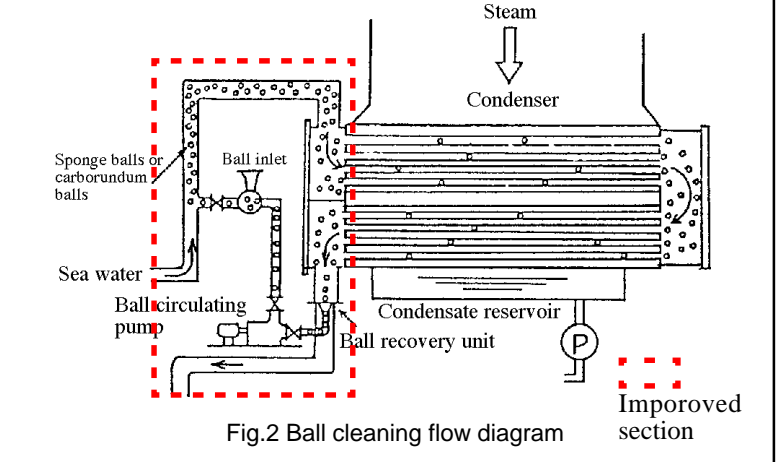


Fig.2 Ball cleaning flow diagram

Energy saving effects	When applied to a 250 MW coal fired power plant (operating rate 82.2%):					
	<table border="0"> <tr> <td>Deterioration of vacuum</td> <td>Saving of fuel (under rated output)</td> </tr> <tr> <td>Before improvement: 6mmHg</td> <td>—</td> </tr> <tr> <td>After improvement : 1mmHg</td> <td>0.65ton/h</td> </tr> </table>	Deterioration of vacuum	Saving of fuel (under rated output)	Before improvement: 6mmHg	—	After improvement : 1mmHg
Deterioration of vacuum	Saving of fuel (under rated output)					
Before improvement: 6mmHg	—					
After improvement : 1mmHg	0.65ton/h					

[Economics] Equipment cost

Investment amount (A): 0.3 million yen

Improvement effect (B): 37.4 million yen/year (operated for 300 days)

Investment payback (A/B): 0.007 years

Remarks

[Example sites] Hokuriku Electric Power Co.	[References] The 16th National Energy Conservation Conference, "1991 Energy Conservation Case Collection,"p.231, the Energy Conservation Center, Japan, 1991	[Inquiry] NEDO/ECCJ(JIEC)
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EG-ME-6

Energy Conservation Directory

[Industry Classification] Electricity Generation	Large-sized type boiler soot blower	[Energy Source] Electricity
[Technology Classification] Machine & Equipment		[Practical Use] Before 1969 -

Outline
In general, irrespective of the size of the boiler or the kind of the fuel burned in the boiler, the boiler is provided with a soot blower to remove being deposited on the heating surface of the boiler. The soot blower for use with a large-sized boiler introduced here is a high-performance soot blower to clean the heating surface of the boiler which burns coal or heavy oil which contains particularly large amount of ash content by removing the dust deposited on the heating surface by periodically jetting out high pressure steam or compressed air.

Principle & Mechanism
1) Dust deposited on the heating surface is blown off by steam or compressed air jetted out. (Ordinarily, the injection pressure from the nozzle is approximately 10 - 20 kg/cm² g.)
2) In the case of steam, for the purpose of preventing erosion of the heating surface by drain, superheated steam of saturation temperature + 50 -100°C is desirable. Furthermore, since the steam inside the piping becomes condensed as drain during stop, it is necessary to install the drain purge piping as well as drain separator at the inlet of each soot blower.

[Type and construction of the soot blower]
(Refer to Fig. 1 and 2.)
1) The following types are available depending on the form and structure of the heating area to be cleaned.
• Short retractable type of soot blower: For cleaning in main radiation heating surface of a heating furnace, and others.
• Long retractable type of soot blower : For cleaning in main suspended type of heating tubes.
• Half-travel type of soot blower : For cleaning in main horizontal type of heating tubes.
2) For a large type generator boiler, 50 - 90 units each of the above respective blowers are installed, being engaged in sequential injection operation of 3 - 6 times a day.

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

Fig.1 Outline diagram of the long retractable type of soot blower

Fig. 2 Installation of soot blowers in the boiler

Energy saving effects
As regards the evaluation of energy saving of this system, in view of the fact that when the temperature of waste gas rises by 10Åé due to the deposit of dust and soot on the heating surface of the boiler, the efficiency of the boiler drops by around 0.5%, reduction of efficiency can be prevented by the introduction of this system.

[Economics]
Equipment cost
Investment amount (A): million yen
Improvement effect (B): million yen
Investment payback (A/B): years

Remarks
This technology was implemented and verified by NEDO (The New Energy and Industrial Technology Development Organization, Japan) as a "Soot Blower Model Project" at Tien-tsin Jun Liao Cheng Power Plant, China. (completed in 1996)

[Example sites] Applied at many sites	[References] In-house technical reference material of boiler manufacturers.	[Inquiry] NEDO/ECC(JIEC), JEMA
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EG-ME-7

Energy Conservation Directory

[Industry Classification]
Electricity Generation

Repowering combined cycle system of exhaust repeat
combustion type

[Energy Source]
Electricity

[Technology Classification]
Machine & Equipment

[Practical Use]
1992

Outline
This system is used for repowering aged thermal power plants for the purpose of improving the output and efficiency. Repowering means in this context utilization of the waste gas of an additionally installed gas turbine instead of using combustion air supplied by a blower in an existing steam turbine power plant. By remodeling an existing thermal power plant into an exhaust repeat combustion type combined cycle plant by combining this gas turbine power plant and the steam power plant, improvement in output and efficiency is expected.

Principle & Mechanism

- When repowering an existing power plant, the efficiency, operability, and economics mainly depend on the selection of the gas turbine to be combined with the existing boiler.
- In selecting the system, it is necessary to optimize the system by verifying the stability of the boiler in a low oxygen atmosphere in combustion test, stability of operation under varying load, as well as its reliability and economics.

[Description]
[Characteristics of the repowering system] (Refer to Fig. 1.)
In the case of the power plant introduced here, a 120,000 kW class (1,100 °C class) gas turbine having an appropriate quantity of residual oxygen in waste gas suitable for the existing boiler capacity has been selected and a high temperature wind box has been installed, which enables the hot waste gas of the turbine to be used directly for boiler combustion. Thus, it has been remodeled as a system for recovering heat from the waste gas of the boiler.

Structure explanation, Shape, and/or System diagram

Fig. 1 Cycle flow diagram before and after repowering system

Energy saving effects

Table 1 Comparison of performance before and after repowering into an exhaust repeat combustion type combined cycle repowering system

	Before repowering	After repowering	Effect of repowering
Output	350,000 kW	476,000 kW (at 5° C)	Increase by 36%
Gross thermal efficiency	38.5%	41.5% (at 15° C)	Improved by approx. 3 %
Fuel consumed by steam power plant (LNG fuel)	390,000 t/y	350,000 t/y	40,000 t/y reduced (rate of use 70%)
Pollutant value Nox	63m ³ N/h	40 m ³ N/h (denitration facility)	38% reduced
Reduction equivalent to crude oil consumption			Reduce by 549,900 kL/y

[Economics] Equipment cost

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

Remarks

[Example sites]

[References]
“Energy saving journal (Vol.47 No.9, 1995, p.100)”

[Inquiry]
ECCJ (JIEC)

EG-ME-8

Energy Conservation Directory

[Industry Classification] Electricity Generation	Industrial repowering system	[Energy Source] Electricity
[Technology Classification] Machine & Equipment		[Practical Use] 1992

Outline
Industrial repowering here means remodeling an existing steam turbine boiler power generation system (hereafter called BTG) by additionally installing a gas turbine in order to increase the output and improving the efficiency. It has been adopted mainly for the purpose of strengthening the capacity of industrial thermal power generation plants

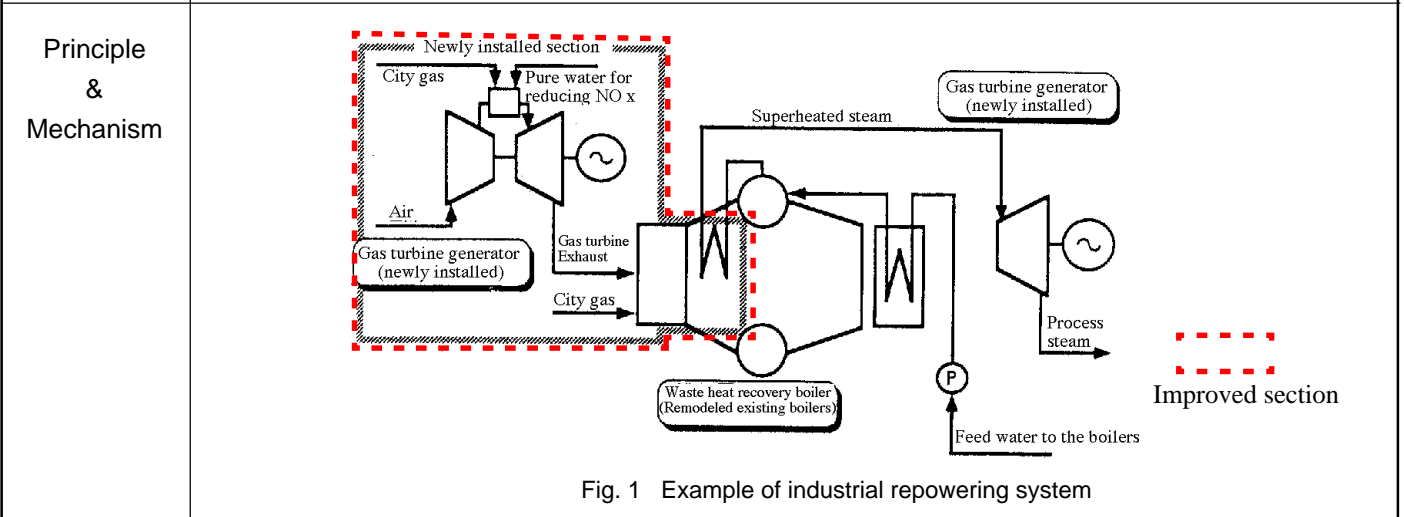


Table 1 Repowering systems and its characteristics

	Feed water heating system	Waste heat recycle system	Waste heat recovery system
[Description] Characteristics	In this system, gas turbine exhaust is utilized for heating feed water of the existing BTG	Gas turbine waste heat is utilized as combustion air for the existing boiler	After removing the existing boiler, a boiler utilizing gas turbine waste heat is newly installed, forming a combined cycle repowering system
Structure explanation, Shape, and/or System diagram	Schematic diagram of the system (a newly installed system shown in the bold-lined area) 		
Newly installed major equipment	Gas turbine generation equipment and feed water heaters	Gas turbine generation equipment	Gas turbine generation equipment and waste heat recovery boilers
Performance	Output increase	10 - 30 %	20 - 40 %
	Efficiency improvement	Small	Large
Operation controllability	Easy	Turbines and boilers balanced operation	Easy
Installation cost	Small	Large	Large
Construction term for remodeling	Short	Long	Long
CO ₂ and NO _x reduction effect	Small	Large	Large

Energy saving effects

[Economics] Equipment cost	Investment amount (A): million yen
	Improvement effect (B): million yen
	Investment payback (A/B): years

Remarks

[Example sites] Applied at many sites	[References] “Energy Saving Journal (Vol.46 No.8, 1994, p.21 ~ 39)”	[Inquiry] NEDO / ECCJ (JIEC) JEMA
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EG-ME-9

Energy Conservation Directory

[Industry Classification] Electricity Generation	Rotation speed control of large boiler blower and exhauster through wet type multi-plate speed reducer	[Energy Source] Electricity
[Technology Classification] Machine & Equipment		[Practical Use] 1973 -

Outline
This speed reducer is a kind of rotation speed control equipment having mechanical speed reducing mechanism like a fan and a pump. Introduced here is an example of controlling rotation speed by means of a wet type multi-plate speed reducer in accordance with the change of output of the power station boiler to secure operation with an appropriate capacity of the exhauster and the blower, thereby achieving a great deal of energy saving.

Principle & Mechanism
As shown in Fig. 1, the wet type multi-plate speed reducer controls hydraulic pressure by electric signals by control valve, steplessly controlling the rotation speed of the output axis by arbitrarily changing the pressure to be applied to the clutch plate through the hydraulic piston.

Fig. 1

[Description]
[Performance and features]
1) Shown in Figure 2 are comparison of required electrical powers between two cases, one using the wet type plate speed reducer and the other using the damper and valve, for controlling gas quantity and flow rate of the fan, blower, and pump.
Structure explanation, Shape, and/or System diagram
<Example> In the case wind quantity is reduced to 50%.
Damper control : Required electric power is 75% of the basic power requirement.
Control by the multi-plate speed reducer :Required electric power is 25% of the basic power requirement. (Energy saving of 50% is achieved in comparison with the damper type.)
2) Rotation speed control range is 30 - 100%.
3) Control response speed is as fast as 3 - 7 seconds, and transmission efficiency is around 95% (100% in the case of direct connection without loss).

Improved section

Fig. 2 Electric power saving for the blower

Energy saving effects
By the reduced electric power consumption for the blower (forced draft fan, FDF) and the exhauster (induced draft fan, IDF) for an electric power generation boiler of 200,000 kW output, energy saving of approximately 1,300 t/year, when converted into coal consumption, has been achieved. (Saving when converted into crude oil consumption : 858 kL/year)

[Economics] Equipment cost
Investment amount (A): million yen
Improvement effect (B): million yen
Investment payback (A/B): years

Remarks
1) This technology has been put into practice by the cooperation of NEDO at Tianjian Army Power Station, Tianjian City, China, as "Model Project of the Wet Type Multi-plate Speed Reducer" (completed in March 1997).
2) This technology can be applied as energy saving technology not only to the boiler, but also various kinds of rotating equipment in every industry.

[Example sites] Many sets of the unit installed	[References] "General Survey of Energy Saving Facilities" (1984), "Collection of Energy Conservation cases"(1981), p.63	[Inquiry] NEDO / ECC(JIEC) JEMA
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EG-OM-1

Energy Conservation Directory

[Industry Classification] Electricity Generation	Low-pressure operation of natural circulation boiler	[Energy Source] Fuel (general)
[Technology Classification] Operation & Management		[Practical Use] Early 1980'

Outline Fuel-saving operation through minimizing the reduction of thermal efficiency under low load operation of a natural circulation or forced circulation drum boiler.

Before Improvement At a power plant relatively aged, or the one operated to adjust the amount of power generated (i.e., an adjustment thermal power plant), the following problems are posed.
 1) When operated for power adjustment, minimum load operation, mainly during night, comes to around 40%.
 2) When operated under minimum load at a constant pressure, there arise the following problems.
 * Increased pressure loss due to the narrowed regulation valve of the turbine.
 * Steam consumption of the steam turbine to drive the boiler feed water pump is not negligible from the point of the thermal efficiency of the plant.

[Description of Improvement]

- 1) The pressure is kept constant (169kgf/cm²) until the load is reduced to the minimum, for the purpose of improving the response to load change.
- 2) After the load is reduced to the minimum, the steam pressure is reduced to 110kgf/cm².
- 3) By reducing the pressure, pressure loss due to the narrowed regulation valve is decreased.
- 4) Accordingly, steam consumption to drive the boiler feed water pump is saved.
- 5) The improvement of the gross thermal efficiency in the load range of 25% to 50% is shown at Fig. 1.

Structure explanation, Shape, and/or System diagram

Constant pressure operation
 Reduced pressure operation
 Improved section

Fig. 1 The improvement of the gross thermal efficiency

Energy saving effects

- 1) Under low load operation, the gross thermal efficiency can be increased by 0.5 - 0.6% by reducing the pressure as shown at Fig. 1.
- 2) When the low pressure operation was applied to the minimum load (75,000kW) operation at a 350,000kW generation unit, consumption of C-grade heavy oil was saved by 291kl per year (saving of 19 million yen a year).

[Economics] Equipment cost

Investment amount (A): none(manual operation adopted to conventional facility)
 Improvement effect (B): 19 million yen/year (350,000kW unit)
 Investment payback (A/B): none

Remarks This method is also applicable at the startup and low load operation of an once-through boiler.

[Example sites] Applied at many sites	[References] The 9th National Conference of Energy Conservation, "Collection of Energy Conservation Cases 1983", p. 1957, the Energy Conservation Center, Japan, 1984	[Inquiry] NEDO / ECC (JIEC) JEMA (for equipment), FEPC (for operation)
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EG-OM-2

Energy Conservation Directory

[Industry Classification] Electricity Generation	Operation method of increased temperature of main steam at boiler outlet	[Energy Source] Fuel (general)
[Technology Classification] Operation & Management		[Practical Use] Early 1981

Outline A method to improve thermal efficiency and to reduce fuel consumption by raising the temperature of the main steam at the boiler outlet to 561°C (previously 541°C).

Before Improvement	The following are the previous operational condition of the boiler and turbine. Temperature of main steam at the boiler outlet 541°C Temperature of main steam at the turbine inlet 538°C Vacuum of the condenser 722mmHg Gross thermal consumption rate 2,208kcal/kWh Thermal efficiency 38.95% Secondary superheater heat transfer area 390 m ² Secondary superheater tube material SUS 321HTB
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[Description of Improvement]

- 1) Improvement of thermal efficiency by increasing the temperature of the main steam is evaluated by examining the T-s diagram of the Rankine cycle.
- 2) For increasing the temperature of the main steam, it is necessary to increase the heat transfer area, for which space is needed.
- 3) At the same time, high temperature corrosion resistance of the heat transfer tube needs to be increased.
- 4) Based on the above examination, it was decided to raise the temperature of the main steam to 561°C, and the following measures were implemented.
 *Temperature of main steam at the boiler outlet: 561°C (increased by 20°C)
 *Temperature of main steam at the turbine inlet: 556°C (increased by 18°C)
 *Secondary superheater heat transfer area : 750 m² (approx. twofold increase)
 *Secondary superheater tube material SUS 347HTB
- 5) The secondary superheating tube has been changed from the previous 1-loop type to 2-loop type.

Layout of the superheater (before modification)

..... Improved section

Fig. 1 Layout of the superheater (before modification)

Energy saving effects

The effect of this method applied to a 220,000 kW generation plant is shown below.

Load	220,000 kcal/kWh (rated)	Annual fuel saving Approx. 1,100 kL (at an utilization rate of 30%)
Gross thermal consumption rate	2,195 kcal/kWh	
Thermal efficiency	39.23 %	
Improvement of thermal efficiency	0.28% (absolute value)	

[Economics]	Investment amount (A): 118 million yen
Equipment cost	Improvement effect (B): 63.8 million yen/year (at an utilization rate of 30%)
	Investment payback (A/B): 1.8 years

Remarks This method is applicable to a generation plant where main steam of comparatively low temperature is used. Remark: In a latest power generation plant, the temperature of main steam at the boiler outlet is around 580°C.

[Example sites] Yokkaich power plant. Chubu Electric Power Co.	[References] The 8th National Conference of Energy Conservation, "Collection of Energy Conservation Cases 1983", p. 2171, the Energy Conservation Center, Japan, 1983	[Inquiry] NEDO / ECC(JIEC)
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EG-OM-3

Energy Conservation Directory

[Industry Classification] Electricity Generation	Gas recirculating steam temperature control system	[Energy Source] Fuel (general)
[Technology Classification] Operation & Management		[Practical Use] 1980s

Outline
For the purpose of balancing the thermal absorption between the evaporation section of the boiler (mainly radiation heat in the furnace) and the superheating section for the steam (mainly convective heat transfer in the superheater, reheater, and the economizer), boiler exhaust gas at the economizer outlet is recirculated by the recirculation fan to the bottom of the furnace.

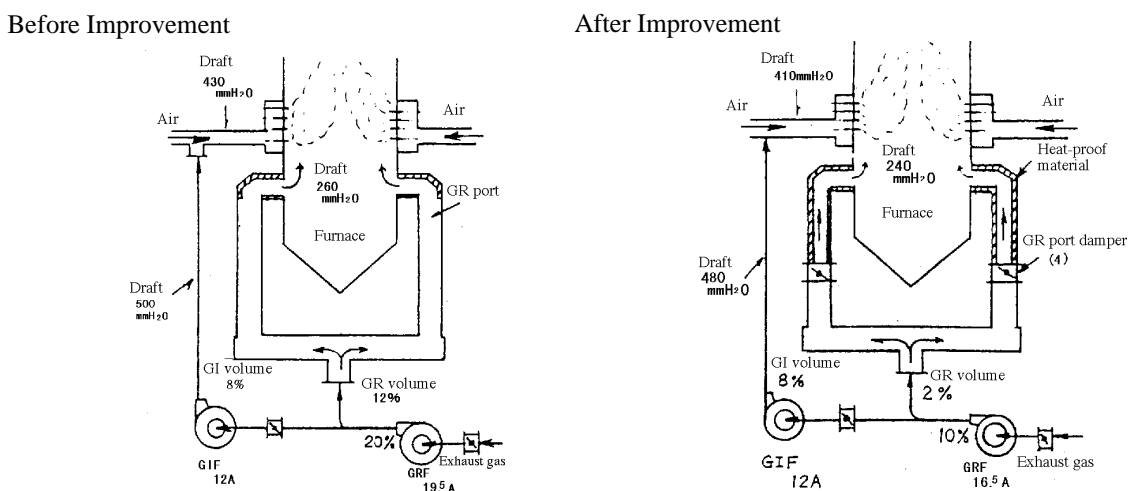
Before Improvement (Conventional process)

- 1) Previously, the thermal absorption balance would tilt toward the superheating section, and when the temperature of the superheated steam was in excess of the designated value, spray water was injected into the superheated steam to lower the temperature (water spray steam temperature control system).
- 2) As the water spray method would lower the boiler efficiency, this method was not thermally efficient. Boiler efficiency is lowered by 1 - 1.5%.
- 3) The thermal absorption balance differs conspicuously depending on the kind of the fuel used (heavy oil, crude oil, natural gas, coal, etc.). For this reason, the thermal absorption balance changes by converting the fuel, and the steam temperature often deviates from the designated value upward or downward.

[After Improvement] (New process)

- 1) For decreasing the quantity of water spray, it is necessary to increase the thermal absorption at the evaporation section of the boiler. Countermeasures for that purpose include to increase the furnace volume and cleaning of the furnace wall (for the improvement of heat transfer efficiency).
- 2) For decreasing the heat transfer at the superheating section, such measures as cutting short the heat exchange tubes, fitting the baffle plates, and heat transfer inhibition coating are conducted.
- 3) But the above methods cannot be taken immediately at fuel conversion.
- 4) By the gas recirculation method, the amount of evaporated steam is decreased (or increased), and the temperature of the superheated steam goes up (or goes down), as the recirculation gas is increased (or decreased). As this adjustment is made easily by adjusting only the damper of the recirculation fan, it can be readily applied to various fuels such as heavy oil, crude oil, natural gas, etc.

Structure explanation, Shape, and/or System diagram



Energy saving effects	Thermal efficiency	Improvement by 0.48% in both SH and RH
	Power cost	Saving of power for the recirculating fan equivalent to thermal efficiency of 0.02%
	Total	Improvement equivalent to thermal efficiency of 0.5% (converted in fuel cost)

SH: Superheater RH: Reheater

[Economics] Equipment cost

Investment amount (A): 50 million yen
 Improvement effect (B): 40 million yen/year (Boiler at 250MW class)
 Investment payback (A/B): 1.3 years

Remarks
This method is applicable to a generation plant where main steam of comparatively low temperature is used. Remark: In a latest power generation plant, the temperature of main steam at the boiler outlet is around 580°C.

[Example sites] Sakaiminato Power Plant, Kansai Electric Power Co.	[References] The 9th National Conference of Energy Conservation, "Collection of Energy Conservation Cases 1983", p. 2031, the Energy Conservation Center, Japan, 1984	[Inquiry] NEDO / ECC(JIEC) JEMA
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EG-OM-4

Energy Conservation Directory

[Industry Classification] Electricity Generation	Reduction of starting-up time of cold plant	[Energy Source] Fuel (general)
[Technology Classification] Operation & Management		[Practical Use] Around 1980

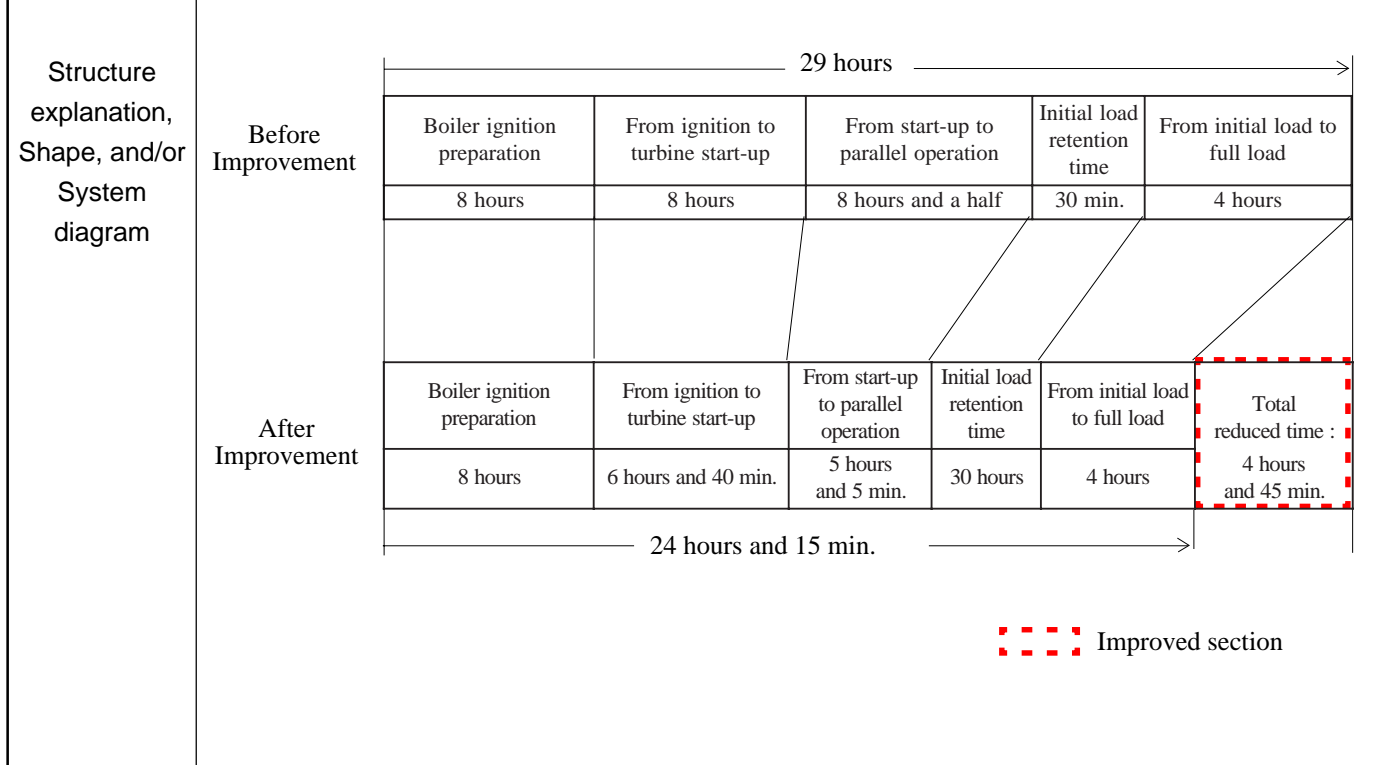
Outline When starting up a power plant after a long shutdown(a cold plant), energy loss in starting up is reduced by reducing the starting-up time.

Before Improvement

- 1) Shown below is the conventional starting-up schedule of a cold plant, which requires 29 hours in total.
- 2) In the starting-up time, a long time is required for warming up the turbine.
- 3) In starting up, it is necessary to observe various limiting values on the turbine rotor, such as the surface thermal stress, Bohr's thermal stress, surface temperature, mean volume temperature, and Bohr's temperature.

[Description of Improvement]

- 1) If the hot water cleaning is omitted between the ignition and the start-up of the turbine, the time can be shortened by 1 hour and 20 minutes.
- 2) The time can be shortened by 3 hours and 25 minutes by shortening the turbine warming-up between the start-up and the parallel operation.
- 3) As a result, the time can be shortened by 4 hours and 45 minutes in total.
- 4) After the above reduction of time, the time schedule for each process is as follows.



Energy saving effects

The effect of this operation method when applied in a 250MW once-through boiler power plant is as follows.

- 1) The starting-up time is reduced by 4 hours and 45 minutes (from 29 hours to 24 hours and 15 minutes), making it possible to start supplying electric power earlier than before.
- 2) Combustion of light oil in the boiler for starting up can be saved by 38kl per one starting-up. Saving per year, which depends on the number of starting up per year, cannot be stated definitely. With increasing operation of the adjustment thermal power plants, which have frequent stops and starts, there are significant savings by this operation method

[Economics] Equipment cost

Investment amount (A): million yen

Improvement effect (B): million yen

Investment payback (A/B): years

Remarks

[Example sites]	[References]	[Inquiry] NEDO / ECC(JIEC) JEMA
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EG-OM-5

Energy Conservation Directory

[Industry Classification] Electricity Generation	Stop of operation of high pressure gas feeding apparatus by developing high back pressure ejector for high pressure feeding of LPG	[Energy Source] Electricity
[Technology Classification] Operation & Management		[Practical Use] 1993

Outline
At gas companies in general supply of LPG/Air gas, 85 % of energy used in the process of production and supply of gas is by the consumption of electric power by high pressure gas feeding equipment. In the case introduced here, in stead of this high pressure feeding equipment, a high back pressure ejector for gas supply has been developed, stopping the use of the high pressure feeding equipment, achieving a great saving of electricity.

Principle & Mechanism

In the process of gas production and supply, LPG (liquid), which is a raw material, is sent out with a supply pump from the storage tank, and after heating and evaporizing it with a vaporizer, the gas is jetted out from the nozzle of the ejector (Figure 1), thereby sucking in the air by the minus pressure generated at that time, air diluting LPG. The gas thus produced is led into the surge tank, and through controlling ON/OFF of the tank pressure at 0.5 - 0.8 kg/cm², the gas is fed out.

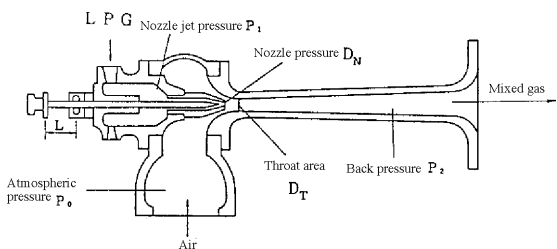


Fig. 1 Diagram of the outline of the ejector

[Description]

Structure explanation, Shape, and/or System diagram

[Before Improvement]

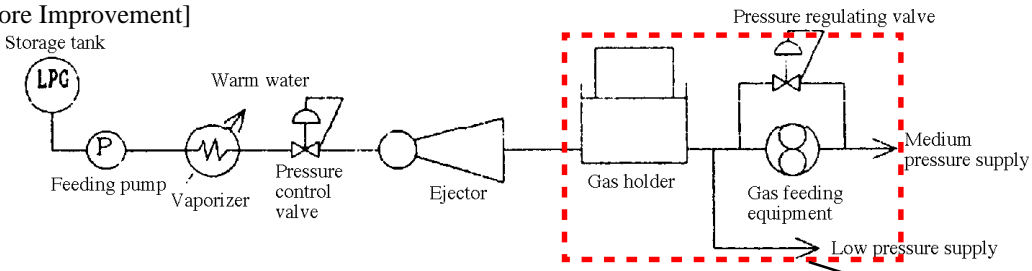


Fig. 2 Conventional high pressure feeding system

[After Improvement]

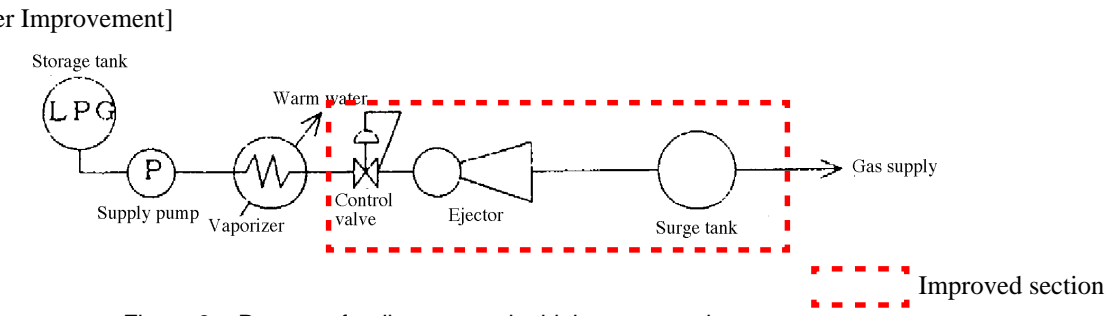


Figure 3 Pressure feeding system by high pressure ejector

Energy saving effects

Table 1 Effect of energy saving

	Before improvement		After improvement , Ejector	Effect
	Pressure feeder (constant speed)	Pressure feeder (variable type)		
Quantity of supply per 1kWh	9.43Nm ³	12.23 Nm ³	62.9 Nm ³	6.6 times
Electric power for producing 1 Nm ³	2 yen	0.95 yen	0.2 yen	1/10
Electric power saving				960 MWh/y
Conversion into crude oil				233 kL/y

[Economics]
Equipment cost
Investment amount (A): million yen
Improvement effect (B): million yen
Investment payback (A/B): years

Remarks
As performance required of an ejector, it permits mixing of liquid with high accuracy to an arbitrary mixing ratio, supplying liquid with high stability.

[Example sites] Buyo Gas Co.	[References] “Collection of Energy Conservation Cases”(1994), p.561-ECJ	[Inquiry] NEDO / ECC(JIEC) JEMA
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EG-OM-6

Energy Conservation Directory

[Industry Classification] Electricity Generation	Conversion of heat source of absorption type air-conditioner by utilizing excess boiler steam of gasification equipment	[Energy Source] Fuel (LNG)
[Technology Classification] Operation & Management		[Practical Use] 1980

Outline
Introduced here is an example of energy saving by converting the conventional gas-fired absorption type air-conditioner into a hot water absorption type air-conditioner by utilizing steam as its heat source that has become excessive due to the change of the balance of steam from the exhaust heat boiler of gasification equipment in accordance with the trend of changing the raw material for city gas to LNG.

[Description]
[Before improvement]
Steam generated from an existing exhaust heat boiler, a gasification equipment of naphtha, became excessive, due to the shifting of the raw material for the production of city gas from naphtha to LNG. In the meantime, the absorption type air-conditioner depended on gas combustion for its heat source.

Structure explanation, Shape, and/or System diagram

Figure 1 System before the improvement

[After improvement]
The absorption type air-conditioner, which is based on steam as its heat source, comes in two type, steam type and hot water type which makes use of hot water converted from steam as its heat source. In this system, the hot water type is adopted.

Figure 2 System after the improvement

Energy saving effects
Quantity of reduction of city gas : Approx. 330,000 m³/year
Reduction when converted into crude oil consumption : Approx. 393 kL/year.

[Economics] Equipment cost
Investment amount (A) : Hot water absorption type air-conditioner (10 refrigeration ton x 2 sets)
15 million yen (including construction cost)
Improvement effect(B) : 25 million yen/year
Investment payback : 0.6 years

Remarks
This is an example of conversion of fuel that can be applied to any industrial field.

[Example sites] Toho gas Co. Chita Plant Many adopted examples	[References] "Collection of Energy Conservation Cases"(1981), p.167	[Inquiry] EIAJ / ECC(JIEC)
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