Section 10
Technologies Commonly Applicable to Many Industries

Process Flow
Data Sheets

Flow diagram of energy saving technologies commonly applicable to many industries

Energy saving technologies commonly applicable to many industries

[Technology] → [Device Type] → [Device]

- **Combustion technology**
  - **Combustion control device**
    - Air-fuel-ratio control device
    - O_2 concentration control & device
    - Suction outlet damper control device
  - **Combustion device**
    - Oxygen-enriched combustion device
    - Radiant tube combustion device
    - Regenerative combustion device
- **Heat recovery technology**
  - **Steam transportation & recovery device**
    - Drain recovery device
    - Steam recompression device
    - Steam ejector & vacuum pump
  - **Heat exchange**
    - Economizer & air preheater
    - Heat exchanger
    - Heat pipe
  - **Waste heat recovery**
    - Waste heat recovery boiler
    - Absorption refrigerator
    - Heat pump
- **Power recovery technology (including power generation)**
  - **Waste heat & residual pressure recovery power generation**
    - Steam turbine power generation
    - Gas turbine power generation
    - Power recovery turbine power generation
    - Cogeneration
    - Industrial repowering
- **Heat storing & insulating technology**
  - **Heat storing & insulating material**
    - Heat storing device
    - Steam accumulator
    - Recuperater
    - Ceramic-fiber refractory brick
- **Optimum control technology**
  - **RPM control device**
    - Fan/pump/compressor capacity optimization
    - Optimum load operation control devise
    - Group operation control device
  - **Optimum control device**
    - Sequence control device
    - Optimum load operation control device
    - Group operation control device
  - **Energy management device**
    - Power demand control device
    - Power factor improvement control & phase-advancing capacitor
    - Energy monitoring device

Item No.	Technology Item/Title
MI-ME-1	Energy saving combustion system for small to medium sized boilers
MI-ME-2	Impulse city gas combustion system for industrial furnaces
MI-ME-3	Intelligent burner system for industrial heating furnace
MI-ME-4	Oxygen enriched combustion system

Item No.	Technology Item/Title
MI-ME-5	Vacuum steam heating system
MI-ME-6	Improvement in recovering steam drain in plywood factory
MI-ME-7	Control of exhaust gas humidity of plywood dryer by high temperature hygrometer
MI-OM-1	Improvement for full recovery of waste heat from steam drain
MI-OM-2	Multistage recovery of flash steam

Item No.	Technology Item/Title
MI-OM-3	Improvement of drain recovery by plate type heat exchanger

Item No.	Technology Item/Title
MI-ME-8	Waste heat recovery vacuum type hot water producing system
MI-ME-9	Heat pump type steam recompression cylinder dryer for drying process
MI-ME-10	Introduction of heat pump using cooling water for air compressors as its heat source
MI-ME-11	Heat pump type low temperature vacuum concentrator
MI-ME-12	Refrigerating machine waste heat recovery system
MI-ME-13	Effective use of exhaust heat from waste incineration
MI-OM-4	Improvement of thermal efficiency of dryer for refractory brick

Item No.	Technology Item/Title
MI-ME-16	Recovery of power by installing steam turbine in steam pressure reducing line
MI-ME-17	Introduction of low pressure steam expansion turbine
MI-ME-18	Low pressure condensing steam turbine
MI-ME-19	Mixed steam extraction turbine power generator

Item No.	Technology Item/Title
MI-ME-14	Waste heat boiler cogeneration system with secondary burner
MI-ME-15	Gas turbine cogeneration system with variable heat-electricity ratio
MI-ME-31	Cogeneration system directly utilizing waste heat at drying oven

Item No.	Technology Item/Title
MI-ME-20	Introduction of hydraulic coupling to high pressure injection pump
MI-ME-21	Energy saving improvement of blowers and pumps
MI-ME-24	Improvement of a motor for a plastic extruder
MI-ME-25	High efficiency inverter driven screw compressor
MI-ME-26	Air volume control of forced draft fan for boiler by microcomputer

Item No.	Technology Item/Title
MI-OM-5	Reduction of coke ratio in cupola
MI-OM-7	Improvement of efficiency of turbo air compressor

Item No.	Technology Item/Title
MI-ME-30	Hot-blast-generating cupola
MI-OM-5	Reduction of coke ratio in cupola
MI-OM-8	Improvement of the efficiency of the melting process by continuous desulfurization

Item No.	Technology Item/Title
MI-ME-22	Energy saving through improving efficiency of sludge dehydrator in factory waste water treatment
MI-ME-23	Improvement of flow rate control for reverse osmosis (RO) system for pure water

Item No.	Technology Item/Title
MI-ME-27	PAM motor with variable number of poles
MI-ME-28	High efficiency illumination system with constant current electric power transfer method
MI-ME-29	Refrigerating dehumidifier

MI-ME-1

Energy Conservation Directory

[Industry Classification] Many Industries	Energy saving combustion system for small to medium sized boilers	[Energy Source] Fuel, Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1990 -

Outline

In general, a combustion control mechanism of a small-to-medium-sized boiler is of a mechanical-link-control type, and is operated with excess to prevent incomplete combustion, taking into consideration the backlash of the link control mechanism. This is an energy-saving-type combustion system with the optimum 0_2 control and the rotation control of the forced draft fan (FDF) incorporated in the existing boiler.

Before Improvement

In general, a control system of a small-to-medium-sized boiler is provided with a master controller, which keeps the steam drum pressure constant. It compares the measured value of the steam pressure with the set value and controls the fuel and air volume so as to nullify the deviation by means of the link mechanism from the master controller.

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

1. Features of the optimum 0_2 control system
1) This combustion control system controls the air-fuel ratio in accordance with the boiler load.
2) Adjustment of combustion through 0_2 control is carried out by the rotation control of the FDF by an inverter.
3) The air-fuel ratio is controlled over the whole load range from the minimum to maximum, and its response is quick.
4) The control system is easily incorporated in an existing boiler.
2. Construction of the combustion system (Refer to Fig. 1)
The combustion system consists of the combustion control unit, exhaust-gas 0_2 sensor, automatic damper open-close control unit, and FDF drive control unit.

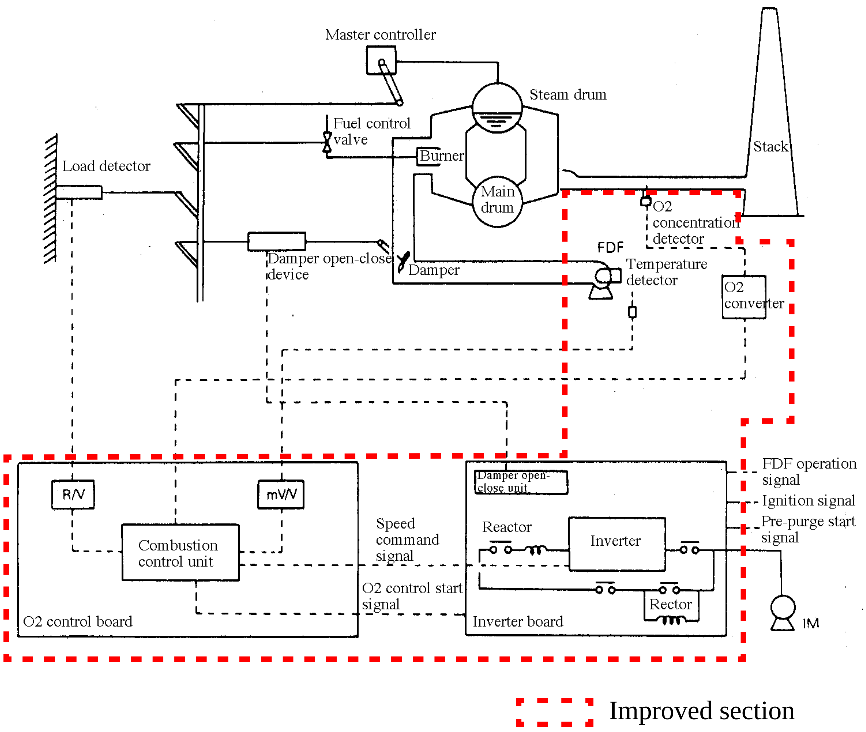


Fig. 1 Optimum 0_2 control system

Energy saving effects

Table 1 Comparison of exhaust gas loss and electric power of forced draft fan (FDF) before and after improvement

	Before improvement	After improvement	Effect
Reduction in heat loss (Improved thermal efficiency)	11.38 %	10.21 %	1.17 %
Reduction in heavy oil consumption **			65 kL/y
Reduction in FDF input electric power	27.2 kW	4.1 kW	23.1 kW
Reduction in electric power consumption **			166,320 kWh/y
Reduction in crude oil equivalent			119.3 kL/y

[Economics] Equipment cost

Investment amount (A): 15 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

Note * : Specification of the boiler 14t/h, 10kg/cm² water-tube boiler
**: Steam generation 240 t/day, Operating days 300 days/year

[Example sites]	[References]	[Inquiry]
	"Energy Saving Journal (Vol. 46, No. 5, 1994)" P. 66	NEDO / ECCJ (JIEC)

MI-ME-2

Energy Conservation Directory

[Industry Classification] Many Industries	Impulse city gas combustion system for industrial furnaces	[Energy Source] Fuel
[Technology Classification] Machinery & Equipment		[Practical Use]

Outline

Generally, industrial heating furnaces are required to have uniformity of temperature distribution inside of them and energy-saving characteristic. But combustion heating furnaces with conventional position-proportional control require skills and experiences of operators.
The impulse-combustion system introduced here controls the temperature of an industrial furnace through changing the ON-OFF time ratio of plural burners performing fixed-rate combustion. By employing numbers of burners which allow high-speed gas flow, the atmosphere inside the furnace is actively agitated, and the temperature distribution inside of the furnace is made uniform, contributing to energy saving.

Principle & Mechanism

As shown in Fig. 1, each burner performs fixed-rate combustion (ON) for a certain duration of time, and stops combustion (OFF) with only a pilot burner kept burning. The ratio of the ON time and OFF time controls the combustion volume. This time ratio changes every moment in accordance with output signals from the temperature controller.

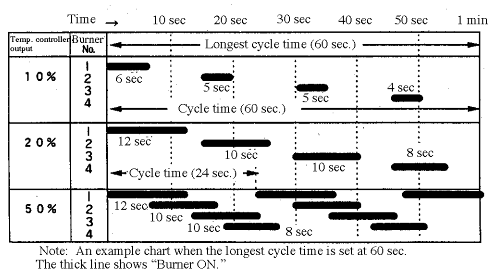


Fig. 1 Example of impulse-combustion time chart

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

[Outline and characteristics of impulse-combustion system]
The basic construction of this system is shown in Fig. 1. In comparison with a conventional position-proportional control system, this system has the following advantages.

1) The temperature distribution inside of the furnace is kept uniform. Even for a small heat load, the temperature distribution inside of the furnace is kept uniform because of the agitation of the furnace atmosphere.
2) Self-circulation of exhaust gas effected by the high-speed burners and the low NOx control system allow low-NOx operation.
3) Combustion control is easy and highly reproducible.
4) The inside of the furnace is uniformly heated, and the energy-saving effect by constant-air-ratio combustion is large.

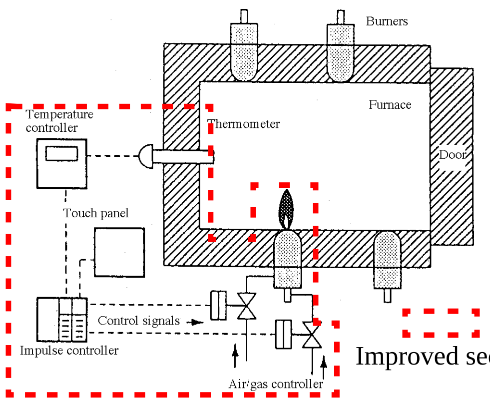


Fig. 2 Conceptual diagram of impulse gas combustion system

Energy saving effects

1) Energy saving effect:
Energy of about 18 % is saved over a conventional gas burner with position-proportional control.

Note*: Gas consumption from the ambient temperature to the end of holding at1,000 ˚C for 2 hours˚C

Table 1 Comparison of performance between position-proportional control system and impulse combustion control system

Control	Position-proportional control			Position-proportional control		
Treatment temperature	400˚ C	700˚ C	1000˚ C	400˚ C	700˚ C	1000˚ C
Temperature distribution	±8 ˚ C	±5˚ C	±4˚ C	±10˚ C	±10˚ C	±8˚ C
NOx (O2 = 0% conversion)	55ppm	55ppm	54ppm	72ppm	76ppm	77ppm
Gas fuel consumption*	90m³/ch (100)			110m³/ch (122)		
Energy saving rate	18 %			Standard		

2) Comparison of performance

Table 2 Comparison between oil-firing furnace (before improvement) and gas-firing furnace (after improvement)

control	Oil-firing furnace (before improvement)	Gas-firing furnace (after improvement)	Effect
Temperature distribution	± 57˚ C	± 12˚ C	
NOx	210 ppm	50 ppm	
Specific energy consumption	248 kWh/t	181 kWh/t	67 kwh/t

[Economics] Equipment cost

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

Remarks

[Example sites]	[References]	[Inquiry]
	"Collection of Energy Conservation Cases 1997" "Energy Saving Journal (Vol. 50 No.9 1998) p.26	NEDO / ECCJ (JIEC)

MI-ME-3	Energy Conservation Directory	
[Industry Classification] Many Industries [Technology Classification] Machinery & Equipment	Intelligent burner system for industrial heating furnace	[Energy Source] Fuel [Practical Use] 1990 -

Outline

This system is an advanced gas-burner control system that permits precise control of furnace conditions following optimum patterns by computers in accordance with materials being processed, and contributes to saving in energy and labor, and improvement in yield and quality.

Principle & Mechanism

This is a gas-burner control system using computers, and applied to heating furnaces.

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

[Characteristics of intelligent burner control system]
The combustion condition for each burner is individually entered from the computer. Various operations, such as combining combustion patterns, and registering and retrieving data, are performed by one touch,. Fig. 1 shows the flow diagram of this system. The following are the functions of respective component units.

1) Master control
- To set the individual combustion quantity.
- To set the individual air ratio.
- To set the combination.

2) Slave controller
One controller is installed for each burner.
- To perform the preset control adopting compound throttling.
- To perform the cross limit control
- To perform the temperature and pressure adjustment
- To switch the operation modes such as normal, excess, and cooling.

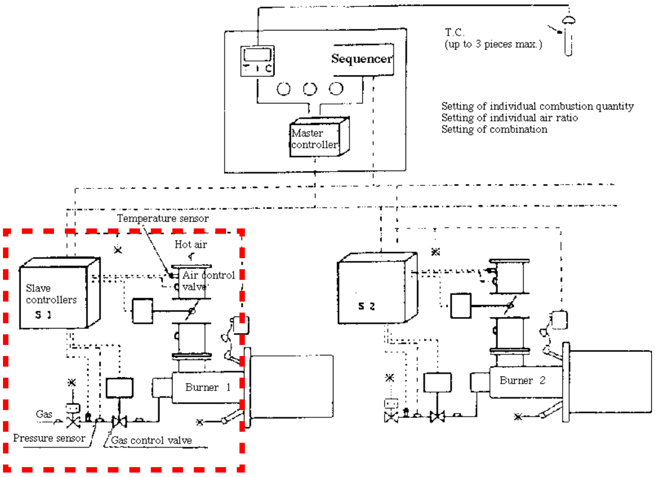


Fig. 1 Flow diagram of intelligent burner control system

Improved section

[Performance and improvements]
<Conditions of operation>
Type of furnace: box-type batch heating furnace
Temperature setting: 800˚C , 900˚C, 1000˚C
Temperature distribution: within −7.5˚C of set temperatures
<Improvements>

Before improvement	After improvement
The air ratio was set at a constant value without regard to the furnace temperature setting.	The air ratio is adjusted for each furnace temperature setting so that desired temperature distribution is secured.

Energy saving effects

Table 1 Energy saving effect

Furnace temperature setting	Before improvement		After improvement (air ratio proportionally adjusted)		Energy saving rate (rate of CO_2 reduction)
	Air ratio	Temp. difference (˚ C)	Air ratio	Temp. difference (˚ C)	
800˚ C	1.4	± 7.5	1.4	± 7.5	-
900˚ C	1.4	± 7.5	1.3	± 4.5	6.2%
1000˚ C	1.4	± 7.5	1.1	± 3.5	19.7 %

[Economics] Equipment cost

Investment amount (A): 8 million yen (for 1 set of the system)
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

This system was awarded a prize by Japan Machinery Federation in 1995.

[Example sites]	[References]	[Inquiry]
	“Energy-Saving Journal (Vol. 47 No. 9, 1995)“ P. 93, by ECCJ	NEDO / ECCJ (JIEC)

MI-ME-4	Energy Conservation Directory

[Industry Classification] Many Industries	Oxygen enriched combustion system	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1992

Outline

Oxygen enriched combustion is a method of combustion to use air with enriched oxygen as a combustion air. This method of combustion is characteristic of increased heating capability with a very high flame temperature and diminished heat loss of exhaust gas, enabling a very large energy saving over ordinary combustion. The problem is to find the countermeasure for the generation of NOx as the result of the combustion of enriched oxygen.

Principle & Mechanism

[Characteristics of the enriched oxygen combustion]

(1)Flame temperature and heating capacity increase. The optimum oxygen concentration in the air to obtain a high temperature flame is in the range of 25 - 30% and also combustion in this range is economical. (Refer to Fig. 1)

(2)By the oxygen enriched combustion, both the amount of combustion exhaust gas and heat loss of the exhaust gas will decrease. (Fig. 2.)

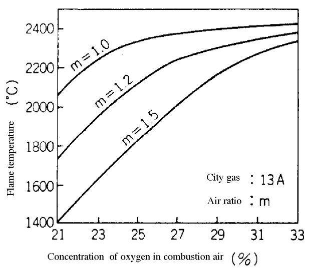


Fig. 1 Theoretical adiabatic temperature of the oxygen enriched combustion

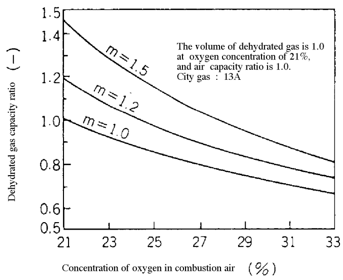


Fig. 2 Oxygen concentration and exhaust gas volume

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

[Oxygen enriched combustion system] (Refer to Fig. 3.)

Improved section

[Production of oxygen enriched air]

At present, the most economical method of producing oxygen-enriched air, which is producing about 30% oxygen-enriched air, is the membrane separation method. (Refer to Fig.4.)

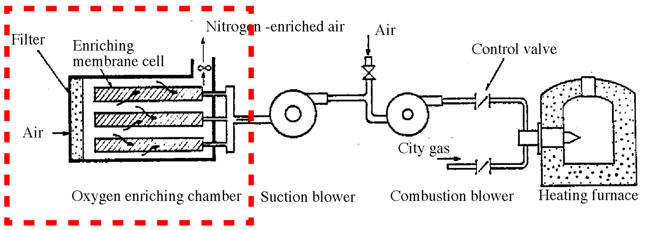


Fig. 3 Oxygen-enrich combustion system by the membrane separation method

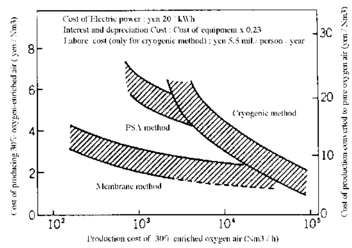


Fig. 4 Production cost of 30% enriched oxygen air

Energy saving effects

Shown in Fig. 5 are oxygen concentration of combustion air and rate of fuel saving.

[Example of trial calcualtion]

Conditions : Cost of electric power for the membrane separation system is 20 yen/kWh,

Interest and depreciation cost : Cost of equipment x 0.23,

If the cost of production of 30% oxygen-enriched air is 3 yen/ Nm^3 ,cost for fuel is 24 yen for 10^4kcal . If the cost of fuel is 100 yen per 10^4kcal ,this system pays when fuel saving rate is more than 30%.

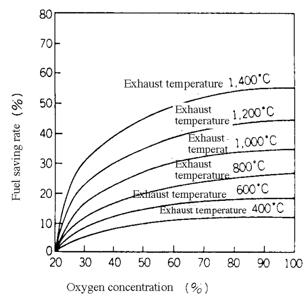


Fig. 5 Oxygen concentration of combustion air and fuel saving rate

[Economics] Equipment cost

Investment amount (A): 10 million yen(excluding installation cost)
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

As quantity of NOx generated will increase by the increase of flame temperature, such NOx control measures as 2-sage combustion and installation of a denitration apparatus are necessary.

[Example sites]	[References]	[Inquiry]
	“Basic Knowledge of Industrial Furnaces (1994) ” Japan Association of Industrial Furnaces	NEDO / ECCJ (JIEC)

MI-ME-5

Energy Conservation Directory

[Industry Classification] Many Industries	Vacuum steam heating system	[Energy Source] Fuel (steam)
[Technology Classification] Machinery & Equipment		[Practical Use] 1996

Outline	In a heating process, steam heating is an useful source of heat due to its high productivity and safety. However, it is not suited for heating below 100˚C. In these processes, steam was converted into warm water and used as a heat source conventionally. This system permits uniform heating utilizing the latent heat intrinsic to steam.
Principle & Mechanism	When used for a heating system, steam exhibits excellent characteristics such as ease in transportation and operation, low cost and safety. However, physically it cannot be used as a heat source below 100˚C unless it is converted into warm water. In the system introduced here, vacuum steam heating is adopted, which allows steam heating below 100˚C. Temperature controllability increases as well. In contrast to the interfacial heat transfer coefficient of 1,000-2,000 kcal/(m^2 h˚C) in warm water heating, the value in steam heating is as large as 6,000-8,000 kcal/(m^2 h˚C).

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

[Flow of vacuum steam heating]
This system consists of following three elements.
- Ejector-type vacuum pump
- Vacuum pressure reducing valve
- Temperature reducing system

[Standard specifications]
Feed steam temperature: 60-110˚C (−1˚C)
Feed steam pressure: 150-1,100 torr.

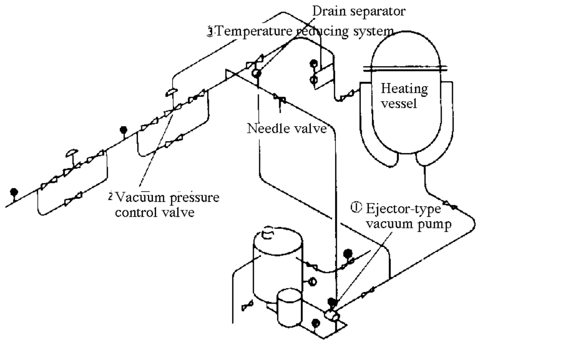
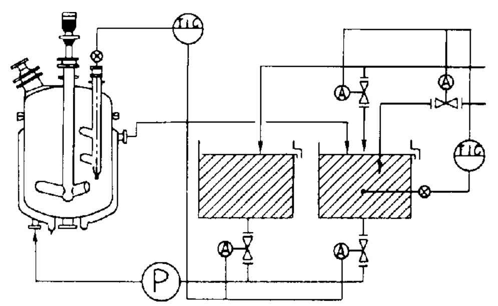


Fig. 1 Standard flow diagram of vacuum steam heating system

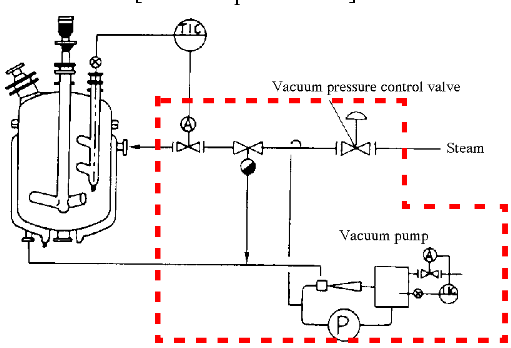
[Characteristics of this system]
1) It provides a uniform heat source, allowing uniform heating by latent heat at low temperatures below 100˚C.
2) Heat transfer coefficient of steam heating is 4-6 times higher than that of warm water, contributing to increase of productivity. (Interfacial heat transfer coefficient : 6000 - 8000 kcal (m^{2}h˚C) in case of steam, 1000 - 2000 kcal /(m^{2}h˚C) in case of hot water.)

[Example] Application to existing polymerization apparatus

[Before improvement]



[After improvement]



Improved section

Energy saving effects	[Improvement effect] 1) Temperature controllability was improved, and reaction temperature deviation was also improved from 70−3˚C to 70−1˚C. 2) As a result of changing the heat source from warm water of 90˚C to steam of 90˚C, production of warm water is no more necessary at operation start-up, shortening the start-up time of 3 hours to 1 hour, increasing the productivity accordingly.
[Economics] Equipment cost	Investment amount (A): 5 million yen Improvement effect (B): million yen/year Investment payback (A/B): years
Remarks	[Major application]Most suited for batch-production processes in fine chemical industry, for example, polymerization, distillation, concentration, maturation, and drying.

[Example sites]	[References]	[Inquiry]
Applied at more than 200 sites	TLV’s technical material, “Energy Saving Journal (Vol. 45, No. 6, 1993)”	NEDO / ECCJ (JIEC)

MI-ME-6	Energy Conservation Directory	
[Industry Classification] Many Industries [Technology Classification] Machinery & Equipment	Improvement in recovering steam drain in plywood factory	[Energy Source] Fuel (steam) [Practical Use] 1980s -

Outline	In plywood production, a log is cut into veneers 0.8-4.0 mm in thickness by a rotary lathe, dried by a drier, combined into a designated structure by glue, and hot-pressed by a hot-press machine. Previously, a large quantity of steam used in many of these thermal processing units was not sufficiently recovered. Introduced here is an example of improvement whereby all the steam drain, both the high-pressure drain and the low-pressure drain, has come to be recovered, greatly contributing to energy saving.

[Description]

Structure explanation, Shape, and/or System diagram

[Steam and drain recovery system of plywood factory] (Refer to Fig. 1)

1) In this factory, steam of 16kg/cm^{2}G generated in the boiler is led into the high-pressure header, from which it is fed to the veneer drying process. Drain from the dryer is collected into a flash tank in a closed cycle.
2) From the low-pressure head, steam is fed to thermal facilities such as the hot press, dryer in the fabrication process, and wood drying chamber in the lumbering process. Drain of this low-pressure steam is transferred to the hot water tank for boiler feeding by means of the pumping trap shown in Fig. 2 or by a vacuum pump, and recovered.

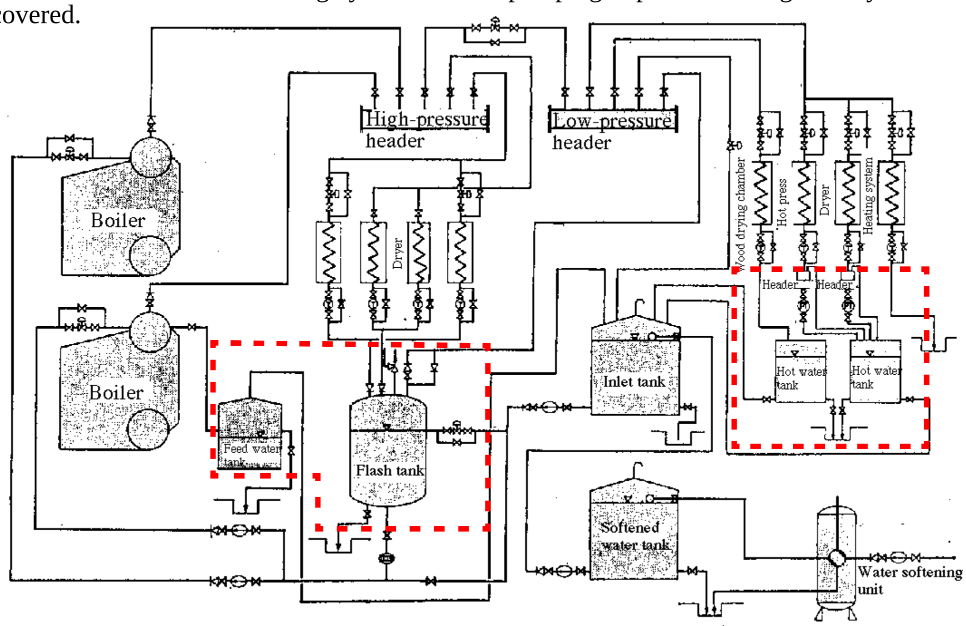


Fig. 1 Typical steam and drain recovery system in plywood factory

Improved section

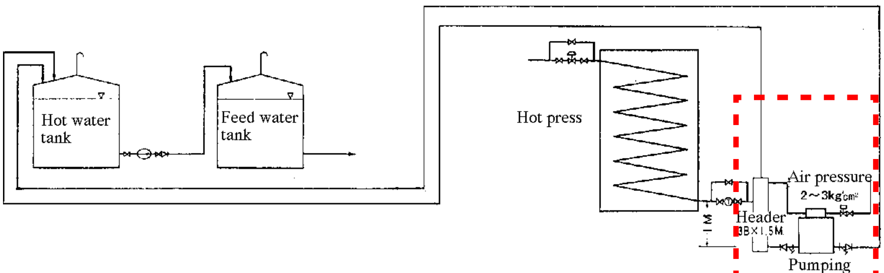


Figure 2 Example of low-pressure drain recovery

Energy saving effects	The rate of steam drain recovery in this case is over 95%. With only the improvement in low-pressure drain recovery, the apparent increase of the boiler capacity was 3.65%.
[Economics] Equipment cost	Investment amount (A): million yen Improvement effect (B): million yen/year Investment payback (A/B): years
Remarks	This drain recovery technology is a fundamental technology that is widely applicable to any industrial field where steam is used.

[Example sites]	[References]	[Inquiry]
Most of plywood plants in Japan apply tihs technology.	"Energy Saving Journal (Vol. 26, No. 9, 1974)," p. 35. Makers' technical documents	NEDO / ECCJ (JIEC)

MI-ME-7	Energy Saving Directory	
[Industry Classification] Many Industries [Technology Classification] Machinery & Equipment	Control of exhaust gas humidity of plywood dryer by high temperature hygrometer	[Energy Source] Fuel (steam) [Practical Use] 1980s -

Outline

Previously, there was no such hygrometer for process use as was applicable for measuring humidity in the high-temperature atmosphere in an accurate and stable manner with good response. This energy-saving devise employs a zirconia-based hygrometer which can be used in the temperatures of 0-600Åé, and has come to be widely applied for process humidity control of various industrial dryers.

Principle & Mechanism

[System construction of high-temperature hygrometer] (Refer to Fig. 1)

This high-temperature hygrometer is a zirconia-based instrument consisting of a detector, converter, and standard gas unit. It does not matter even if dust is contained in the atmosphere to the extent of 5mg/m^3, and its real gas response time is 10-30 seconds. It can be directly installed in the equipment such as a dryer and exhaust gas duct.

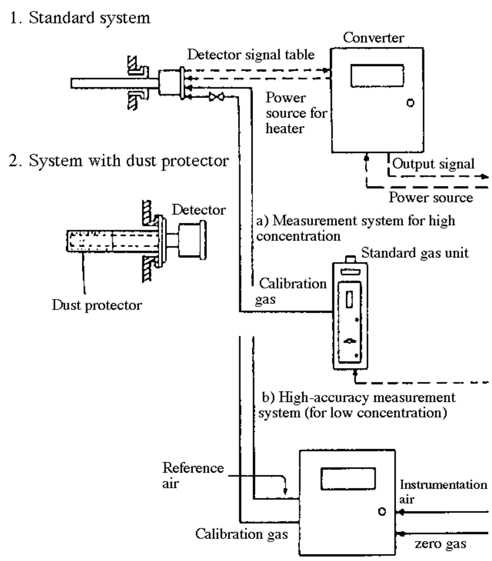


Fig. 1 System construction of high-temperature hygrometer

[Description]

Structure explanation, Shape, and/or System diagram

[Example of application to dryer for construction materials (plywood and gypsum board)] (Refer to Fig. 2)

Fig. 2 illustrates an exhaust humidity control loop for a plywood dryer. By conducting set-point control of humidity in the exhaust duct, it stabilizes the plywood dryness and saves steam consumption.

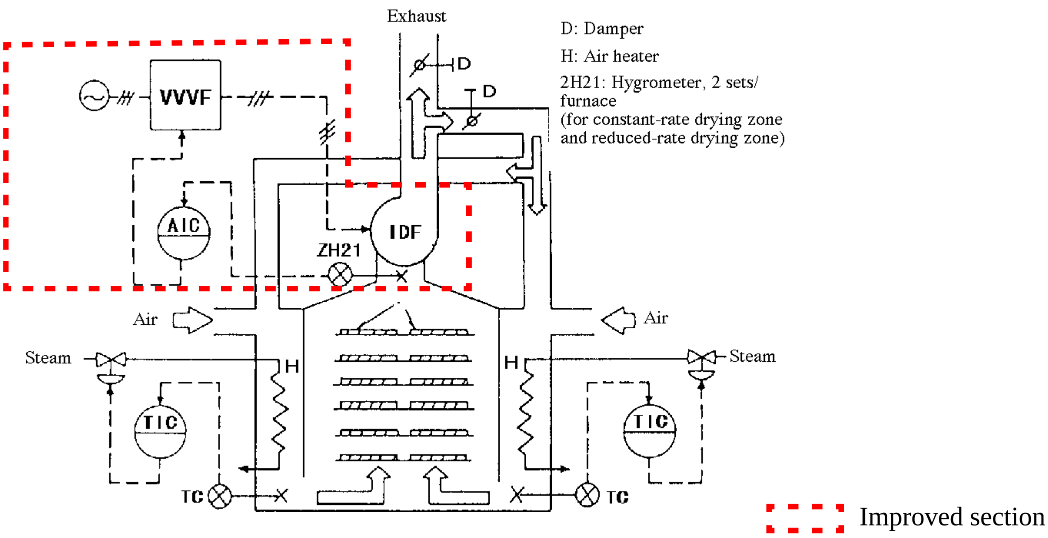


Fig. 2 Exhaust humidity control loop for plywood veneer dryer

Energy saving effects

In the case introduced here, steam saving of more than 11% was achieved.

[Economics] Equipment cost

Investment amount (A):	10 million yen(in case of dryer for construction use)
Improvement effect (B):	million yen/year
Investment payback (A/B):	years

Remarks

This technology is widely applied for dryers and steamers in various fields such as textile industry, electronic components industry (humidified decomposition furnace) and food industry, as well as construction material industry and pulp and paper industry. The following are examples of the application of this technology.

[Application in humidity control loop for paper-making machine]

1) In the air system of the closed hood of the paper-making machine dryer, the feed air volume can be reduced by increasing its humidity to the extent not to cause condensation in the exhaust, thereby reducing the steam content in the feed air, and also reducing the cost involved in driving the feed air fan.
2) The humidity control loop shown in Fig. 3 controls the exhaust volume so that an appropriate mixture ratio be attained in accordance with the temperature of the exhaust by measuring the mixture ratio of the exhaust and the temperature in the exhaust hood.
3) By applying this technology, 1.6% of steam consumption was saved in a facility producing paper of the weight of $125 g/m^2$ at a rate of 360 t/day.
4) In the paper-making industry, several hundreds sets are being used for humidity conditioners, Yankee dryers, and coater-machine dryers.

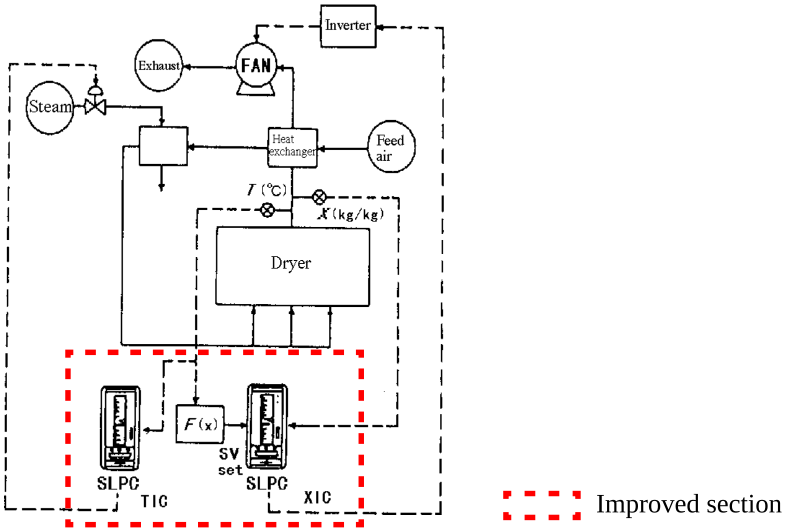


Fig. 3　Humidity control loop paper-making-machine dryer

[Application in humidity control loop of high-grade white sugar dryer]

Previously with respect to the high-grade white sugar dryer, the moisture content was measured by an infrared moisture meter at the outlet of the sugar cooler in the downstream of the drying process. From the time the raw material is loaded into the dryer, it took 15 minutes for the exhaust to reach the cooler outlet. Therefore, appropriate moisture control was not possible. By installing the hygrometer introduced here at the outlet of the dryer, moisture control has become possible.

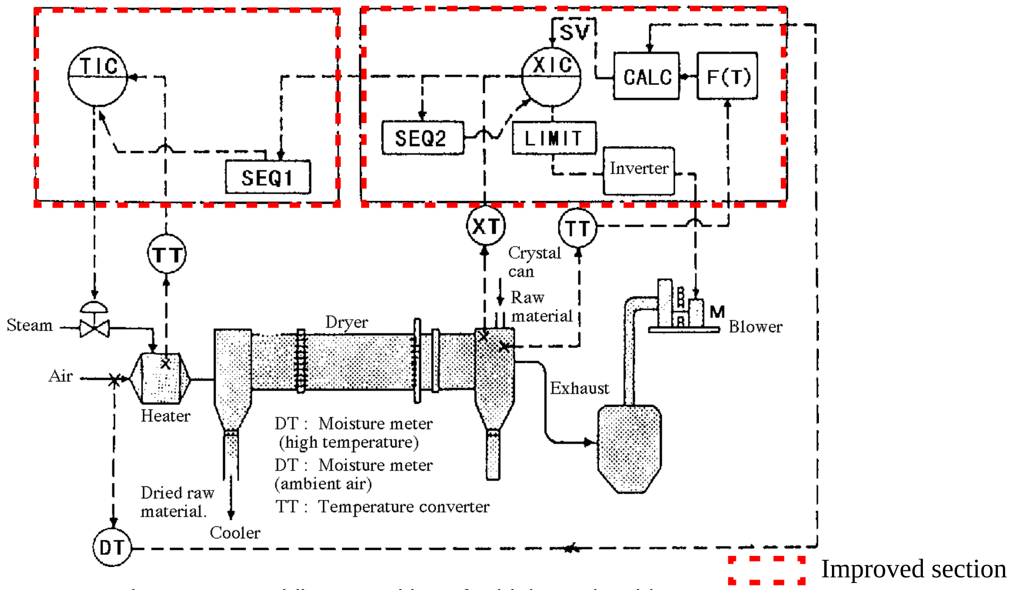


Figure 4　Humidity control loop for high-grade white sugar

[Example sites]	[References]	[Inquiry]
Applied at many sites for drying process.	“Energy Saving Journal (Vol. 37, No. 10, 1985),” P. 79	NEDO / ECCJ (JIEC)

MI-ME-8	Energy Conservation Directory

[Industry Classification] Many Industries	Waste heat recovery vacuum type hot water producing system	[Energy Source] Fuel
[Technology Classification] Machinery & Equipment		[Practical Use] 1980s

Outline

This is a system to recover heat from waste gas of the temperature of about 250˚C from a boiler or other combustion system. Waste heat of this temperature range was hitherto difficult to recover. The waste gas is used to heat a heating medium in a vacuum, and then the heating medium is used to heat feed water. The waste heat is recovered as hot water of the arbitrary temperature in the range of about 65-95˚C, contributing to energy saving.

Principle & Mechanism

The working principle of this waste heat recovery is that, when waste gas is passed through a vacuum vessel filled with a deaerated heating medium, the heating medium is heated under a reduced pressure and boiled, and generates a low-pressure vapor of about 90 ˚C. Feed water is heated by this vapor through a heat exchanger built in the vacuum vessel.

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

[Features of this apparatus] (Refer to Figs. 1 and 2)

1) The heating medium is heated and boiled by waste heat in the vacuum vessel.
2) The heating medium is heated to its boiling temperature all over the heat transfer area. As it is beyond the dew point of the waste gas, corrosion by acid dews, etc. is prevented.
3) Normally the operation is controlled by opening and closing the waste-gas damper in accordance with the heating-medium temperature detected by the thermistor.

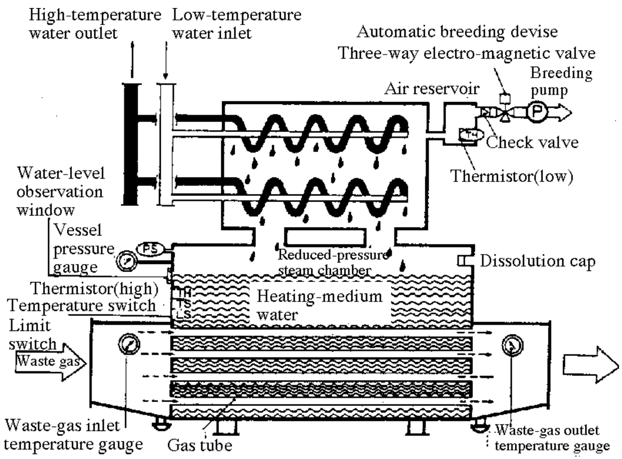


Fig. 1 Construction of waste heat recovery vacuum type hot water producing system

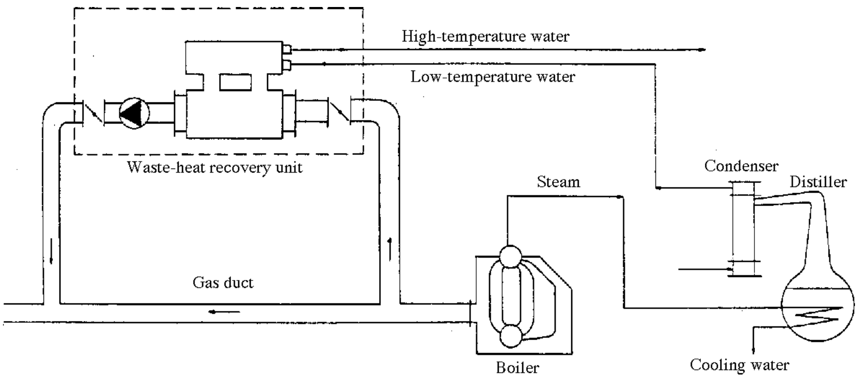


Fig. 2 Example of heat recovery system flow diagram

Energy saving effects

Hot water of 65-95˚C is recovered by heat exchage with low-temperature waste gas.

[Economics] Equipment cost

Investment amount (A): 10 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

Systems for waste-gas volume of 3,000-30,000 m^3 N/h and waste-gas temperature of 200 - 450˚C are standardized.

[Example sites]	[References]	[Inquiry]
Adopted at many sites.	Energy Conservation Equipment Directory," the Agency of Natural Resources and Energy/ECCJ; Makers' catalogs	NEDO / ECCJ (JIEC)

MI-ME-9	Energy Conservation Directory	
[Industry Classification] Many Industries [Technology Classification] Machinery & Equipment	Heat-pump-type steam-recompression cylinder dryer for drying process	[Energy Source] Fuel (steam) [Practical Use] 1980s -

Outline	Traditionally in drying the fabric by steam cylinders, the heating steam was discharged inside the factory after being used to vaporize moisture in the fabric and to heat the air. In the present system, the cylinder dryer is enclosed in a sealing box, the exhaust steam is recovered, and recompressed for reuse, consequently achieving energy saving.
Principle & Mechanism	- The present system recompresses the steam by a screw-type heat pump, a technology known as VRC or MRC. - The screw compressor can achieve a high compression ratio. It also has a high allowance for sucking foreign materials together with steam, and its operational reliability is high. - The COP in this case is as high as 6.9.
[Description] Structure explanation, Shape, and/or System diagram	1) As Fig. 1 shows, this system consists of a cylinder dryer, a sealing box, and a heat pump (steam compressor). 2) As the dryer is enclosed in a sealing box, air is prevented from entering and steam emitted from the fabric is recovered. 3) The steam in the sealing box is introduced to the steam compressor through a duct, compressed to 1.9 Kg/cm^{2}g, and supplied to the drying cylinders. After used to heat the fabric, the steam becomes drain. 4) The energy used for drying the fabric is almost entirely recovered and reused. Only energy to be added to this system is electric power for the motor to drive the compressor and a small amount of backup steam.

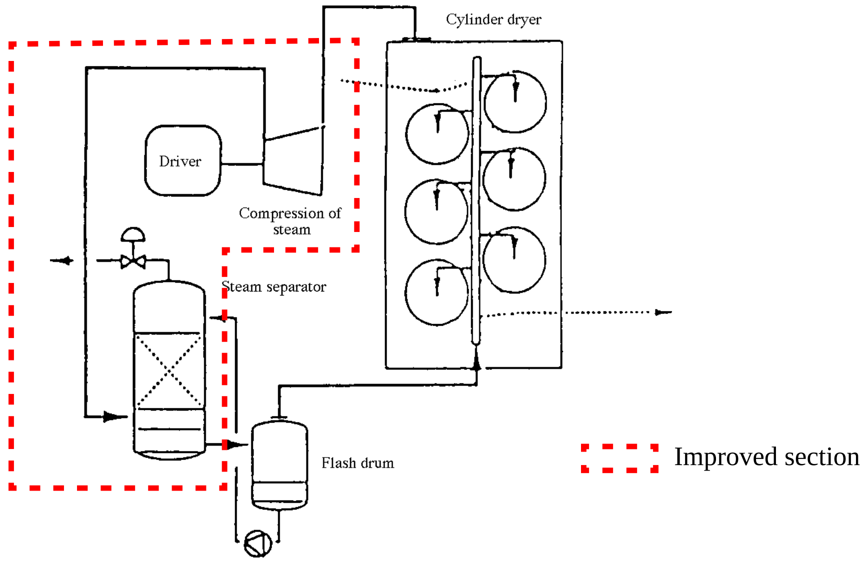


Fig. 1 Heat-pump-type steam-recompression cylinder dryer

Energy saving effects

Table 1 Heat-pump-type steam-recompression cylinder dryer

	Before modification	After modification	Effects
Steam consumption	1.186 t/h		Reduction of 1.186 t/h
Electric power consumption		75 kWh	Increase of 75 kWh
Consumption in terms of primary energy	639 Mcal/h	167 Mcal/h	Reduction of 1.888 Gcal/y*
Energy saving - crude oil equivalent			20.3 kL/y

Note: * Operation of 4,000 hours/year

[Economics] Equipment cost	Investment amount (A): 15 million yen Improvement effect (B): million yen/year Investment payback (A/B): years
Remarks	

[Example sites]	[References]	[Inquiry]
Adopted at dyeing plants	Maekawa Seisakusho's technical materials	NEDO / ECCJ (JIEC)

MI-ME-10

Energy Conservation Directory

[Industry Classification]	Introduction of heat pump using cooling water for air compressors as its heat source	[Energy Source]
Many Industries		Fuel, Electricity
[Technology Classification]		[Practical Use]
Machinery & Equipment		1985s -

Outline

In general, the consumption of power by air compressors in a factory is as large as 10-30% of the total power consumption. The improvement introduced here is to utilize cooling water (warm water) for compressors, the heat of which was hitherto discharged from a cooling tower, as a heat source for a heat pump.

Before Improvement

[Before improvement]

- The cooling water for the air compressors was circulated from the cooling tower, and reused.

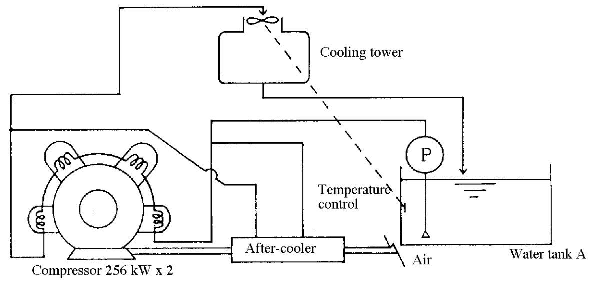


Fig. 1 Flow diagram of cooling water system for air compressors before improvement

[Description of Process]

Structure explanation, Shape, and/or System diagram

[After remodeling]

- Heat pumps (15 kW x 2sets, 7.5 kW x 1 set) were installed, which use the cooling water (warm water) as their heat source.
- Operation method: In winter time, the water temperature of the tank C is controlled at 55˚C and the heat is used for air conditioning (heating), thereby reducing the maximum load of the air conditioner from 125 kW to 41 kW. In summer time, by switching the valve, the temperature is controlled at 7˚C, and the cool water is used for air conditioning (cooling).

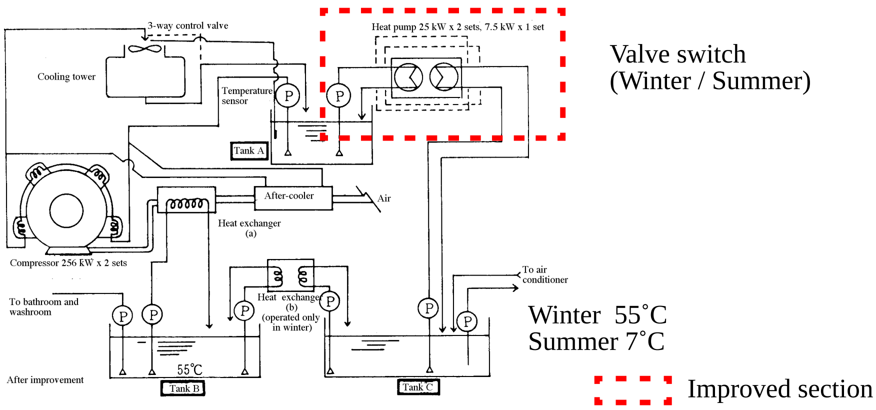


Fig. 2 Flow diagram of heat pump system after improvement

Energy saving effects

Table 1 Energy saving effect of heat pump using cooling water for air compressors as its heat source

	Before improvement	After improvement	Improvement effect
Electric power consumption	164,200 kWh/y	92,400 kWh/y	71,800 kWh/y (reduction by 44%)
Fuel (kerosene) consumption	61,000 L/y	0	Reduction by 61,000 L/y
Reduction in crude oil equivalent			76 kL/y

[Economics] Equipment cost

Investment amount (A): 19.4 million yen
Improvement effect (B): 7.41 million yen/year
Investment payback (A/B): 2.6 years

Remarks

[Example sites]	[References]	[Inquiry]
Adopted at many sites.	“Collection of Improvement Cases at Excellent Energy Management Plants“(1986)	NEDO / ECCJ (JIEC)

MI-ME-11	Energy Conservation Directory	
[Industry Classification] Many Industries [Technology Classification] Machinery & Equipment	Heat pump type low temperature vacuum concentrator	[Energy Source] Fuel, Electricity [Practical Use] 1991

Outline

This apparatus, applying a heat pump of an excellent heat efficiency, is capable of conducting evaporation and concentration under a normal temperature by keeping the inside of the apparatus evacuated. It can be applied, for example, to waste liquid treatment, thereby concentrating the waste liquid to facilitate easy incineration. The steam generated during the process can be retrieved as condensate water by means of the heat pump and reused.

Principle & Mechanism

[Principle of concentration] (Figure 1)
A heat pump using R-22 is used for concentration. The evaporator and the steam condenser are kept evacuated (approx. 20 Torr) by the water ejector. From the viewpoint of the heat pump, the evaporator is a refrigerant condenser and the steam condenser is a refrigerant evaporator.

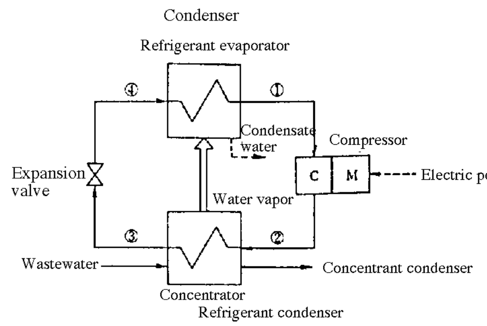


Figure 1 Flow chart of heat-pump-type concentrator

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

[Features of the apparatus]
Since concentration is carried out in a vacuum, concentration under a normal temperature is possible. The heating temperature inside the apparatus is controlled at 40-50˚C and the condensing temperature at approximately 20˚C, preventing the concentrated liquid from deteriorating or decomposing under high temperatures.
[Construction of the apparatus] (Refer to Fig. 2)
The apparatus consists of an evaporator / condenser, heat pump unit, vacuum pump (water ejector), driving water pump, chilled water tank, and a phase pump for concentrated liquid.

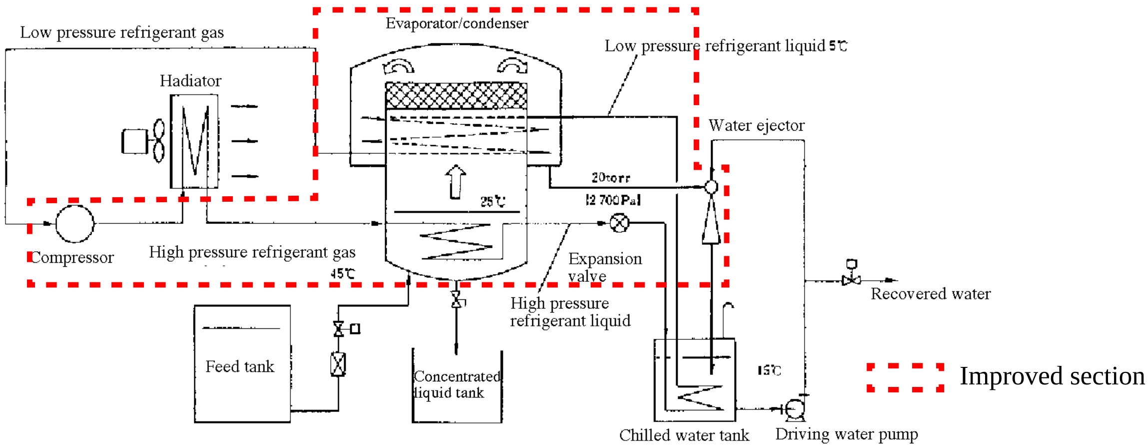


Figure 2 Heat-pump-type low-temperature vacuum concentrator

Energy saving effects

[Economics] Equipment cost

Investment amount (A): 20 million yen
Improvement effect (B): million yen/year
Investment payback (A/B) : years

Remarks

The apparatus is applicable to recovery and reuse of washing water for electronic and mechanical parts, concentration of waste liquid from factories for metal plating, foods, chemicals, etc. Also applicable to recovery of various solvents.

[Example sites]	[References]	[Inquiry]
There are a number of practical applications at factories and research laboratories.	“Ebara Engineering Review (No.161 1993-01)”	NEDO / ECCJ (JIEC)

MI-ME-12	Energy Conservation Directory	
[Industry Classification] Many Industries [Technology Classification] Machinery & Equipment	Refrigerating machine waste heat recovery system	[Energy Source] Electricity, Fuel [Practical Use] 1980s -

Outline	The improvement shown here is to utilize recovered low-temperature heat of condensation generated by the refrigerant when compressed by the compressor of the refrigerating machine, and produce warm water to be effectively used in other processes.
Principle & Mechanism	1) The first step is to perform heat exchange between the refrigerant of the refrigerating machine and the circulating hot water by using a plate-type heat exchanger, thereby raising the temperature of the circulating hot water from 40˚C to 44 ˚C. 2)The second step is to heat the circulating hot water by steam up to a temperature required for a specific purpose (in this example, 51˚C), then to perform heat exchange wherever the heat is required. Thereafter, the circulating hot water returns to the refrigerating machine.

[Description]

Structure explanation, Shape, and/or System diagram

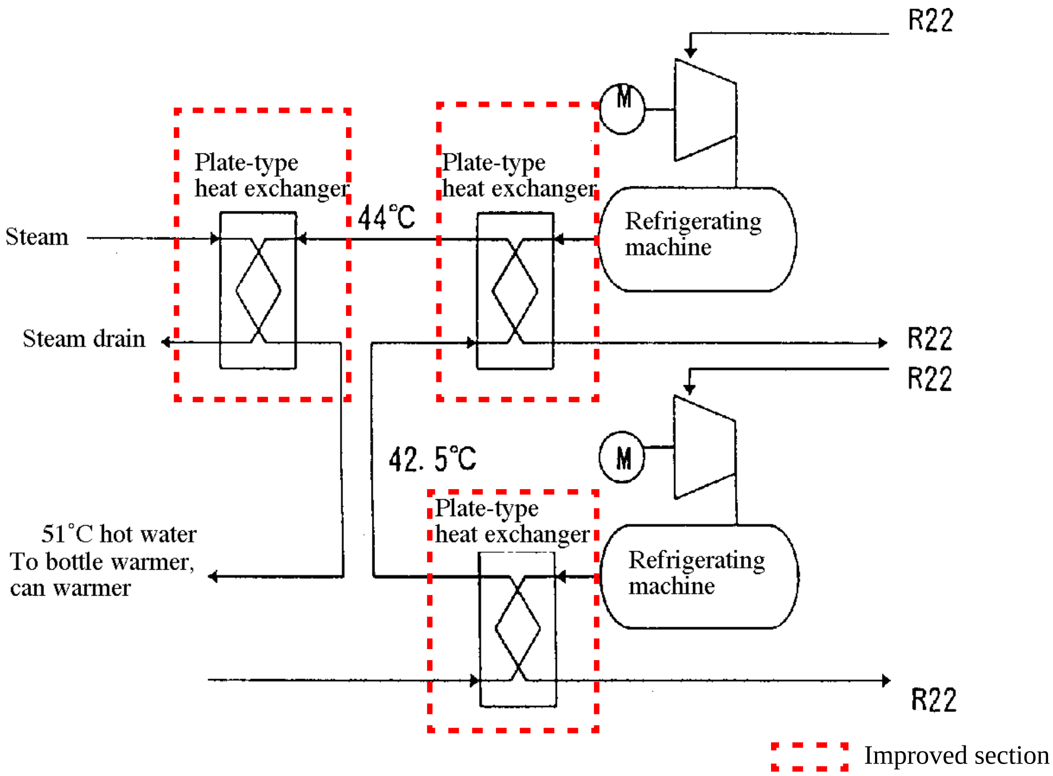


Fig. 1 Flow diagram of refrigerating machine waste heat recovery system

Energy saving effects

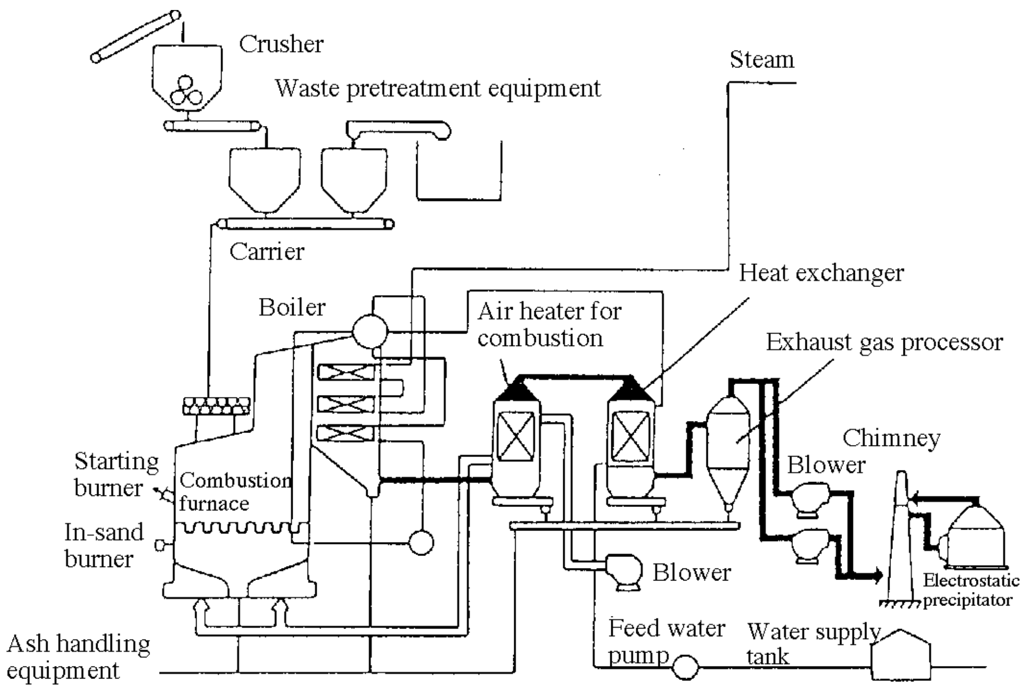
Table 1 Energy saving effect by refrigerating machine waste heat recovery.

	After improvement	Remarks
Reduction in steam consumption	4,500 t/y (15 t/d)	Operation days: 300 d/y
Reduction in crude oil equivalent	367 kL/y	

[Economics] Equipment cost	Investment amount (A): 5 million yen(excluding installation cost) Improvement effect (B): million yen/year Investment payback (A/B): years
Remarks	Suited to warm water of comparatively low temperature (40-50˚C) used for processes and utility purposes in various factories.

[Example sites]	[References]	[Inquiry]
Many similar applications	Makers' in-house case reports	NEDO / ECCJ (JIEC)

MI-ME-13	Energy Conservation Directory	
[Industry Classification] Many Industries [Technology Classification] Machinery & Equipment	Effective use of exhaust heat from waste incineration	[Energy Source] Fuel [Practical Use] 1980s -

Outline	This technology is applied for recovering exhaust heat, an energy unutilized previously, that is generated when incinerating municipal waste like general household waste, contributing to effective use of natural resources.
[Description] Structure explanation, Shape, and/or System diagram	[Construction of exhaust heat recovery system for waste incineration] (Refer to Fig. 1) 1) An waste-heat boiler is installed to a fluidized-bed incineration furnace applicable to incinerate various wastes, and is used for supplying steam for industrial uses and for space heating. 2) In the case introduced here, the waste-heat boiler generates 16 t/h of steam.  Fig. 1 Fluidized-bed incineration furnace for general waste (provided with waste-heat boiler)
Energy saving effects	Steam generation: 112,000 t/year Reduction in crude oil equivalent: approx. 10,200 kL/year.
[Economics] Equipment cost	Investment amount (A): million yen(excluding installation cost) Improvement effect (B): million yen/year Investment payback (A/B): years
Remarks	This technology is being planned to be applied in the "Model Project of Effective Use of Waste Heat Generated in Waste Incineration" to be operated for demonstration in Harbin, Heilongjiang, China by NEDO. This project is scheduled to be completed by March 2001.

[Example sites]	[References]	[Inquiry]
Implemented at many sites.	NEDO's technical reference material.	NEDO / ECCJ (JIEC)

MI-ME-14

Energy Conservation Directory

[Industry Classification] Many Industries	Waste heat boiler cogeneration system with secondary burner	[Energy Source] Electricity, Fuel
[Technology Classification] Machinery & Equipment		[Practical Use] 1992

Outline

Introduced here is a 6,000 kW class gas turbine cogeneration system installed in an edible oil factory. Steam and power generation is adjusted individually in accordance with the change in steam and power demand. It is a system excellent in its capability to respond to the changing load and minimizes the electricity purchase.

Principle & Mechanism

Energy balance is compared at the atmospheric temperature of 15˚C between waste-heat boilers with and without a secondary burner as shown below.

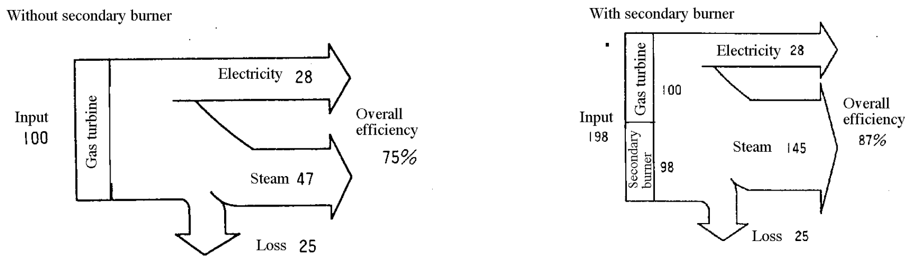


Fig. 1 Comparison of energy balance between waste-heat boilers with and without secondary burner

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

[System construction and flow diagram] (Fig. 2)

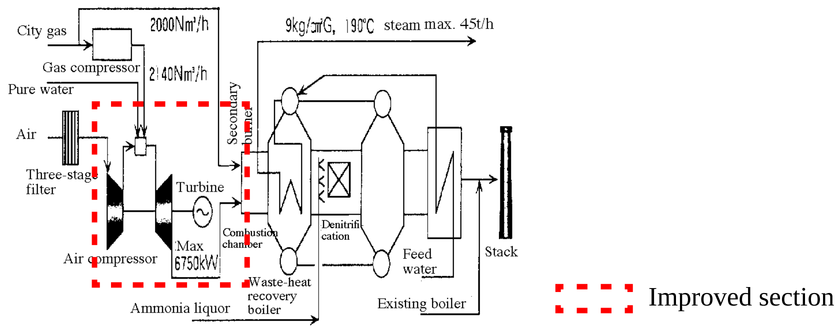


Fig. 2 Flow diagram of gas-turbine cogeneration system

[Characteristics of the system]

1) Three-hold secondary burner system
   A duct burner was adopted for three-fold secondary combustion using gas turbine waste gas as a combustion gas, which can generate steam of 45 t/h. This burner controls the load allotment with the existing boiler in accordance with changing steam load. The overall thermal efficiency of the system reaches 87%. Refer to Fig. 1.
2) Denitrification system
   As a countermeasure to NOx, a denitrification system based on ammonia-liquor dry-contact reduction is also used.
3) Power output control
   This system is arbitrarily operated either in the constant power generation mode or constant power purchase mode.

Energy saving effects

Table 1 Evaluation of waste-heat boiler with three-fold secondary (based on annual average load)

	Conventional system	Improved system	Reduction in crude oil equivalent
Annual consumption in primary energy equivalent	24,900 kL/y	19,900 kL/y	5,000 kL/y

[Economics] Equipment cost

Investment amount (A): 400 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

Inco-H is adopted as the material of the burner to make possible continuous operation under the high temperature of three-fold secondary combustion. The water-cooled wall is adopted to lower the temperature of the combustion chamber.

[Example sites]	[References]	[Inquiry]
"The Nisshin Oil Mills' Yokohama Isogo Plant	"Cogeneration in Japan (1997)" "Energy Saving Journal (Vol. 47, No. 11, 1995)"	NEDO / ECCJ (JIEC)

MI-ME-15

Energy Conservation Directory

[Industry Classification] Many Industries	Gas turbine cogeneration system with variable heat-electricity ratio	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1992

Outline

The gas turbine cogeneration system with variable heat-electricity ratio can increase shaft output by feeding steam obtained by recovering exhaust heat into the turbine. This system is most suitable in the applications where the demand ratio for heat and electricity drastically changes depending on seasons and time periods, and its use is expanding.

Principle & Mechanism

1) Steam is usually injected near the outlet of the combustion chamber of the gas turbine, mixed with the combustion gas, and enters the turbine section as a two-fluid gas, contributing to the increase of the shaft output and shaft-end thermal efficiency.
2) The heat-electricity ratio is varied by controlling the injection volume.

[Description]

Structure explanation, Shape, and/or System diagram

[Outline of the system] (Fig. 1)
The gas turbine drives the generator and send the exhaust gas to the heat recovery system, where steam is generated. Part of the generated steam is supplied to the factory as process steam, and the rest is injected into the turbine via the superheater.
By controlling this injection volume, the ratio between the process steam volume (heat) and the electrical power output (electricity) converted from the shaft output can be varied. By carrying out supplemental combustion by adding a duct burner to the boiler, the steam generation is further increased, enabling even more flexible operation.

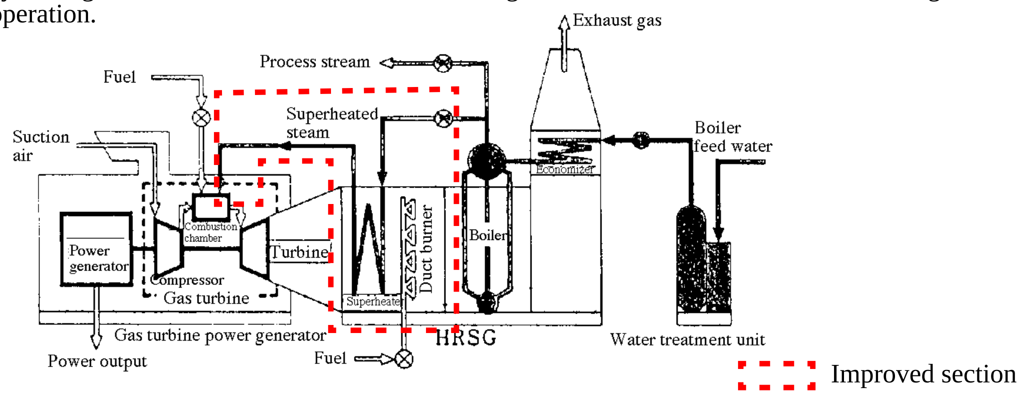


Fig. 1 Construction of gas turbine cogeneration system with variable heat-electricity ratio

[Performance of gas turbine cogeneration system with variable heat-electricity ratio and its operation area]
<Example of operation>
Gross thermal efficiency: 2,300 kW (Refer to Fig. 2)
1) Usually, the gas turbine is operated on the OA line.
2) Supplemental combustion by the duct burner is performed in the area indicated as ③.
3) By the injection of steam, operation with arbitrary heat-electricity ratios is possible within the range of ①.
4) When a duct burner is added to the variable-heat-electricity-ratio operation, operation is possible in all the areas of ①, ②, and ③.
5) The point A is the maximum output point when operated under a simple-cycle mode, and gives the gross thermal efficiency of 21%; at the point B, the process steam volume is zero, and the gross thermal efficiency is 32 %.

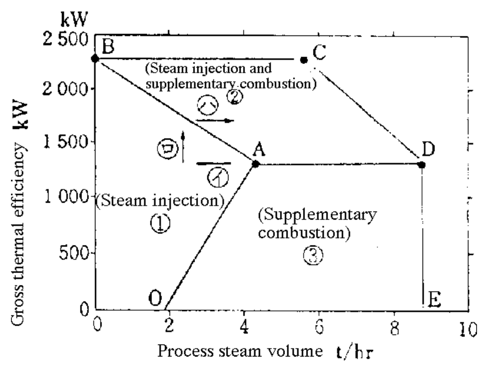


Fig. 2 Operation area of the system

Energy saving effects

In contrast to the gross thermal efficiency of 1,300 kW by a conventional type, the power output is increased by 2,300 kW (1.77 times) by full steam injection.

[Economics] Equipment cost

Investment amount (A): 200 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

[Example sites]	[References]	[Inquiry]
	"Journal of the Japan Society of Mechanical Engineers (Vol. 95, No. 879, 1992)," and other materials	NEDO / ECCJ (JIEC)

MI-ME-16

Energy Conservation Directory

[Industry Classification]
Many Industries

[Technology Classification]
Machinery & Equipment

Recovery of power by installing steam turbine in steam pressure reducing line

[Energy Source]
Electricity

[Practical Use]
1983

Outline

In the case introduced here, formerly steam of 12 kg/cm^2 was received from a boiler plant in the factory at a rate of 50 t/h, and its pressure was reduced to 10 kg/cm^2 and 4 kg/cm^2 to be used at a rate of 28 t/h and 22 t/h respectively. To save energy, a steam turbine was installed in place of the pressure reducing valve, and used for driving a refrigerator.

Principle & Mechanism

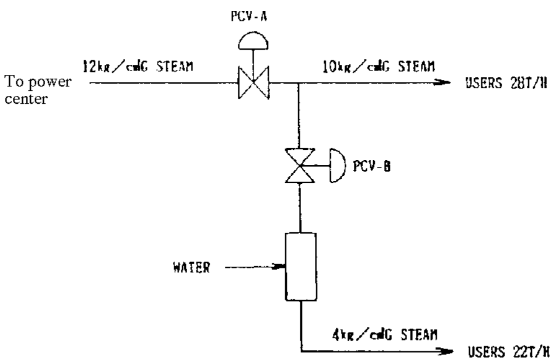
The pressure reducing valve reduces the pressure by squeezing the valve port and causing the pressure loss, where the enthalpy drop caused by adiabatic squeezing is utilized. In the same manner, the principle of a steam turbine is to utilize the enthalpy drop to generate power. The recoverable power is calculated by the following formula.

$$P=(G_o \text{ x } Dh \text{ x } n)/860$$

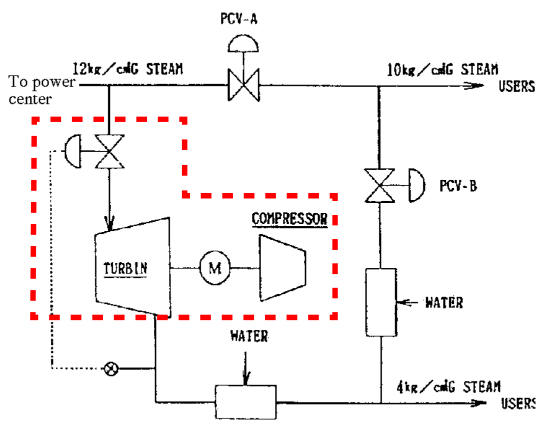
where, P is the recoverable power, Dh is the enthalpy drop (kcal/kg), and n is the turbine efficiency.

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

[Before improvement]



[After improvement]



Improved section

Energy saving effects

Table 1 Energy saving effect by steam turbine driving

	Reduction effect	Remarks
Reduction in power consumption	544 kWh/h	(0.1273 kL/h)
Increase in steam consumption	0.75 t/h	(0.0576 kL/h)
Reduction in crude oil equivalent	577 kL/y	(Operation hours : 8,000 h/y)

[Economics] Equipment cost

Investment amount (A): 50 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

[Example sites]
Similar technology adopted at many sites.

[References]
"Collection of Improvement Cases at Excellent Energy Management Plants (1984)," p. 1095

[Inquiry]
NEDO / ECCJ (JIEC)

MI-ME-17	Energy Conservation Directory	
[Industry Classification] Many Industries [Technology Classification] Machinery & Equipment	Introduction of low pressure steam expansion turbine	[Energy Source] Electricity [Practical Use] 1989

Outline	Previously, in summer time, excessive low-pressure steam was discharged into the atmosphere, and in winter time, due to an increase of demand for steam, medium-pressure steam was converted to low-pressure steam by bypassing it and reducing the pressure. This operation caused loss in energy utilization. As a countermeasure, expansion turbines were installed between the medium-pressure system and the low-pressure system, as well as between the low-pressure system and the atmosphere, thereby generating electricity and contributing to effective use of energy.
Principle & Mechanism	[A point considered in designing the turbine system] This turbine is of an ordinary type in the working principle and construction, but as the inlet steam pressure is lower than that of an ordinary turbine, the steam flow path is designed wider.
[Description] Structure explanation, Shape, and/or System diagram	1) Installation of expansion turbines and power generator (Fig. 1) - The turbines consist of the high-pressure unit and the low-pressure unit. - The low-pressure steam from the high-pressure unit is used as process steam in the factory. - The low-pressure turbine generates electricity using surplus steam in accordance with the demand balance in the factory.

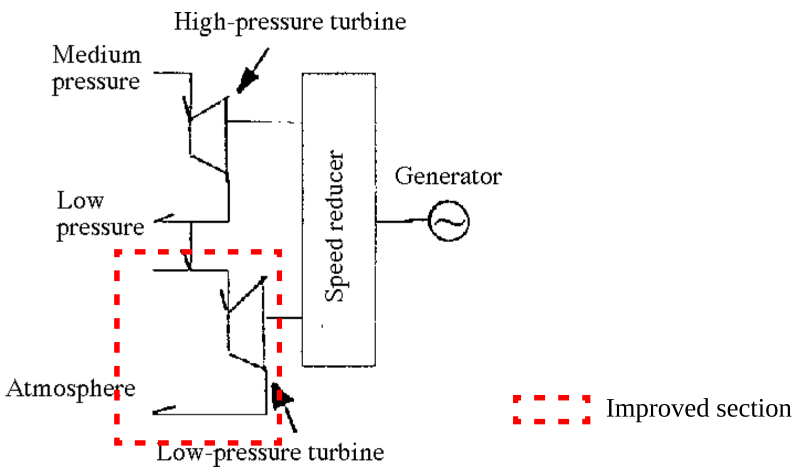


Fig. 1 Flow diagram of the low- and medium-pressure steam expansion turbines

Energy saving effects

Table 1 Energy saving effect by expansion turbines

	Energy recovery effect	Remarks
Recovered energy in fuel oil equivalent (heavy oil C)	5,650 kL/y	
Recovered energy in crude oil equivalent	5,989 kL/y	

[Economics] Equipment cost	Specification of the equipment: expansion turbine (output 2,390 kW), generator, controllers,and auxiliary work (piping, instrumentation, electrical wiring) Cost of the equipment: 173 million yen (including 58 million yen for auxiliary work)
Remarks	

[Example sites]	[References]	[Inquiry]
	Oil companies' in-house materials	NEDO / ECCJ (JIEC)

MI-ME-18

Energy Conservation Directory

[Industry Classification] Many Industries	Low pressure condensing steam turbine	[Energy Source] Fuel(steam),Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1980s -

Outline

This low-pressure condensing turbine generates electricity by using low-pressure steam which is not ordinarily used for electricity generation. As a steam turbine, it is small and has a special structure. Low-pressure process steam of about 2-3 kg/cm^3 is used in many factories, and in some cases, surplus steam is generated. This improvement is to install a power generating turbine to make use of this surplus steam effectively.

Principle & Mechanism

A low-pressure condensing turbine is basically the same in its working principle and structure as a normal-pressure turbine, but it is so designed as to obtain an appropriate internal flow speed for low-pressure steam.

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

[Example of improved system]
By combining a small low-pressure condensing turbine with an existing back-pressure turbine, a large increase of the output from the existing back-pressure turbine is attained, even if the output from the low-pressure condensing turbine is small. Thus, a large increase of the overall electricity output is attained.

Illustrated at right is the flow diagram when a low-pressure condensing turbine is installed. The area enclosed by the broken line shows a newly-installed condensing turbine.

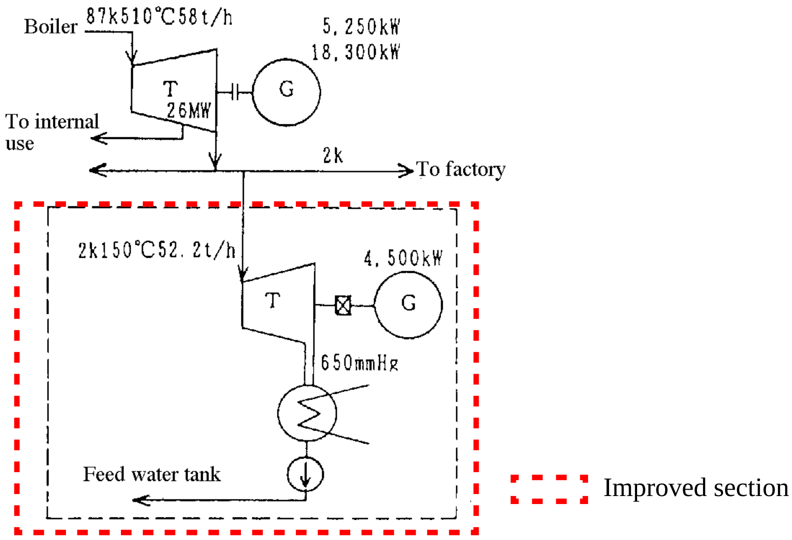


Fig. 1 Example of system flow diagram for existing back-pressure turbine combined with low-pressure condensing turbine

Energy saving effects

Table 1 Improvement effect by combining an existing back-pressure turbine with a low-pressure condensing turbine

	Back-pressure turbine	Combination of existing back-pressure turbine and low-pressure condensing turbine	
	Measured value before improvement	After improvement	Output increase
Inflow steam to existing back-pressure turbine	30.6 %	56.6 %	
Generated electric power	15.4 %	51.7 %	36.3 %
Inflow steam to newly-installed condensing turbine		24.5 %	
Generated electric power		16.3 %	16.3 %
Increase in overall electric power generated	15.4 %		52.6 %

[Economics] Equipment cost

Investment amount (A): 50 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

This energy-saving technology can be adopted in various industrial fields. For example, paper and pulp industry uses a large volume of low-pressure steam in production processes, and many numbers of this system have been installed.

[Example sites]	[References]	[Inquiry]
Many similar cases	Makers' in-house technical documents	NEDO / ECCJ (JIEC)

MI-ME-19	Energy Conservation Directory	
[Industry Classification] Many Industries [Technology Classification] Machinery & Equipment	Mixed steam extraction turbine power generator	[Energy Source] Electricity,Fuel (steam) [Practical Use] 1990s -

Outline

The mixed steam extraction turbine is a type of steam turbine that generates electricity by using steam of different pressures (high and low pressures). This system makes it possible for a plant, which is provided with both high-pressure and low-pressure boilers and is generating electricity by using only the high-pressure boiler and the back-pressure turbine, to use steam effectively for power generation when back-pressure steam for processing becomes excessive.

Before Improvement

[Before improvement]

1) Boiler-turbine power generation system
- 9 MW power generation system: Boiler and back-pressure turbine (100 kg/cm^{2}g to 3 kg/cm^{2}g)
- 7 kW power generation system: Boiler and back-pressure turbine (100 kg/cm^{2}g to 3 kg/cm^{2}g)

2) Waste-heat boiler for process (Steam generation: 60 t/h, pressure: 14 kg/m^{2}g)

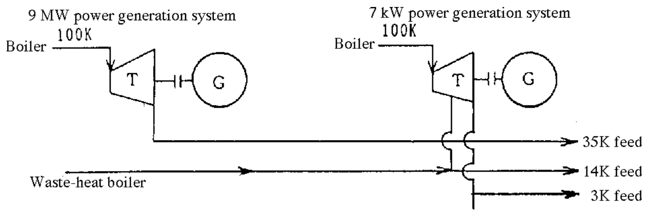


Fig. 1 Flow diagram of before improvement

[Description of Process]

Structure explanation, Shape, and/or System diagram

[After improvement]

1) Newly-installed power generation system:
7 MW mixed steam extraction turbine

Table 1 Increase of power generation by additional installation of mixed steam extraction turbine

	Before improvement (summer/winter)	After improvement (summer/winter)
9 MW power generation	3,400 kW / 5,250 kW	6,200 kW / 8,400 kW
7 MW power generation	0 kW / 800 kW	0 / 0
Power generation by new 7 MW turbine		7,000 kW / 7,000 kW
Total	3,400 kW / 6,050 kW	13,200 kW / 15,400 kW

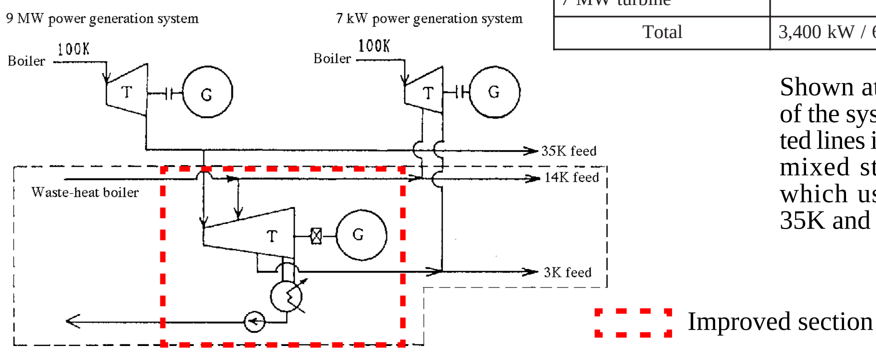


Fig. 2 Flow diagram after improvement

Shown at left is the flow diagram of the system. Inside the fine dotted lines is a newly-installed 7 MW mixed steam extraction turbine which uses two types of steam, 35K and 14K.

Energy saving effects

Table 2 Effect of power generation increase by newly-installed mixed steam extraction turbine

	Before improvement (summer/winter)	After improvement (summer/winter)	Increase (summer/winter)
Total power generation	3,400 kW / 6,050 kw	13,000 kW / 15,000 kW	9,800 kW / 9,350 kW
Annual increase in power generation			75,833,000 kWh/y
Reduction in crude oil equivalent			18,427 kL/y

[Economics] Equipment cost

Investment amount (A): 200 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

Cost reduction by this improvement is even larger in a case where surplus process steam is discharged into the atmosphere.

[Example sites]	[References]	[Inquiry]
Some similar cases adopted at sites.	Makers' in-house technical documents	NEDO / ECCJ (JIEC)

MI-ME-20	Energy Conservation Directory

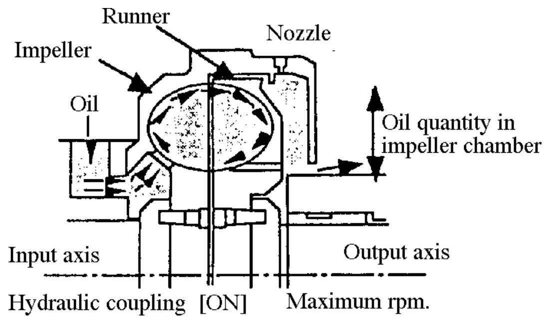
[Industry Classification] Many Industries	Introduction of hydraulic coupling to high pressure injection pump	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1975s -

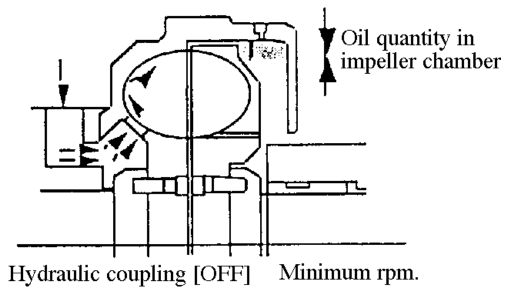
Outline

This is a case where energy saving was achieved by installing a hydraulic coupling to a water pump which frequently repeats the on-off operation.

Principle & Mechanism

The working principle of the hydraulic coupling is to perform ON-OFF switching operations by feeding and discharging oil alternately. When the solenoid valve is opened, much oil is injected from the nozzle and the impeller chamber is filled and the torque is transmitted to the output axis. Conversely, when the solenoid valve is closed, although oil is still fed from the orifice, only a small quantity of oil is injected from the nozzle. Therefore, the quantity of oil remaining in the impeller chamber becomes small, and the rotation of the output axis decreases.



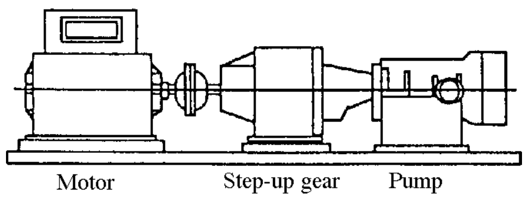


[Description]

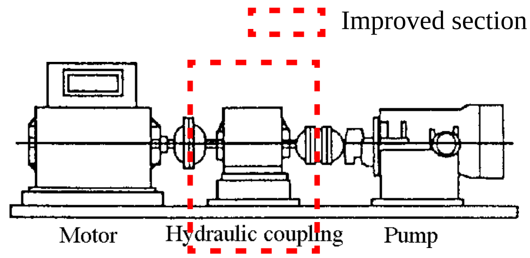
The step-up gear or speed-change gear installed between the pump and the motor is removed. Instead, a high-speed fluid coupling with a built-in step-up gear is installed there.
This hydraulic coupling permits to switch the operation from low speed to high speed in 5 seconds, and promptly meet a changing load based on the working condition, making possible frequent ON/OFF (low-speed/high-speed switching) control of the pump.

Structure explanation, Shape, and/or System diagram

[Before improvement]



[After improvement]



Energy saving effects

Table 1 Reduction in specific power consumption

(in a case of water use 10.000t/d and operating days of 330 d/y)

	Before improvement	After improvement	Effect
Specific power consumption	11.2 kWh/t	8.5 kWh/t	2.7 kWh/t Reduction of 24%
Reduction in crude oil equivalent			2,165 kL/y

[Economics] Equipment cost

Investment amount (A): 360 million yen
Improvement effect (B): Approx. 120 million yen/year
Investment payback (A/B): Within 3 years

Remarks

[Example sites]	[References]	[Inquiry]
Kawasaki Steel's Mizushima Plant	"Collection of Improvement Cases at Excellent Energy Management Plants," National Committee for the Effective Use of Electricity	NEDO / ECCJ (JIEC)

MI-ME-21

Energy Conservation Directory

[Industry Classification] Many Industries	Energy saving improvement of blowers and pumps	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1992

Outline	The basis of energy saving in blowers and pumps which are used widely and in a large number for production, construction, air conditioning, etc., is to optimize their capacity for each application. Introduced here are typical measures taken for improvement.

[Description]

Structure explanation, Shape, and/or System diagram

1) In the case of a constant flow rate:

① To cut down the outer diameter of the impeller:
When the flow rate is 10-20% in excess of the required rate, the outer diameter of the impeller shall be cut down. If the cut-down rate is small (e.g., 80%), the required shaft power changes approximately proportionally to the 4th power of the outer diameter.

② To change the impeller to the one with a smaller capacity:
When the flow rate is required to be reduced by more than 20%, the modification in the outer diameter becomes too large, and the operation range is narrowed down, resulting in efficiency drop. In such a case, it is better to change it to an impeller with a smaller capacity.

③ To reduce the number of the impeller stages:
When the number of the impeller stages is no more than 2-3, the outer diameter of the impeller shall be cut down. When the number of the stages is more than 5-6, however, some of the impellers shall be removed. When the impeller on the high-pressure side is removed, mainly the pressure drops. When that on the low-pressure side is removed, both the pressure and flow rate drop.

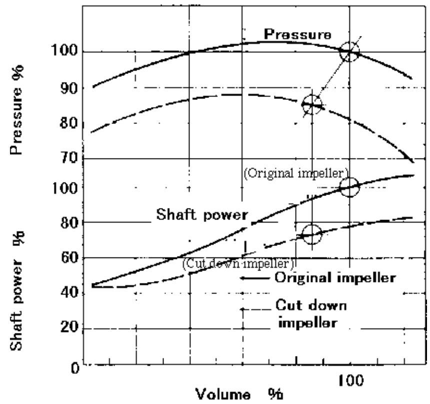


Fig. 1 Example of reducing the outer diameter of the impeller

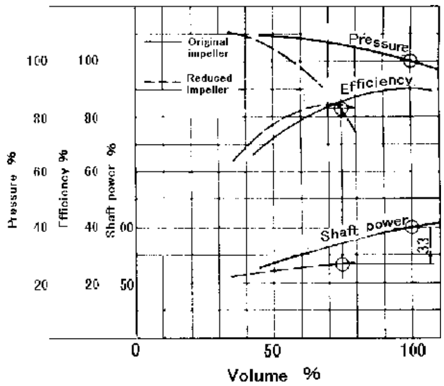


Fig. 2 Example of changing to a smaller-capacity impeller

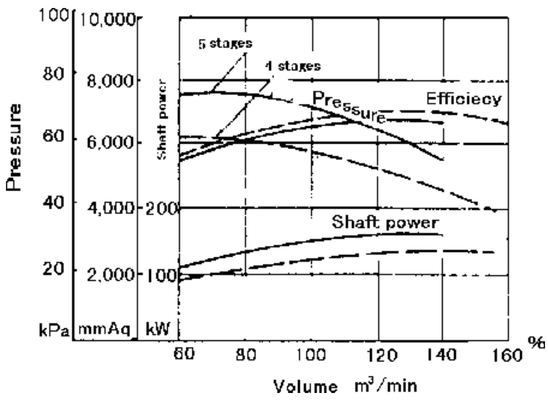


Fig. 3 Example of saving electric power by changing a 5-stage blower to a 4-stage blower

2) In the case of a changing flow rate:

① Damper control

② Suction vane control

③ Control by the number of installed sets

④ Control by variable pitches of moving vanes

⑤ Rotation number control

Energy saving effects

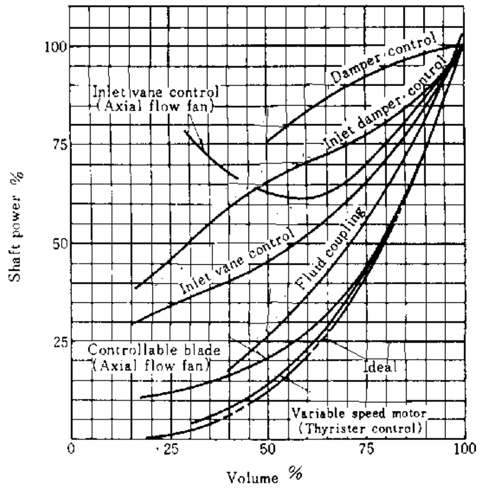


Fig. 4 Shaft power at partial flow rate of blower
(in the case where the resistance is proportional to the second power of the flow rate)

		Inlet damper		Inlet vane control		Fluid coupling		Variable speed motor	
Capacity	%	100	40	100	40	100	40	100	40
Shaft power ratio	–	1.0	0.59	1.0	0.405	1.04	0.18	1.0	0.075
Driver efficiency	–	0.95	0.94	0.95	0.92	0.95	0.82	0.92	0.70
kW Input power ratio	–	1.053	0.628	1.053	0.440	1.095	0.220	1.087	0.107
Motor input power	kW	1243	741	1243	519	1292	259	1283	126
Annual operating hours	h	2430	4570	2430	4570	2430	4570	2430	4570
Annual power consumption	kWh	6.407×10^6		5.392×10^6		4.323×10^6		3.694×10^6	
Power consumption ratio	%	100		84.2		67.5		57.7	
Power saving cost	Ten thousand yen	–		1015		2084		2713	

[Economics] Equipment cost

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

Remarks

[Example sites]

[References]
"Ebara Engeneering Review No. 112 (1980)"

[Inquiry]
NEDO / ECCJ (JIEC)

MI-ME-22

Energy Conservation Directory

[Industry Classification]
Many Industries

[Technology Classification]
Machinery & Equipment

Energy saving through improving efficiency of sludge dehydrator in factory waste water treatment

[Energy Source]
Electricity

[Practical Use]
1980-

Outline

In a clarifier sludge treatment process for factory waste water, the sludge dehydrator usually consumes a large amount of electric power. Introduced here is an example of energy saving by introducing an energy-saving-type sludge dehydrator.

Principle & Mechanism

- There are two methods for dehydrating sludge discharged from factory waste water treatment facilities: the centrifugal separation method and belt-press dehydration method.
- The water content in dehydrated cakes is in general smaller in those made by the belt-press dehydration method. Electric power consumption is also smaller in the belt-press type due to the construction of the apparatus.

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

[Before improvement]

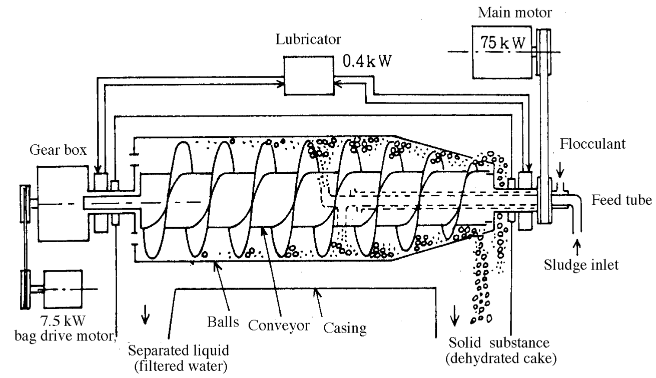
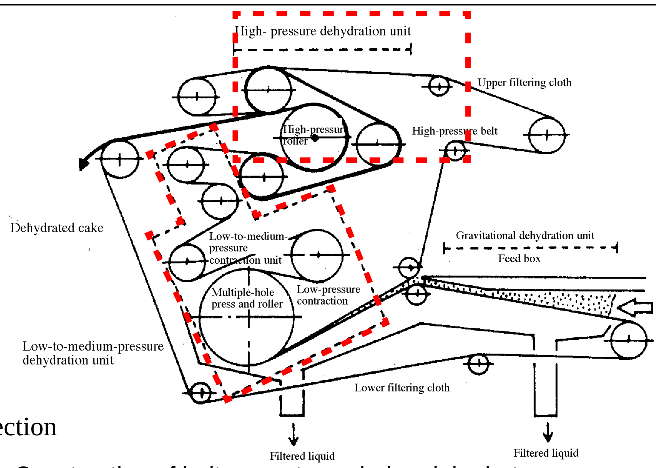


Fig. 1 Construction of centrifugal-separation-type sludge dehydrator

[After improvement]

- By introducing the belt-press dehydrator, the water content of the dehydrated cake was reduced to 72-68%. Accordingly, the consumption of fuel for incineration was reduced.



Improved section

Fig. 2 Construction of belt-press-type sludge dehydrator

Energy saving effects

Table 1 Energy saving effect

		Before improvement	After improvement	Reduction effect
Capacity of facility		413 kW	22 kW	
	Electric power consumption	2,073,600 kWh/y	172,800 kWh/y	1,900,800 kWh/y
	Heavy oil consumption	672 kL/y	360 kL/y	312 kL/y
Reduction in crude oil equivalent				331 kL/y

[Economics] Equipment cost

Investment amount (A): 64 million yen
Improvement effect (B): 44.7 million yen/year
Investment payback (A/B): 1.4 years

Remarks

[Example sites]
Adopted at many factories

[References]
"Collection of Improvement Cases at Excellent Energy Management Plants (1986)," p. 29

[Inquiry]
NEDO / ECCJ (JIEC)

MI-ME-23

Energy Conservation Directory

[Industry Classification] Many Industries	Improvement of flow rate control for reverse osmosis (RO) system for pure water	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1997

Outline

For producing pure water, a large quantity of which is required for cleaning in semiconductor manufacturing and other industrial processes, the reverse-osmosis (RO) membrane system is widely adopted as the degree of integration of IC increases. The improvement introduced here is an example of energy saving in the RO system by incorporating an inverter and return-flow control.

System configuration

[Features of the RO system]
For the RO system, water needs to be supplied under a pressure higher than the osmotic pressure because of the characteristic of the membrane. For this reason, the feed water pump consumes a large amount of electric power.

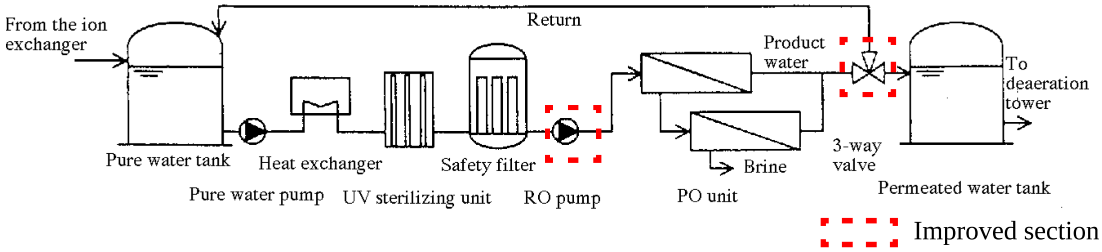


Fig. 1 Flow diagram of the RO and related facilities

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

[Combined control of RO inlet water flow rate by inverter and 3-way valve] (Refer to Fig. 2,3)
Since it is not possible to eliminate the return completely by 3-way valve control, combined control using an inverter and a 3-way valve was adopted, where the following measures are taken in accordance with the water requirement at the inlet of the permeated water tank.

1) The level of the permeated water tank is controlled by the inverter when the water requirement is more than that corresponding to the inverter minimum frequency (30 Hz).
2) The level of the permeated water tank is controlled by the 3-way valve when the water requirement is less than that corresponding to the inverter minimum frequency (fixed at 30 Hz).
3) The 3-way valve is controlled to be set at the minimum opening as a countermeasure against water pooling in the return line of the pure water unit.

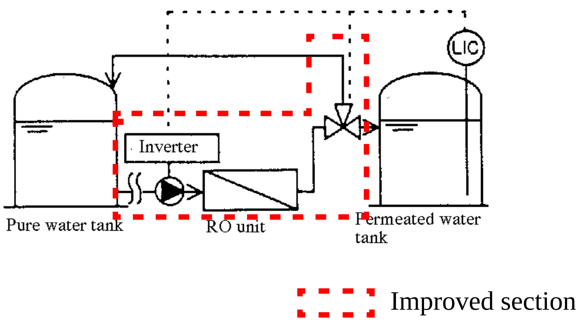


Fig. 2 Control of permeated water tank level
(by inverter and 3-way valve)

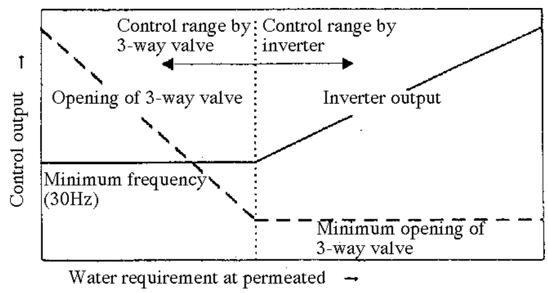


Fig. 3 Image of combined control
by inverter and 3-way valve

Energy saving effects

The energy-saving effect was that specific consumption of heavy oil A was reduced by 26 L/t in comparison with the original condition before improvement. This is a reduction of 210 kL/year in crude oil equivalent.

[Economics] Equipment cost

Investment amount (A): 20 million yen
Improvement effect (B): 9.5 million yen/year
Investment payback (A/B): 2.1 years

Remarks

The technology is applicable not only to the production of semiconductors, but also to many other factories where pure water is demanded for production. Furthermore, it is applicable to the ultra-low-pressure RO membrane that has become commercially available in recent years.

[Example sites]	[References]	[Inquiry]
Tousihba's Oita plant	" Collection of Energy Conservation Cases 1998," p. 79	NEDO / ECCJ (JIEC)

MI-ME-24	Energy Conservation Directory	
[Industry Classification] Many Industries [Technology Classification] Machinery & Equipment	Improvement of a motor for a plastic extruder	[Energy Source] Electricity [Practical Use] 1989

Outline

The inverter control (hereafter called VVVF) drive system replaces a conventional VS coupling (vortex spiral) motor, which is characterized by a large energy loss, as the main motor for the PE (polyethyelene) extruder, At the same time, the previous two-extruder operation has been changed to a large one extruder operation, thereby improving comprehensive efficiency of the system and contributing to the improvement of electric

Principle & Mechanism

[Characteristics of various rotation control systems]
(Refer to Fig. 1.)
- Speed - torque characteristics of VS coupling can be easily controlled by adjusting exciting current and is deprived of any friction area,, however as same as the fluid coupling, considerable power loss inevitably occurs in proportion to sliding. The total efficiency becomes relatively low as a result.

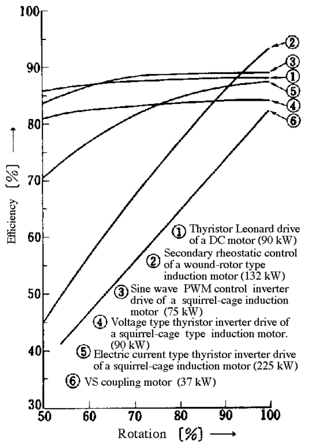
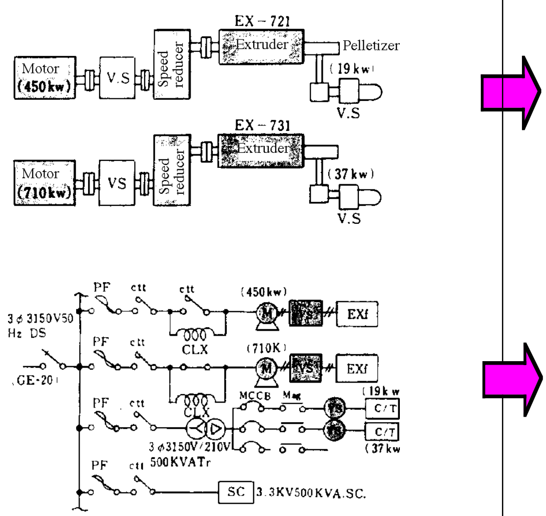


Fig. 1 Comparison of various rotation control systems

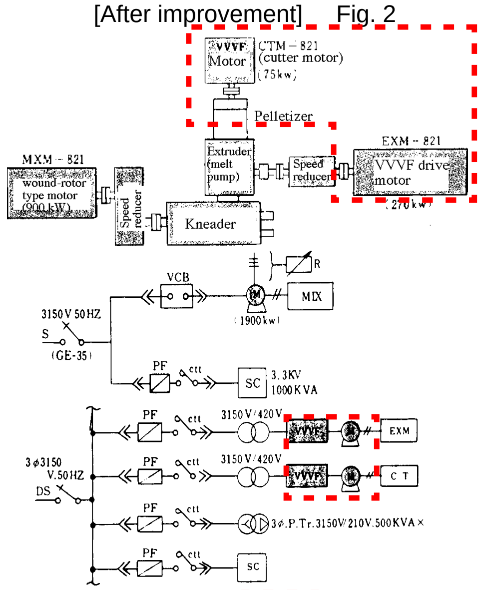
[Description] Structure explanation, Shape, and/or System diagram

(1)Previously, 2 sets of medium type extruders driven by the VS coupling motor were used for the production, but in the new system, a combined set of a large mixer and amelt pump is used.
(2)For the main driving motor, a coil-winding type is adopted, and VVVF drive type motor also has been adopted for extruder. (Refer to Fig. 2 and 3.)

[Before improvement] Fig. 1



[After improvement] Fig. 2



Improved section

Energy saving effects

Table 1 Effect of energy saving of the extruder after improvement

	Energy effect	Remarks
Reduction of electric power consumption	3,900,000 kWh/y	(Operation time: 7,920 h/y)
Reduction converted into crude oil	948 kL/y	

[Economics] Equipment cost

Investment amount (A): 100 million yen
Improvement effect by (B): 43 million yen/year
Investment payback (A/B) : 2.3 years

Remarks

The technology is applicable not only to the production of semiconductors, but also to many other factories where pure water is demanded for production. Furthermore, it is applicable to the ultra-low-pressure RO membrane that has become commercially available in recent years.

[Example sites]	[References]	[Inquiry]
Many similar cases adopted at sites.	"Collection of Improvement Cases at Excellent Energy Management Plants (1990)"	NEDO / ECCJ (JIEC)

MI-ME-25 | Energy Conservation Directory

[Industry Classification]	High efficiency inverter driven screw compressor	[Energy Source]
Many Industries		Electricity
[Technology Classification]		[Practical Use]
Machinery & Equipment		1993 -

Outline

In this inverter screw compressor, the input power is decreased almost in proportion to the operating air ratio. Its energy saving characteristic is 20-30% better than the conventional one over the whole operation range. When used in a case where the required air quantity widely fluctuates or used as a backup system in parallel operation, its energy saving characteristic is pronounced.

Principle & Mechanism

[Structure of control system of inverter screw compressor]
By the inverter with a built-in P.I.D. (Proportional, Integral & Differential Control) circuit board, the rotation of the motor to drive the compressor is controlled so that the delivery pressure is kept constant. (Refer to Fig. 1)

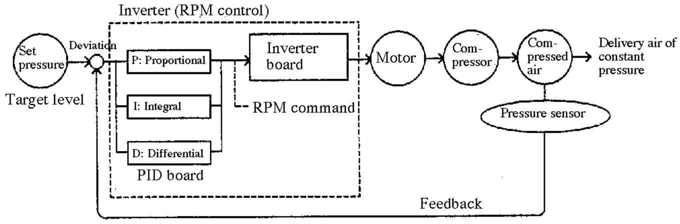


Fig. 1 Control structure of inverter screw compressor

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

[Energy saving characteristic]

1) A compressed air of a constant pressure is always supplied by RPM control by the inverter. In consideration of the inverter's characteristic under low RPM, the inverter control is applied when the operating air ratio is at 30-100%. When it is below 30%, RPM is kept constant and the volume is controlled by the suction control valve.
2) Constant-pressure control range
Within the RPM control range where the operating air ratio is 30-100%, 6 levels of pressure setting are possible in an increment of 0.5 kg/cm^{2}G from 6.0 to 8.5 kg/cm^{2}G. Highly accurate constant pressure control within Å}0.3 kg/cm^2 G is possible. (Refer to Fig. 2)
3) Energy saving characteristics (Refer to Fig. 3)

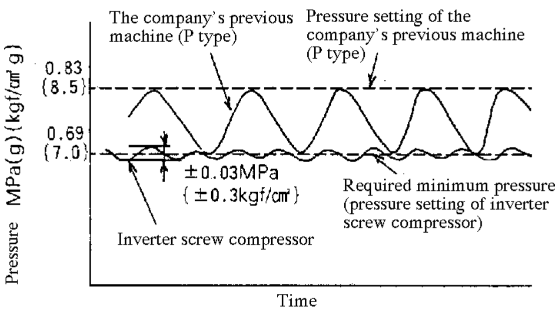


Fig. 2 Constant-pressure control characteristic

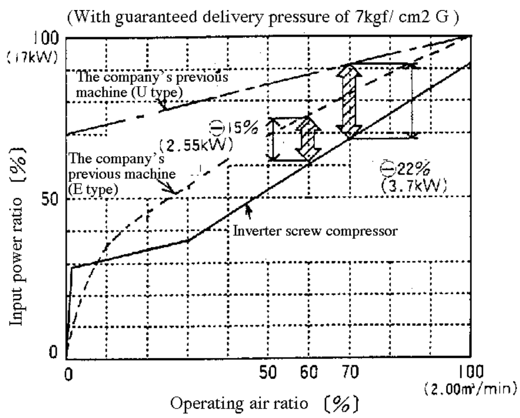


Fig. 3 Energy saving characteristic of 15 kW machine

Energy saving effects

Energy saving of approximately 15-22% over the previous machines was attained.

[Economics] Equipment cost

Investment amount (A): 50 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

[Example sites]	[References]	[Inquiry]
Adopted at many sites.	"Energy Saving Journal (Vol. 47, No. 10, 1995)," p. 52-55	NEDO / ECCJ (JIEC)

MI-ME-26

Energy Conservation Directory

[Industry Classification]
Many Industries

[Technology Classification]
Machinery & Equipment

Air volume control of forced draft fan for boiler by microcomputer

[Energy Source]
Electricity

[Practical Use]
1980s -

Outline

Introduced here is a case of energy saving by improving air-volume control of a forced draft fan for a general-purpose small-to-medium boiler by employing microcomputer cascade control.

[Description]

Structure explanation, Shape, and/or System diagram

[Improvement of control method]
1) Cascade control by a microcomputer-controlled regulator was adopted.
2) A hydraulic-clutch speed reducer was installed between the fan and the motor, and RPM of the fan is controlled by air volume control signals.
3) For optimizing the air volume when the boiler has light load, vane control at the fan inlet was adopted as well.

[Before improvement]

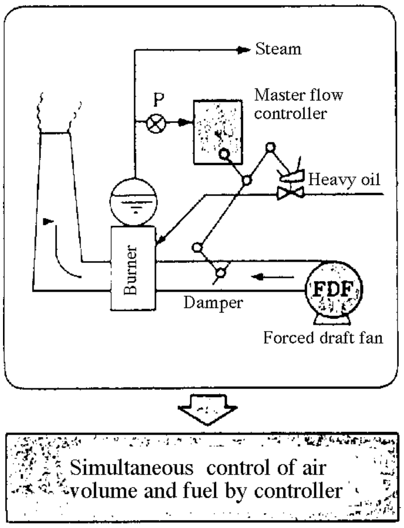
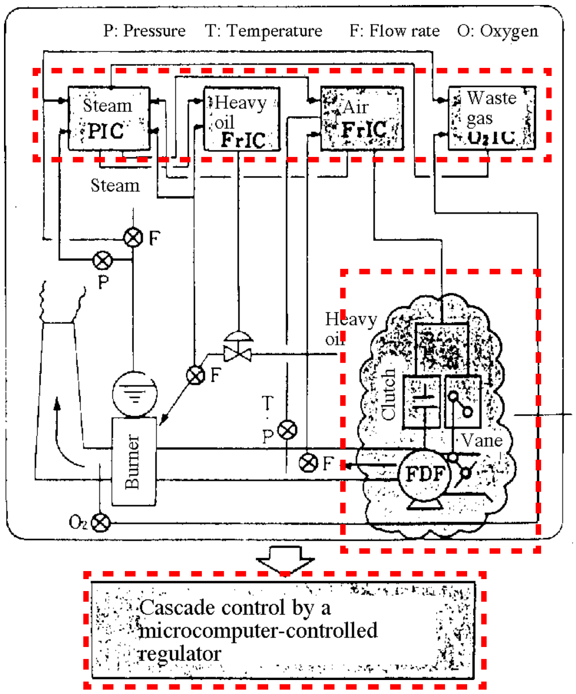


Fig. 1 System flow before improvement

[After improvement]



Improved section

Fig. 2 System flow after improvement

Energy saving effects

Table 1 Energy saving effect by air volume control of forced draft fan for boiler

	Before improvement	After improvement	Effect
Annual average power consumption	2,600 kWh/day	600 kWh/day	2,000 kWh/day
Reduction in crude oil equivalant			130 kL/y

[Economics] Equipment cost

Investment Amount (A): 7 million yen
Improvement effect (B): 9.1 million yen/year
Investment payback (A/B): 0.8 year

Remarks

[Example sites]
There are many similar improvement cases.

[References]
"Collection of Improvement Cases at Excellent Energy Management Plants (1988)"

[Inquiry]
NEDO / ECCJ (JIEC)

MI-ME-27

Energy Conservation Directory

[Industry Classification]
Many Industries

[Technology Classification]
Machinery & Equipment

PAM motor with variable number of poles

[Energy Source]
Electricity

[Practical Use]
1983-

Outline

An electric motor is a highly efficient driving machine by itself compared with internal combustion engines, and widely used as main driving machines in various factories. In the case introduced here, electricity is saved by introducing a PAM-type motor with the variable number of poles, a modern energy-saving technology for electric motors.

Principle & Mechanism

1) This technology is concerned with a single-winding motor with the variable number of poles, which can change the number of poles by changing the external connections based on PAM (Pole Amplitude Modulation) theory.
2) Fig. 1 shows the diagram which explains the principle for changing the number of poles between 8 and 10. Wen the 2-pole modulation is applied to the 8-pole winding and the poles of half of the entire coils are reversed, 10-pole components are produced.

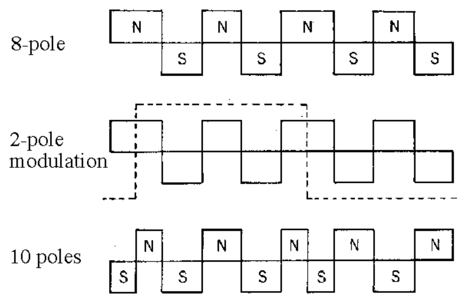


Fig. 1 Principle of PAM-type motor with variable number of poles

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

[Characteristics of PAM motor]
1) The PAM motor permits free selection of the number of both poles within the range of 2n (n = 1, 2, 3,—). Different from the conventional double-winding motor with the variable number of poles, all the windings are used when operated with any number of poles, eliminating the loss.
2) When the "2-step speed change combined with damper control" method using a PAM motor is adopted for a draft fan, which is a fluid machine, electric power consumption generally exhibits the characteristics as shown in Fig. 2, in which the power consumption characteristics of "motor with fixed number of poles combined with WWF" method is indicated as well.
3) In the case of the PAM motor system, energy saving effect is somewhat smaller than the VVVF system because its speed change is 2 steps. But its advantage is that its installation cost is low due to the simple system configuration.

[Example]
By adopting a PAM motor (three-phase squirrel-cage induction motor)of 1,450/750 kW with 8/10 poles for the gas recirculation fan for a power generator boiler, electric power consumption was saved by 35 %.

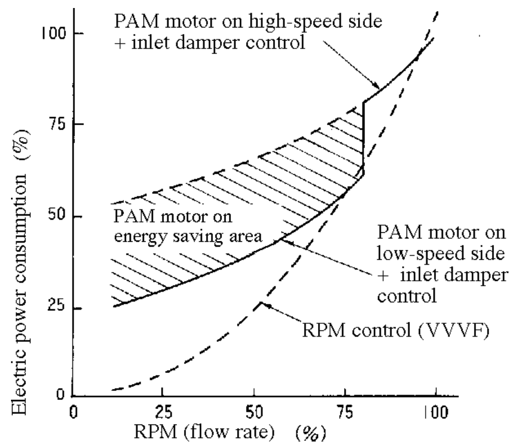


Fig. 1 Electric power consumption characteristics of PAW motor

Energy saving effects

Table 1 Energy saving effect of PAM motor

	Before improvement	After improvement	Reduction effect
Reduction in power consumption	1,450 / 750 kWh/h	725 / 375 kWh/h	725 / 375 kWh/h
Reduction in crude oil equivalent			1,069 kL/y

[Economics] Equipment cost

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

Remarks

[Example sites]
Similar technology adopted at many sites

[References]
"Energy Saving Journal (Vol. 47, No. 10, 1995)," p. 52-55

[Inquiry]
NEDO / ECCJ (JIEC)

MI-ME-28

Energy Conservation Directory

[Industry Classification] Many Industries

[Technology Classification] Machinery & Equipment

High efficiency illumination system with constant current electric power transfer method

[Energy Source] Electricity

[Practical Use] Around 1992 -

Outline

Along with the trend toward more-energy-saving design and higher functionality in various architectural equipment, reduction in investment and operating costs for illumination is also strongly called for. This high-efficiency illumination system was developed and put to practical use aiming for not only the high efficiency of illumination elements themselves but also the overall efficiency of the illumination system as a whole including its maintenance.

Principle & Mechanism

[Constant-current electric power transfer system]
(Refer to Fig. 1)
Using an inverter as a constant-current power source, a high-frequency constant current is run through the loop cable (A). The cable passes through a current transformer (CT) made of a ferrite core. Magnetic force is generated in the CT by the high-frequency constant current, and converted into an electric current by the secondary winding around the CT. The electric current thus generated flows through the electric wire (B) of the lamp circuit, lighting the lamp.

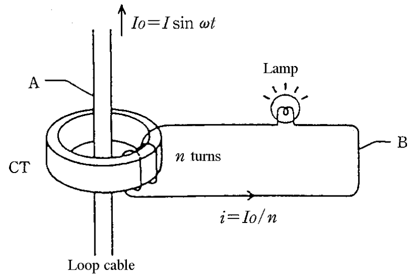


Fig. 1 Working principle of constant-current electric power transfer system

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

[System construction] (Refer to Fig. 2)
This system consists of the following elements.
1) Inverter, 2) Loop cable, 3) Dimmer terminal, 4) CT (current transformer), 5) Illuminance sensor, 6) Remote-control sensor, 7) Fluorescent lump.

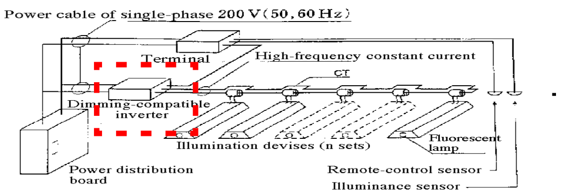


Fig. 2 System diagram of constant-current electric power transfer system

Improved section

[Lower electric power consumption by high-frequencylighting system]
The high-frequency program lighting system adopting inverters realized lower electric power consumption compared with that of the conventional high-frequency lighting system, even when the same fluorescent lamps are used.

[Multi-functional dimming system] (Refer to Fig. 3)
This system lights more than one fluorescent lamps at the same time using one inverter.
By transmitting dimming signals from the dimming terminal to the inverters, lighting in a wide area is dimmed at once, which contributes to the reduction of power consumption. (A maximum number of inverters controlled by one dimming terminal is 16.) The dimming terminal has two functions, daylight-utilizing control and aptitude-maintaining control, in addition to manual-setting control.

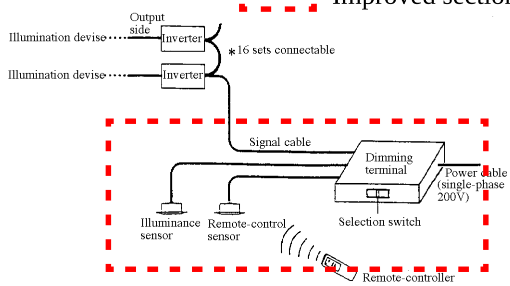


Fig. 3 Automatic dimming system

Energy saving effects

Table 1 Comparison of energy saving between conventional system and high-efficiency illumination system

	Conventional type		High-efficiency illumination system
	Without dimming system	With dimming system	
Electric power consumption per year	100	78	78
Hardware cost	100	137	98
Installation cost	100	119	71

Note: Based on conventional type without dimming as 100.

[Economics] Equipment cost

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

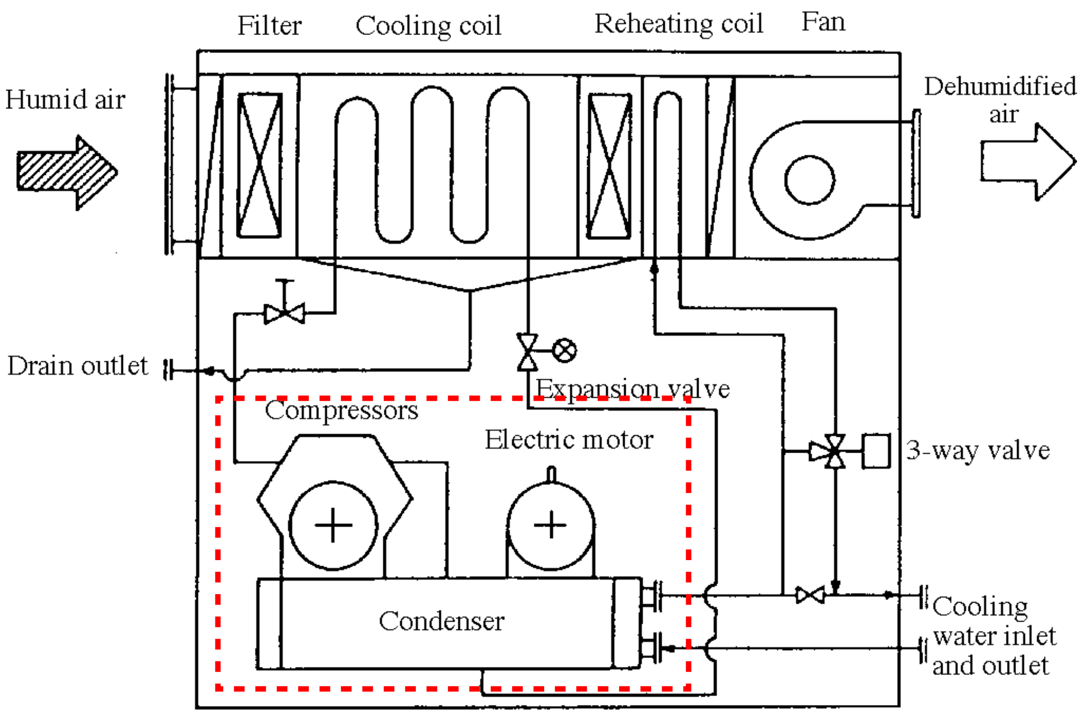
Remarks

[Example sites]
Adopted at some sites.

[References]
"Architectural Equipment Engineers Journal" Oct. 1997

[Inquiry]
NEDO / ECCJ (JIEC)

MI-ME-29	Energy Conservation Directory	
[Industry Classification] Many Industries [Technology Classification] Machinery & Equipment	Refrigerating dehumidifier	[Energy Source] Electricity, Fuel [Practical Use] 1970s -

Outline	Humidity must be maintained at a constant level when production requires environment of constant temperature and humidity. For this reason, a dehumidifier is often required in localities of high humidity. This equipment employs the cold from the freezer to condense moisture and remove it from the air as drain, the resultant dehumidified cold air then being reheated by the hot water from the outlet of the refrigerator system condenser cooling water.
Principle & Mechanism	(1)Air is cooled using the cold from the refrigerator, and absolute humidity reduced by the characteristics of the humid air curve. (2)As the air is cool after dehumidification, it is heated to a temperature close to that prevailing prior to dehumidification by the hot waste water from the condenser section of the refrigerator system where the heat of compression is removed.
[Description] Structure explanation, Shape, and/or System diagram	The general layout and flow of the dehumidification process is shown in the following diagram  Fig.1 The general layout of the Refrigerating dehumidifier
Energy saving effects	(1)Provides saving electric power of 30~40% in comparison with chemical dehumidification methods. (2)Air temperature can be adjusted. This is a system which effectively utilizes the heating and cooling characteristics of the refrigerator system. (3)Much greater continuity of operation in comparison with systems using dehumidifying agents (regeneration of dehumidifying agents not required). (4)The unit is compact by the use of a finned heat-transfer pipe in the cooling section.
[Economics] Equipment cost	Investment amount (A): million yen Improvement effect (B): million yen/year Investment payback (A/B): years
Remarks	

[Example sites]	[References]	[Inquiry]
Adopted at many sites.	"Energy Conservation Equipment Directory," P567, the Energy Conservation Center, Japan	NEDO / ECCJ (JIEC)

MI-ME-30

Energy Conservation Directory

[Industry Classification] Many Industries [Technology Classification] Production Equipment	Hot-blast-generating cupola	[Energy Source] Coke [Practical Use] around 1990

Outline

A cupola melts pig iron continuously by using coke as fuel. This equipment generates hot air blast for combustion in order to enhance the melting efficiency.

Principle & Mechanism

(1)The conventional cupola uses ambient temperature air for furnace blowing. This generator, however, pre-heats the air utilizing the waste heat of cupola combustion exhaust gas.
(2)The cupola exhaust gas is blown into the hot blast generator via the automatic dust removing device.
(3)The air is usually heated from the ambient temperature to 200 - 300˚C. The temperature, however, can occasionally reaches around 400˚C.

[Description]

Structure explanation, Shapes, and/or System diagram

[Before improvement]
The cupola before improvement is illustrated below.

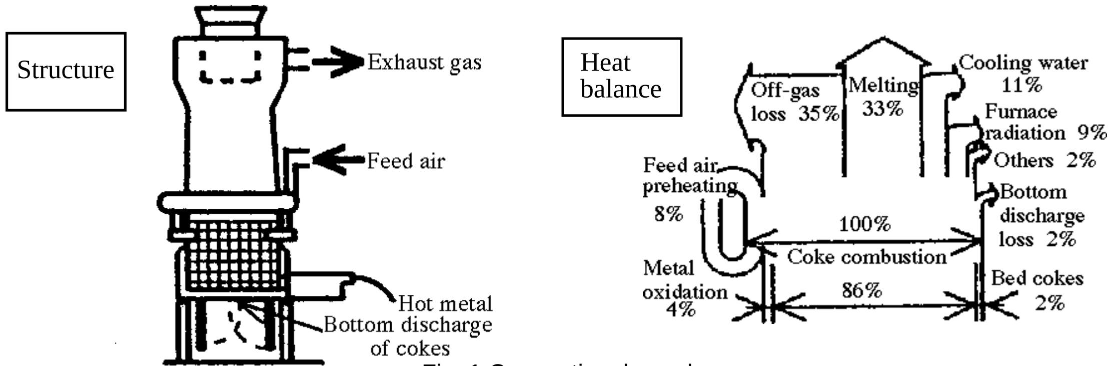


Fig. 1 Conventional cupola

[After improvement]
The hot-blast-generating cupola is illustrated below.

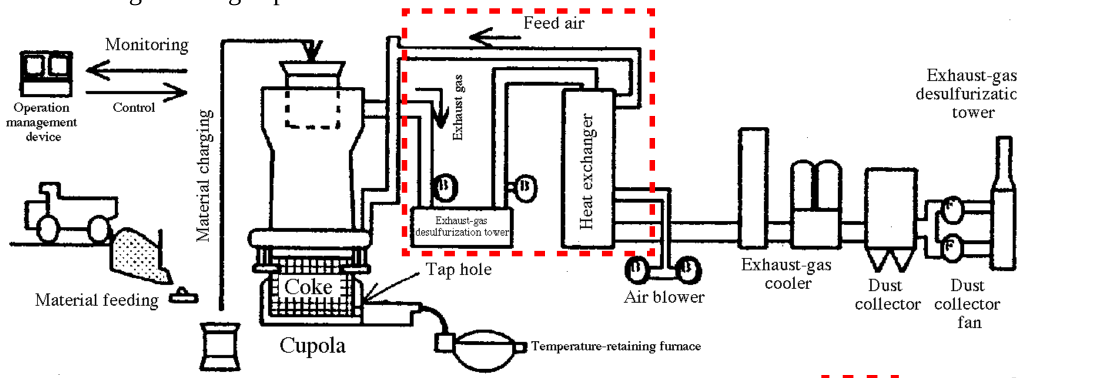


Fig. 2 Hot-blast-generating cupola

Improved section

Energy saving effects

Table 1 Energy-saving effect by improvement

	Conventional cupola	Hot-blast-generating cupola
Energy efficiency	38 %	46 %
Specific energy consumption in crude oil equivalent	0.09 kL/t	0.07 kL/t
Reduction of energy consumption from conventional cupola		225,500 thousand yen / year

[Economics] Equipment cost

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

Remarks

[Example sites]	[References]	[Inquiry]
Toyota Motor's Meichi plant	Collection of presentations at the 18th National Conference for Promoting Energy Conservation	NEDO / ECCJ (JIEC)

MI-ME-31	Energy Conservation Directory	
[Industry Classification] Many Industries [Technology Classification] Machinery & Equipment	Cogeneration system directly utilizing waste heat at drying oven	[Energy Source] Electricity [Practical Use] 1995

Outline

A cogeneration system was introduced under a condition that energy demand in this factory is mainly for electric power and the operation of the line is generally stopped over weekends. The characteristics of this system is that a large gas engine (3,400 kW) which has a higher power generation efficiency than a gas turbine is adopted, and its waste gas is directly used at the existing drying oven.

Principle & Mechanism

[Power output in standard cogeneration systems]
- Diesel engine system: 37%
- Gas engine system: 33%
- Gas turbine system: 20%

[Description]

Structure explanation, Shape, and/or System diagram

1) A lean-combustion-gas engine is used, which generates 3,400 kW of electric power. It is connected with the utility grid and covers approximately 40 % of the peak load and 50% of the power demand of the factory.
2) The engine exhaust gas of 400˚C is directly introduced to an existing direct-gas-fired hot-air drying oven and utilized for drying.
3) The hot water of 90˚C recovered from the engine cooling water is passed through the hot-water/air heat exchanger and utilized for preheating the combustion air for the hot-air drying oven.

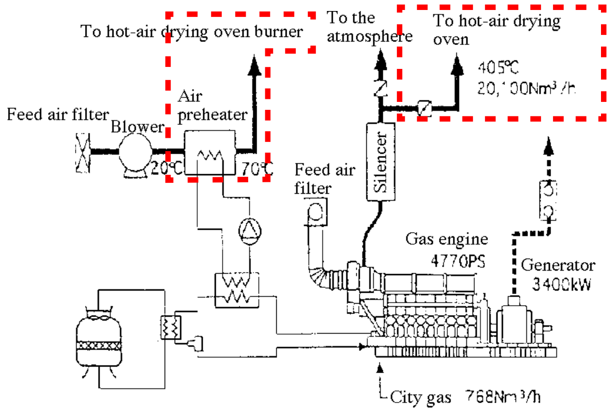


Fig. 1 Flow diagram on engine side

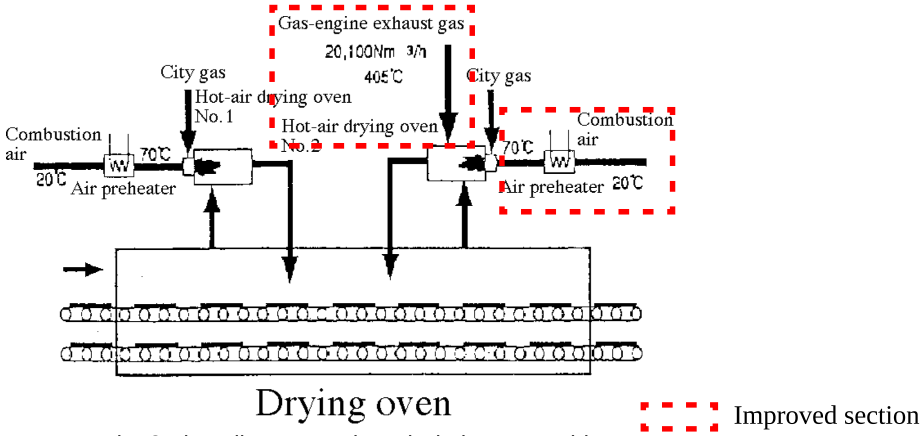


Fig. 2 Flow diagram on hot-air drying oven side

Energy saving effects

- Total efficiency 67.1 %
- Fuel gas for hot-air drying oven equal to 25.8 % of the total heat input was saved.

Table 1 Effect of waste-heat recovery from power-generating gas engine

	Waste-heat recovery effect	Remark
Recovered waste heat in natural gas equivalent	198 Nm³ /h	
Reduction in crude oil equivalent *	1,469 kL/y	

Note *: Operating time 7,000 h/y

[Economics] Equipment cost

Investment amount (A): 60 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

[Example sites]	[References]	[Inquiry]
Nitto spinning Co., Chiba plant	“Energy Saving Journal (Vol. 47, No. 11, 1995)”	NEDO / ECCJ (JIEC)

MI-OM-1	Energy Conservation Directory	
[Industry Classification] Many Industries	Improvement for full recovery of waste heat from steam drain	[Energy Source] Fuel
[Technology Classification] Operation & Management		[Practical Use] 1995 -

Outline

Previously, steam drain from the power-generating boiler was recovered into an elevated heat-storage water tank, but it overflowed from the tank. The technology introduced here is an example of energy saving by installing a plate-type heat exchanger, which is used to fully recover waste heat, and furthermore, by reusing cooled drain as boiler feed water.

Before Improvement

[Before improvement]

The flow of the drain recovery system of the power-generating boiler is shown below.

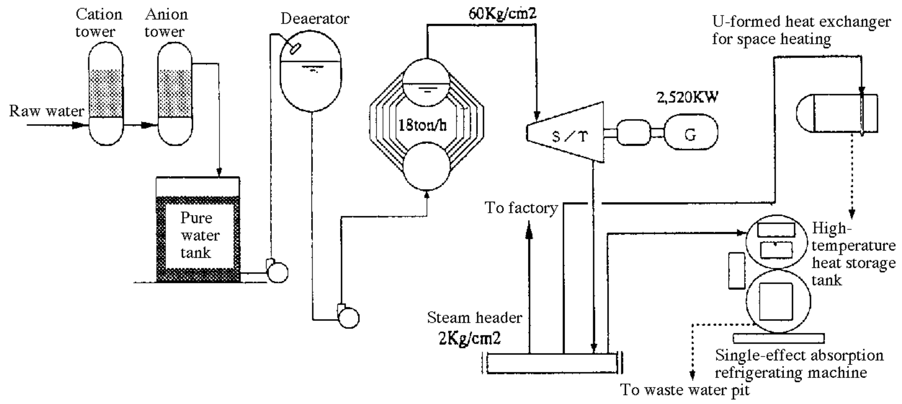


Fig. 1 Flow chart of drain recovery system before improvement

[Description of Improvement]

Structure explanation, Shape, and/or System diagram

[After improvement]

1) In order to fully recover waste heat and use the boiler feed water effectively, a plate-type heat exchanger of a high heat exchange efficiency was installed, and the steam drain is now used for preheating the deaerator feed water.
2) Furthermore, the cooled drain is returned to the raw water tank and reused in the boiler.
3) The energy thus recovered amounts to 578,000 kcal/h.

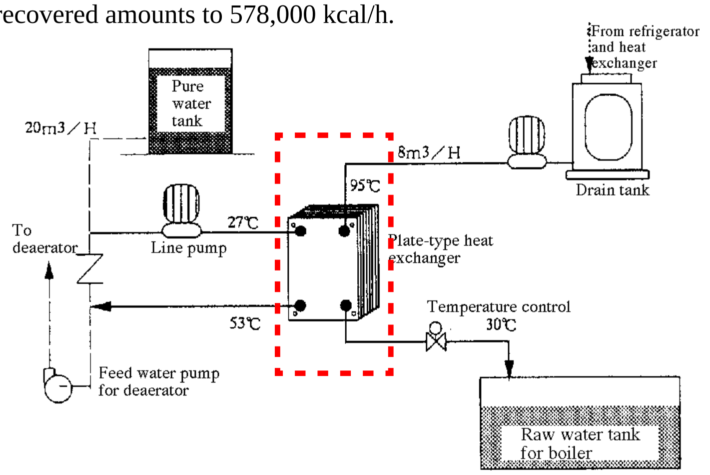


Fig. 2 Flow chart of steam drain recovery system after improvement   Improved section

Energy saving effects

The energy saving effect is 390 kL/year in crude oil equivalent.

[Economics] Equipment cost

Investment amount (A): 16 million yen
Improvement effect (B): 8.5 million yen/year
Investment payback (A/B): 1.9 years

Remarks

Recovery of steam drain is a fundamental requisite for energy saving. The improvement introduced here is a typical example that can be applied to every factory in any industrial field.

[Example sites]	[References]	[Inquiry]
Adopted at Toyota Motor's Kinuura plant, and some other sites.	"Collection of Energy Conservation Cases 1998," p. 763	NEDO / ECCJ (JIEC)

MI-OM-2

Energy Conservation Directory

[Industry Classification] Many Industries	Multistage recovery of flash steam	[Energy Source] Electricity
[Technology Classification] Operation & Management		[Practical Use] 1992

Outline

Recovery of flash steam (regenerated steam) is being generally carried out. In the case introduced here, the recovery was further enhanced by using a multistage cascade system, much contributing to energy saving.

Principle & Mechanism

The quantity of flash steam is given by the following formula.

$$W_F = \frac{h_1' - h_2'}{r} \times W_c$$

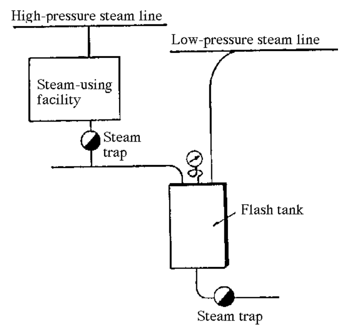
W_F : Quantity of flash steam (kg/h)

W_c : Quantity of drain before flash (kg/h)

h_1' : Specific enthalpy of saturated water at a steam pressure before flash (kcal/kg)

h_2' : Specific enthalpy of saturated water at a steam pressure after flash (kcal/kg)

r : Latent heat of evaporation of saturated water at a steam pressure after flash (kcal/kg)



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

[Before improvement]

1) Previously, in boiler No.1, the drain of the steam separator was recovered as regenerated steam by the flash tanks of 30kg/cm^2 and 1.5 kg/cm^2.
2) While in boiler No.2, the blow water was recovered as steam by the flash tank of 3 kg/cm^2.

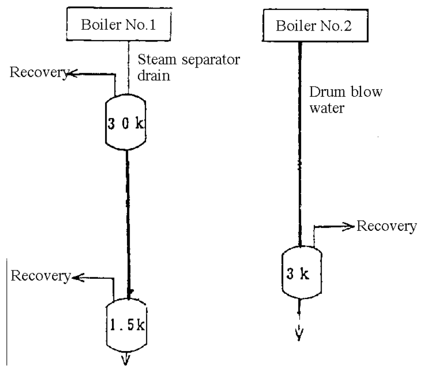


Fig. 1 Flow diagram around flash tanks before improvement

[After improvement]

1) As shown in Fig. 2, a flash tank of 13 kg/cm^2 and piping connecting boiler No.1 and boiler No.2 was newly installed.
2) By this improvement, flash stream of 3 kg/cm^2 and 1.5 kg/cm^2 was reduced and electricity generated by the steam turbine was increased.

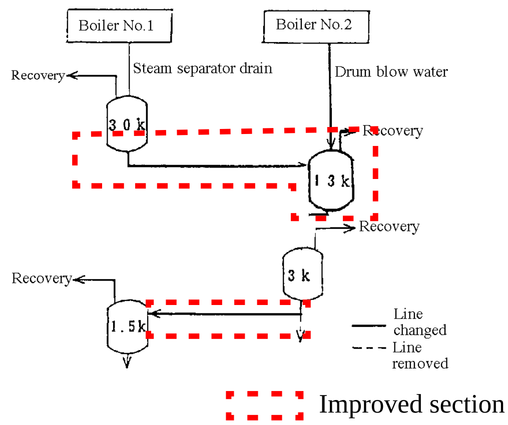


Fig. 2 Flow diagram around flash tanks after improvement

Energy saving effects

Table 1 Energy saving effect by flash steam recovery

	Improvement effect	Annual effect
Recovered steam	50 kg/h	400 t/y
Increase in turbine power generation	51 kWh/h	408,000 kWh
Reduction in crude oil equivalent		132 kL/y

[Economics] Equipment cost

Investment amount (A): 2 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

[Example sites]	[References]	[Inquiry]
Many similar site cases have been reported	" Collection of Energy Conservation Cases 1991," p. 859	NEDO / ECCJ (JIEC)

MI-OM-3 Energy Conservation Directory

[Industry Classification]	Improvement of drain recovery by plate type heat exchanger	[Energy Source]
Many Industries		Fuel
[Technology Classification]		[Practical Use]
Operation & Management		1996

Outline

When recovered steam drain is treated by a pure water unit for reusing it as boiler feed water, it is necessary to lower the drain temperature to 35˚C because the pure water unit can endure the temperature only up to 40˚C. Introduced here is an example of energy saving by adopting a plate-type heat exchanger of a good thermal efficiency, thereby recovering the heat, lowering the drain temperature, and feeding it as feed water to the pure water unit.

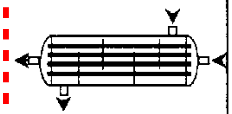
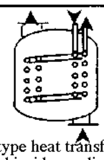
Before Improvement

Drain recovered from the power generation boiler had to be treated by a pure water unit in order to satisfy the required water quality, and it was not directly utilized. The drain temperature was 80˚C,but the current pure water unit can accept the drain only when its temperature is below 35˚C, and previously the waste heat was not recovered.

[Description of Improvement]

Structure explanation, Shape, and/or System diagram

[Selection of heat exchanger]
As shown in Table 1, three types of heat exchangers, plate type, multi-tube type, and single-tube type, were examined for selecting the most suitable one for this purpose. The plate-type heat exchanger turned out to be most suitable.

	Plate-type heat exchanger	Multi-tube-type heat exchanger	Single-tube-type heat exchanger
Outline	 A number of plates are put together, through which high-temperature fluid and low-temperature fluid are passed through alternately.	 A number of heat transfer tubes are set inside a cylindrical shell.	 A coil-type heat transfer tube is provided inside a cylindrical shell
Cost	○	×	×
Space	○	△	×
Problems	Not suitable for high temperature or high pressure use	Complicated structure	Complicated structure
Evaluation	○	×	×

[Flow diagram and effect after installing a heat exchanger] (Refer to Figs. 1 and 2)

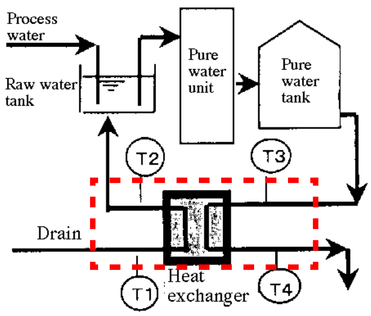


Fig. 1 Flow diagram after improvement

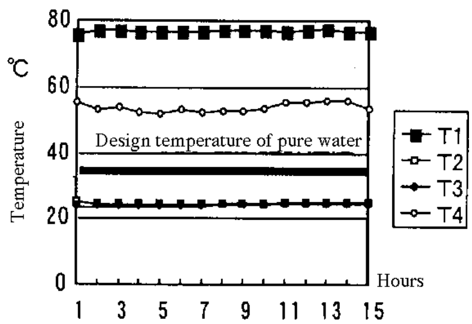


Fig. 2 Result of temperature measurement

Improved section

Energy saving effects

- Drain recovered: 45,000 t/year
- Reduction in crude oil equivalent: 318 kL/year

[Economics] Equipment cost

Investment amount (A): 5 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

Drain recovery is a fundamental measure for energy saving. This is a typical technology applicable to every factory in any industrial field.

[Example sites]	[References]	[Inquiry]
Adopted at Toyota Motor's Kinuura plant, and some other sites.	"Collection of Energy Conservation Cases 1998," p. 763	NEDO / ECCJ (JIEC)

MI-OM-4

Energy Conservation Directory

[Industry Classification]
Many Industries

[Technology Classification]
Operation & Management

Improvement of thermal efficiency of dryer for refractory brick

[Energy Source]
Electricity

[Practical Use]
1980

Outline

Introduced here is a case where a large energy saving was achieved at a dryer for refractory materials by strengthening its heat-insulation characteristic, and improving the operation method and heat balance through recycling the exhaust gas, thereby reducing specific fuel consumption to one-third.

Principle & Mechanism

1. Improvement of operation method
 1) Shortening of operation time : Shortened by 11-17%.
 2) The loading capacity per carriage was increased by 11% to 1.6 ton/carriage.
2. Heat insulation was strengthened by applying castable refractory to the ceiling, side wall, door, and underside of the carriage.
3. Heat balance was improved by recycling the exhaust gas as shown below.

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

[Before improvement]

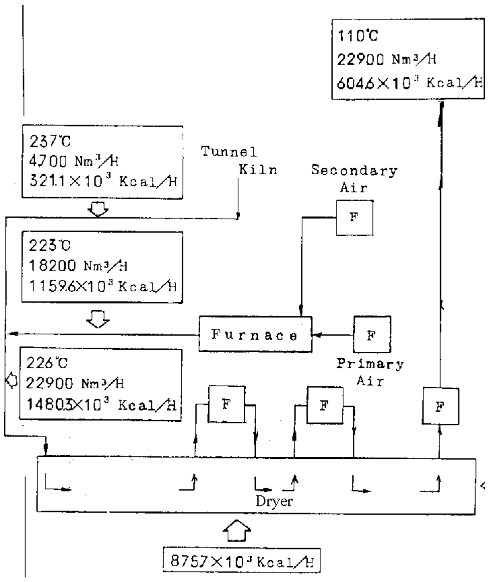
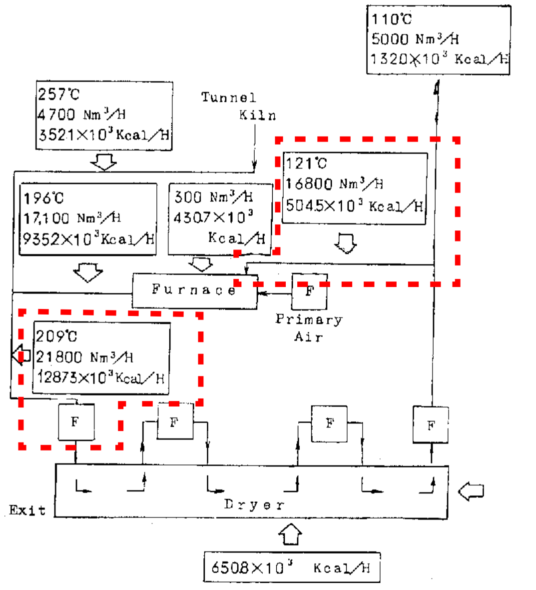


Fig. 1 Flow diagram of finishing process before improvement

[After improvement]



Improved section

Fig. 2 Flow diagram of finishing process after improvement

Energy saving effects

Table 1 Increase of productivity and effect of reduction of specific power consumption

	Before improvement	After improvement	Effect
Dried product quantity	36,000 t/year	40,800 t/year	Increase by 13%
Specific fuel consumption	33.6 L/t	11.0 L/t	Reduced by 22.6 L/t
Fuel consumption	1,209. 6 kL/year	449.3 kL/year	Reduced by 760.3 kL/year
Reduction in crude oil equivalent			Reduced by 806 kL/year

[Economics] Equipment cost

Investment amount (A): 30 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

[Example sites]

[References]

[Inquiry]
NEDO / ECCJ (JIEC)

MI-OM-5

Energy Conservation Directory

[Industry Classification] Many Industries	Reduction of coke ratio in cupola	[Energy Source] Fuel
[Technology Classification] Operation & Management		[Practical Use] 1997

Outline

Energy was saved in the melting process of motorbike and automobile parts in a cupola by improving combustion efficiency, thereby reducing coke ratio.

Before Improvement

[Before improvement]

1) The packing volume efficiency of the furnace was not good because there were much return materials.
2) Frequent hanging phenomenon in the furnace caused the useless operation where only coke was burning.

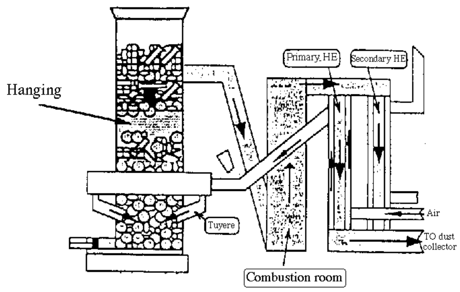


Fig. 1 Conceptual diagram of melting cupola before improvement

[Description of Improvement]

Structure explanation, Shape, and/or System diagram

[After improvement]

1) The order of charging metal materials into the furnace was improved. (Refer to Fig. 2)
   The coke ratio is reduced from 16.3% to 16.1%.

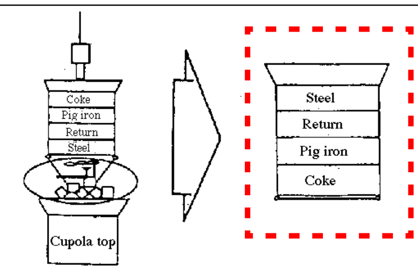


Fig. 2 Improved order of charging metal materials into furnace

2) A crusher was introduced, and the size of return material was changed to avoid the hanging. (Refer to Fig.3)
   The cokes ratio is reduced from 16.6% to 15.5%.

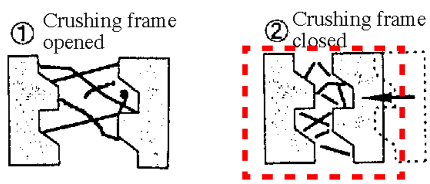
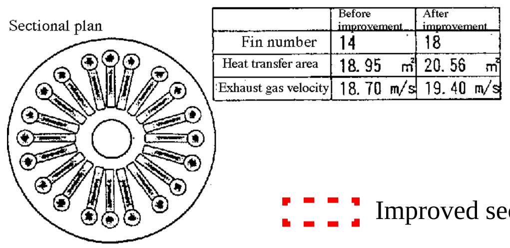


Fig. 3 Decrease of bulk density by crusher

3) The heat-exchange efficiency was improved. (Refer to Fig. 4)
   The hot air temperature was increased from 400˚C to 490˚C. The coke ratio is decreased by 0.4%.



Improved section

Fig. 4 Increase of number of fins of heat exchanger

Energy saving effects

Table 1 Energy saving effect for one set of cupola

	Before improvement	After improvement	Effect
Coke ratio	16.3 %	15.1 %	Improved by 1.2% (7%)
Reduction in crude oil equivalent			135 kL/y

[Economics] Equipment cost

Investment amount (A): 20 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

[Example sites]	[References]	[Inquiry]
Adopted at Honda motor's Suzuka Plant, and some other sites.	"Collection of Energy Conservation Cases 1998," p. 804	NEDO / ECCJ (JIEC)

MI-OM-6

Energy Conservation Directory

[Industry Classification]
Many Industries

[Technology Classification]
Operation & Management

Improvement of pressure control method for in-house power generation boiler

[Energy Source]
Electricity

[Practical Use]
1992

Outline

At this in-house power generation boiler, the outlet pressure was set as the pressure control point. Therefore, the turbine inlet pressure was affected by pressure loss (1-4 kg/cm²) caused by the variation in the flow rate, and the maximum power generation was not always ensured. To improve the situation, the detection point of the pressure control of the boiler was changed to the turbine inlet pressure.

Before Improvement

Previously, the operation pressure of the boiler was controlled to be 59 kg/ cm² for the purpose of keeping the pressure of the turbine inlet at the standard value of 58 kg/cm². For this reason, the turbine inlet pressure went below the standard pressure when generating a maximum steam quantity due to the pressure loss caused the piping, resulting in the decrease of the maximum rated power generation by 150 kW.

[Description of Improvement]

Structure explanation, Shape, and/or System diagram

[Method of improvement]
Since the maximum continuous operating pressure of this boiler is 70 kg/cm², it has a sufficient allowance even if the pressure loss at the time of the maximum flow rate is taken into consideration. Therefore, the pressure control point was changed to the turbine inlet pressure, and it was made possible to keep the turbine inlet pressure always at 58 kg/cm², and the power generation was increased.

[Before improvement]

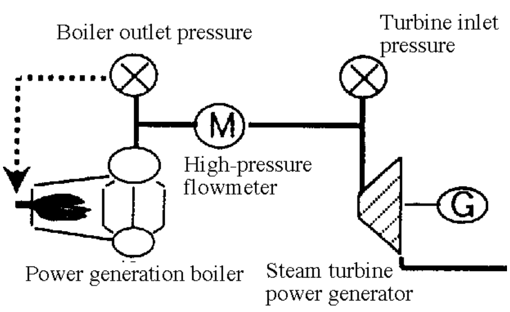


Fig. 1 In-house power generation boiler and steam turbine before improvement

[After improvement]

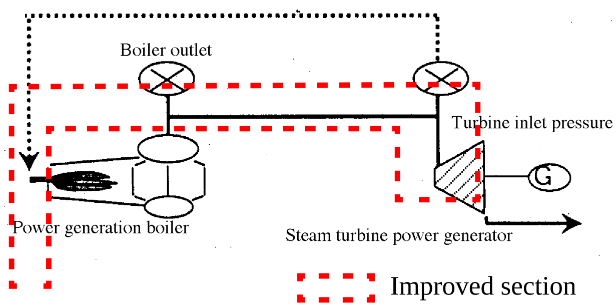


Fig. 2 In-house power generation boiler and steam turbine after improvement

Energy saving effects

Table 1 Effect of improvement of pressure control method of in-house power generation boiler (Working hour: 7,500 h/y)

	Before improvement				After improvement			
	Steam volume	Boiler outlet pressure	Turbine inlet pressure	Power generation (kWh)	Steam volume	Boiler outlet pressure	Turbine inlet pressure	Power generation (kWh)
Rating	62 h/t	63 kg/cm²	58 kg/cm²	8,100	62 t/h			
Rated operation	62 t/h	59 kg/cm²	54 kg/cm²	7,950	62 t/h	63 kg/cm²	58 kg/cm²	8,100
Increase of power generation					from 150 kW/h to 1,125,000 kWh/y			
Reduction volume converted to crude oil	273 kL/y							

[Economics] Equipment cost

Investment Amount (A): 2 million yen
Improvement effect (B): million yen/year
Investment payback (A/B): years

Remarks

[Remark]
It was examined whether the change of the control point affects the boiler's control response. Comparing the rate of the changes of the piping capacity and pressure based on the experience on improvements in the past, it was confirmed that there is no problem.

[Example sites]
Adopted at Toyota Motor's Tahara Plant, and some other sites.

[References]
"Collection of Improvement Cases at Excellent Energy Management Plants (1998)," p. 125

[Inquiry]
NEDO / ECCJ (JIEC)

MI-OM-7

Energy Conservation Directory

[Industry Classification] Many Industries [Technology Classification] Operation & Management	**Improvement of efficiency of turbo air compressor**	[Energy Source] Electricity [Practical Use] Around 1993

Outline

The efficiency of electric power consumption of a turbo air compressor is not good in comparison with reciprocating compressors. One of the reasons is that structurally the heat loss is larger than that of the reciprocating type. To reduce heat generation and improve the efficiency, the impeller and the diffuser, both of which are major structural parts of the turbo air compressor, were improved.

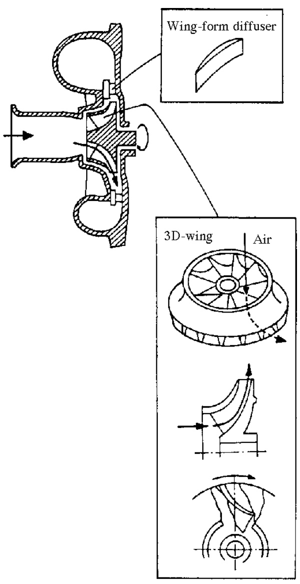
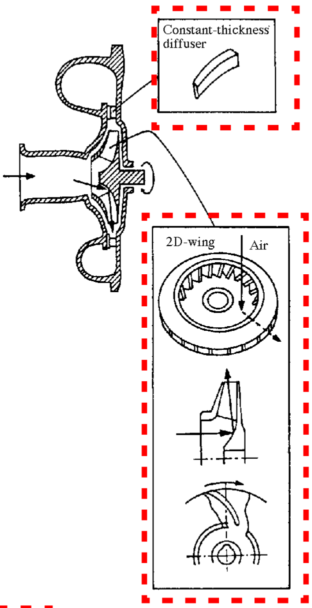
Principle & Mechanism

1) When comparing the compression process of the reciprocating type and the turbo type relative to the reduction of heat generation, following points are basic factors.
   - Reciprocating type: The cylinder is cooled.
   - Turbo type : Structurally, it is not cooled.
2) From the principle of compression work, heat generation is reduced by reducing the flow-path resistance of the impeller and the diffuser and having the compressed air flow smoothly.

[Description]

Structure explanation, Shape, and/or System diagram

Table 1 Improved efficiency by improving the structure of the turbo air compressor

	Before improvement	After improvement
1. Form of the impeller	2D-wing form	3D-wing form
2. Form of the diffuser	Constant thickness form	3D-wing form
3. Construction of turbo compressor main		 Improved section

Energy saving effects

Table 2 Energy saving effect and reduction of CO_2 emissions

	Before improvement	After improvement	Improvement rate	Effect
Heat loss	34 %	29 %	15 %	5 %
Compressed air generation efficiency	10.0 Nm³/kWh	11.4 Nm³/kWh	14 %	1.4 Nm³/kWh
Electrical power consumption	21,000 MWh/y	19,040 MWh/y	9.3 %	Reduced by 1,960 MWh/y
Reduction in crude oil equivalent				Reduced by 476 kL/y

[Economics] Equipment cost

Investment Amount (A): 68.6 million yen
Improvement effect (B): 31.4 million yen/year
Investment payback (A/B): 2.2 years

Remarks

[Example sites]

[References]
"Collection of Improvement Cases at Excellent Energy Management Plants (1990)," National Committee for the Effective Use of Electricity

[Inquiry]
NEDO / ECCJ (JIEC)

MI-OM-8

Energy Conservation Directory

[Industry Classification]
Many Industries

[Technology Classification]
Operation & Management

Improvement of efficiency of melting process by continuous desulfurization

[Energy Source]
Electricity

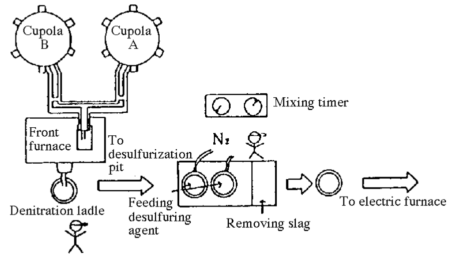
[Practical Use]
1986

Outline

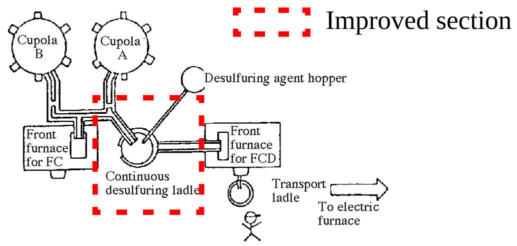
In this automobile components manufacturing plant, FC type cast iron (ordinary cast iron) and FCD type (ductile iron) cast iron are produced. In the example, remarkable results have been achieved in energy saving through rationalizing the paralleled production system of the two lines by remodeling the low frequency induction furnace of the FCD production line for the purpose of improving unit requirement of electric power.

Principle & Mechanism

[Before improvement]



[After improvement]



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

- The low frequency induction furnace has a function to raise the temperature of the molten metal that has dropped by desulfurization or treatment for FCD type of cast iron. This temperature decrease has been restrained, and the load on the induction path has been lessened, and furthermore, the conventional batch type desulfurization system has been remodeled into a continuous desulfurization system. The following are the major points of change (refer to Figs 2 and 3).

(1) Setting of a continuous denitration ladle.
(2) Setting of a pot for automatic feed of a desulfuring agent : a desulfuring agent is automatically supplied to the desulfurization ladle by this device.
(3) Setting of a dedicated launder for molten metal carriage and the front furnace : it facilitates easy changeover from production of FC to FCD production.

- Results : Temperature decrease of the molten iron has been restrained, and a temparature increase of 60˚C from the previous case has been attained, resulting in an increase of 8% of unit requirement of electric power of the induction furnace, improvement of desulfurization efficiency, and improvement of line cycle.

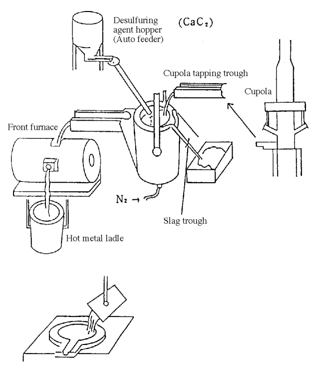


Fig. 2 Concept of continuous desulfurization system

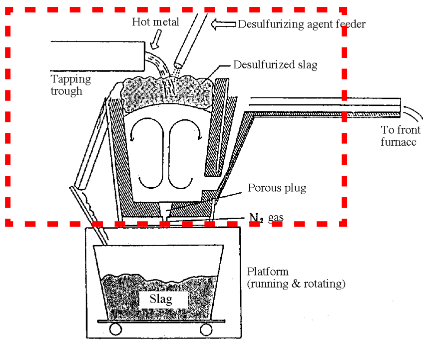


Fig. 3 Continuous desulfurization processing ladle

Energy saving effects

Table 1 Effect of improvements on productivity and energy saving

	Before improvement	After improvement	Effect
Capacity of molten metal handling	65 min	57 min	Reduced by 8 min
Unit requirement of electric power	200 kwh/t	184 kwh/t	Reduction (improvement) by 16 kW/t
Electric power consumption	2,840,000 kWh/y	2,612,800 kWh/y	227, 200 kWh/y (Reduction by 8%)
Reduction converted into crude oil			5.2 kL/y

[Economics] Equipment cost

Investment amount(A): 4 million yen
Improvement effect (B): 14.8 million yen/year
Investment payback (A/B) : 0.25 years

Remarks

The above improvement has turned out to be effective also in labor saving and eventually in personal administration.

[Example sites]
Many similar site cases have been reported

[References]
"Collection of Improvement Cases at Excellent Energy Management Plants (1988)", p.81

[Inquiry]
NEDO / ECCJ (JIEC)