First Batch of Domestic TOP TENs List

Japan BAT List

BAT1：High–efficiency Heat Pump

1.Introduction

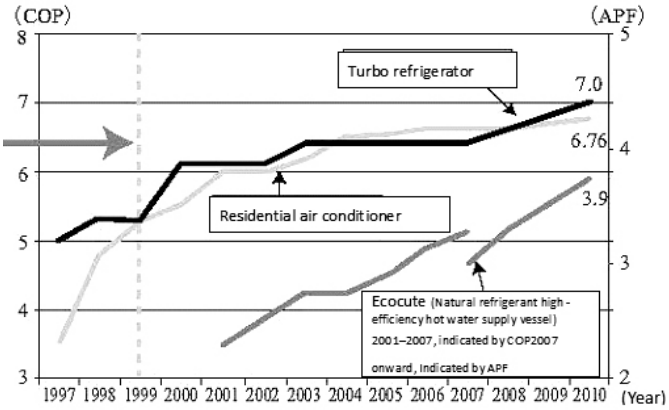
A heat pump is a system that can transfer heat from a low-temperature zone to a high-temperature zone,consuming only a small amount of motive power by means of a change in state such as the pressure and temperature of a heating medium (refrigerant).

A high-efficiency heat pump features a high coefficient of performance* (COP). Heating can be performed at higher efficiency than that achieved by conventional combustion of fossil fuels. this technology thereby contributes to reducing CO_2 emissions and limiting global warming. In its Renewable Energy Directive that came into effect in 2009,the European Union recognized heat energy generated by heat pumps as a form of renewable energy (RE).

As illustrated in Fig. 1,the COP achieved by heat pumps has shown rapid advancements in the past ten years through the enforcement of a top-runner system and other measures. This has been achieved by: (1) Use of an inverter,(2) High efficiency of compressor and heat exchanger,and recently (3) Use of a new refrigerant (R32),among various factors.

2.Technological Trends of Industrial Heat Pumps

(1)Higher Temperature Generated by Industrial Heat Pump



* Values are those of top-runner equipment. Residential air conditioners are 2.2 kW in capacity. Dimensions are not specified.

Fig.1 Year-on-year changes in COP of turbo refrigerator,residential air conditioner and Ecocute*1

At present,several manufacturers produce equipment for hot water supply and heating that can generate temperatures of 90°C. Painting and printing businesses use drying equipment that can generate hot air of 120°C. As of 2013,the highest temperature achieved by a heat-generating pump on the market was 165°C (7 MPa).

(2)Increase in Equipment and Cases for Simultaneous Use of Cooling and Heating

By utilizing both cold energy and hot energy that are generated simultaneously,a heat pump can double the level of efficiency achievable when they are used separately.

Cold water,chilled water,cold wind and other fluids are generated on the cold heat side,while hot wind and steam can also be generated on the hot heat side in addition to hot water and hot wind. The breadth of their possible combinations has expanded,and simultaneous use of cold heat and hot heat is increasing in production processes,air conditioning,hot water supply,and other applications.

(3)Miniaturization of Heat Pump Equipment (Cooling Capacity approximately 10 USRt. 30 kW)

Rather than installing equipment with a large capacity,several compact standard units are installed in order to minimize the capacity of standby equipment,thereby achieving high efficiency when the load is low.

3.Industrial Applications of Heat Pumps

(1)A large number of industrial heat pumps are installed in the foodstuff industry,and usage is expected to increase. The utilization temperature of the foodstuff industry is about -60°C to 120°C,and this temperature range can be supplied by current heat pump technology. Additionally,foodstuff manufacturing lines typically have mixed demands for cold heat and hot heat,allowing easy utilization of both forms of heat available from heat pumps.

(2)The use of heat pumps is expanding in various drying processes. In processes such as painting,printing,and fluidized-bed drying,heat pumps are installed before existing equipment for heating and drying,using waste heat as an energy conservation measure for existing drying equipment.

(3)In the past,only boilers could supply high-temperature steam at temperatures of 120°C or more,for applications such as sterilization,concentration,drying,and distillation. However,high-temperature steam in excess of 120°C can now be supplied by a heat pump.

4.Introduction of Heat Pump Technology and Energy Conservation Cases in Industrial Applications

The following cases describe the items to which the heat pump technology and industrial applications apply.

(1)Development and introduction of simultaneous cooling and heating heat-pump system for production process: Aisin AW Co.,Ltd.

1) Heat pump technology 2-(2)

2) Industrial applications of heat pump 3-(1)

(2)Steam-condensation-type vacuum degreasing cleaner: IHI Machinery and Furnace Co.,Ltd.

1)Heat pump technology 2-(2)

2) Industrial applications of heat pump 3-(2)

(3)Heat pump system for high-efficiency steam supply: Machinery division of Kobe Steel,Ltd.

1) Heat pump technology 2-(1)

2) Industrial applications of heat pump 3-(3) ■

BAT1–1:The Simultaneous Heating and Cooling Heat Pump System

1.Business Categories Adopting This Technology

Automotive parts manufacturing

2.Classification of Technology

Recovery of low-temperature waste heat (used in high-efficiency heat pumps)

3.Energy Source

Waste heat

4.Year of Commercialization

2012

5.Overview

In automotive parts manufacturing process machining line involves cutting and cleaning metals. Cutting machines use a cooler for the cutting fluid while cleaning machines use steam from a boiler to heat the cleaning fluid. A new heat-pump system has been developed to eliminate the use of steam. The heat pump uses the heat generated by cutting machines to heat the cleaning fluid. This new system has been installed on all the lines in the plant.

6.Principles and Operation

The heat pump is a system that can transfer heat from a low-temperature zone to a high-temperature zone consuming only a small amount of power. It accomplishes this by a change in state (i.e.,pressure and temperature) of a heating medium (refrigerant).

(1)Development of the Heat Pump System for the Production Process

The required heating temperature of the cleaning machine is high (50°C–70°C). The cutting machine requires machining accuracy to micrometers and each cutting machine has a cooler to avoid the effects on quality caused by expansion or contraction of the work pieces due to temperature fluctuations. To meet these temperature requirements and ensure product quality,a new system capable of simultaneous cooling and heating (heat pump) was developed for the production process. With this heat pump,it is now possible to heat the cleaning machine using only heat generated by the cutting machines.

(2)One Heat Pump Can Cool Multiple Machines

•Cooling water is circulated in a closed circuit through a

heat pump and heat exchanger.

•Cooling of several machines is simultaneously controlled using valves operated by electric motors.

•A heat-pump compressor inverter controls the cooling power.

7.Improvement Made

See Figure 1&2.

8.Effects of Improvement – Improvement in Energy Consumption Rate (Option for Improvement of Energy Conservation Rate)

See Table1.

9.Economic Efficiency and Changes

(1) Initial equipment investment cost

91,000,000 JPY

(2) Remodeling cost

(3)Running costs

32,920,000 JPY/year → 6,890,000 JPY/year → 26,030,000 JPY/year

(4) Years Needed for Recovery of Investment 3.5 years

See Table 2.

10.Market Situations and Conditions

(1) Penetration Rate at Present Not available

(2) Forecast of Penetration in 2017 (or 2020)

Not known

11.Additional Information for Reference

(1) Reduction of CO_2 Emission

1,094 tons/year

(2) Social Impacts and Other Factors

1) Patents and utility models

•Production line system (Patent application No. 2010-039003,patent application date February 24 2010),Two patents pending (Patent No. 2011-213211,Patent No. 2011-213206),Application date: 12 September 2011)

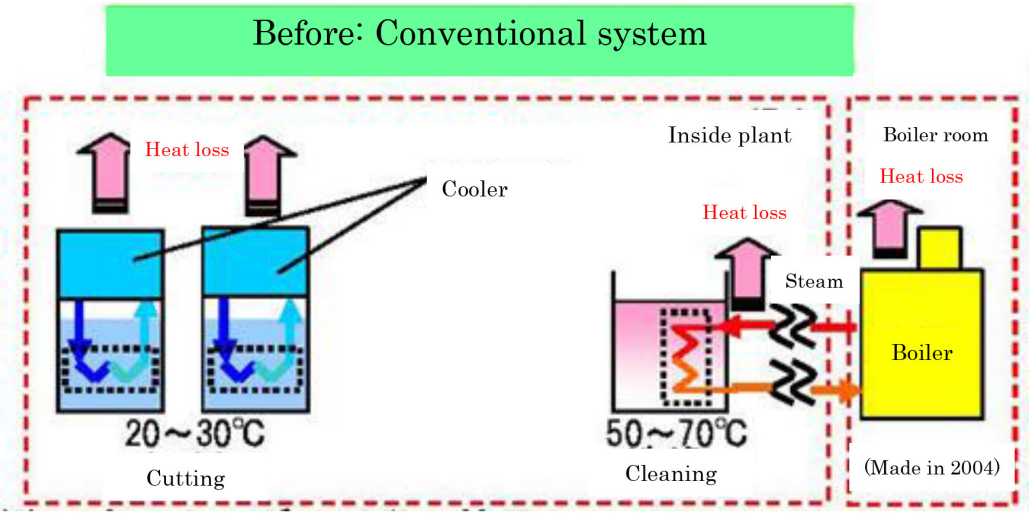


Figure 1

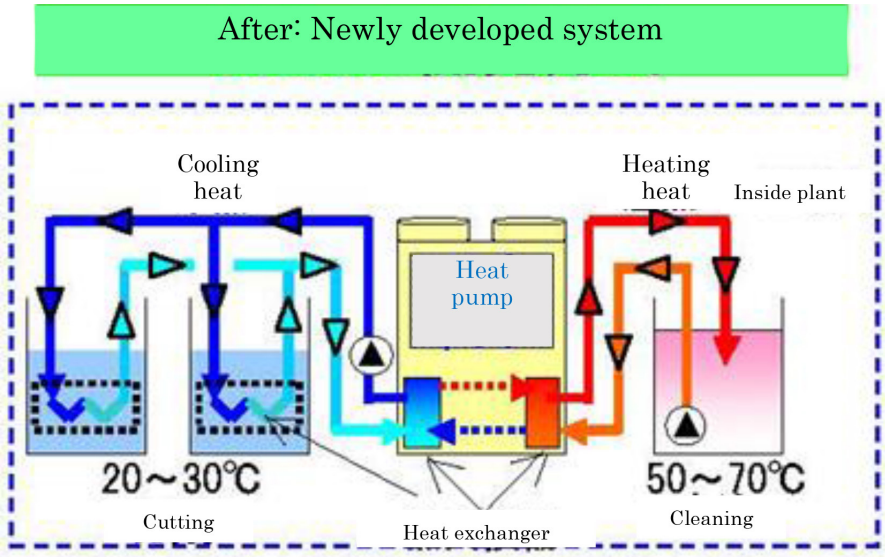


Figure 2

Table 1 Effect of Newly Developed Energy System

	Before		Newly Developed System		Reduction Achieved
Power Consumption (MWh/yr)	193 (100%)	· Boiler auxiliary equipment · Cooler	570 (295%)	· Heat pump	+377 (+195%)
Fuel Oil Consumption (KL/yr)	470 (100%)	· Boiler fuel oil	0 (0%)	· Heat pump	-470 (-100%)
Water Consumption (KL/year)	6,953 (100%)	· Steam raw material	0 (0%)	· Heat pump	-6,953 (-100%)
Heat Loss (MWh/yr)	-15,497 (100%)	· Boiler · Steam · Cooler	0 (0%)	· Heat pump	-15,497 (-100%)
Fuel Oil Equivalent (KL/yr)	522 (100%)	· Boiler · Cooler	85 (16%)	· Heat pump	-437 (-84%)
CO2 Emissions (tons of CO2)	1,364 (100%)	· Boiler · Cooler	270 (20%)	· Heat pump	-1,094 (-80%)

Table 2 Effect of Technology Introduction Cost

	Before (Conventional System)	After (Newly Developed System)
Investment Amount	• Boiler (including piping) JPY 75,300,000 • Steam heater JPY 10,500,000 • Cooler JPY 50,400,000 Total JPY 136,200,000 (100%)	• Simultaneous cooling and heating heat pump system (6-hp units x 6, 12-hp units x 8) Total JPY 91,000,000 (66.8%) (Reduction of JPY 45,200,000 or 33.2%)
Annual Running Cost	• Electricity 193 MWh JPY 2,340,000 • Fuel oil 470 KL JPY 28,130,000 • Water treatment 6,953 KL JPY 2,450,000 Total JPY 32,920,000 (100%)	• Electricity 570 MWh JPY 6,890,000 • Fuel oil 0l JPY 0 • Water treatment 0l JPY 0 Total JPY 6,890,000 (20.9%) (Reduction of JPY 26,030,000 or 79.1%)

2) History of Awards Received

•Recipient of special letter of appreciation from the Heat Pump & Thermal Storage Technology Center of Japan on occasion of 'The 14th Heat Storage Conference'

3) Literature and Other Information

•Monthly 'Energy Conservation' magazine (June

2014,pages 31 to 35),special edition on heat pumps. 'Technology Development News' published by Chubu Electric Power Co.,Inc. (No. 139,July 2010,pages 7 and 8).

12.Bibliography and Reference Information

'Development and Introduction of Simultaneous Cooling and Heating Heat Pump System for Production Process,' recipient of 2011 Energy Conservation Grand Prize (Energy Conservation Sector),Collection of Applications Containing Technological Accomplishments,The Energy Conservation Center,Japan

13.For More Information,Please Contact

Aisin AW Co.,Ltd.
General Heat Pump Industry Co.,Ltd.
Chubu Electric Power Co.,Inc. ■

BAT1–2: Steam–condensation Type Vacuum Degreaser

1.Business Categories Adopting This Technology

Manufacturer of machined metallic parts

2.Classification of Technology

High-efficiency heat pumps

3.Energy Source

Waste heat

4.Year of Commercialization

2013

5.Overview

Degreasing to remove lubricating oil,quenching oil,and other oil and grease,is necessary for mechanical assembly of machined-metal parts. Vacuum degreasers using vacuum-steam condensation with petroleum solvent have widely replaced fluorocarbons and trichloroethane. The use of these two solvents has been prohibited because these substances deplete the ozone layer. However,two problems related to replacement of these degreasers have been the need for a large amount of solvent (more than 2500 liters),and the demand for substantial power to obtain equivalent cleaning performance. The new degreaser reduces the drying time by 90%,and increases the heat-recovery rate four-fold compared with before. The new degreaser also drastically reduces the running cost,by several million yen (JPY) per year. This is achieved by incorporating the following two new technologies: (1) a heat-pump heat-recovery system (energy conservation),and (2) a cryogenic drying system.

6.Principles and Operation

(1) The heat-pump heat-recovery system

This is a heat-energy-reutilization system that incorporates a heat pump using an alternative fluorocarbon refrigerant. The system recovers nearly 100% of the energy needed to regenerate the shower liquid. The shower liquid of the vacuum degreasers is regenerated by vacuum distillation of the shower liquid mixed with oil. Conventional models discharge about 27 kW to the outside. This is energy used to regenerate shower liquids outside of the plant building,using cooling water of a shower-liquid-condensation heat exchanger. Similarly,about 9 kW of the energy needed for a waste-liquid-concentration unit (vacuum-distillation type),and other equipment,is typically discharged to the outside of the plant building

in cooling water. The new system recovers about 27 kW of shower-liquid-regeneration energy using an alternative fluorocarbon refrigerant in place of cooling water. This refrigerant is used for heating and evaporation of the cleaning liquid in the heat-pump system of a 9 kW compressor. Heating output equal to 36 kW by a conventional system can be obtained with only the 9 kW needed to run a compressor.

(2) Cryogenic drying system

The system dries treated materials on the high-temperature side by vaporizing on that side any cleaning solvents remaining from the cleaning process. This system also instantaneously transfers the vapors to the low-temperature condenser.

Drying is adequately feasible if there is a temperature difference of 20°C between the high and low-temperature sides,thereby allowing drying of thin aluminum and stainless steel sheets. In the past,these have been difficult to dry due to rapid lowering of their temperature.

7.Improvement Made

See Figure 1&2.

8.Effects of Improvement - Improvement in Energy Consumption Rate (Option for Improvement of Energy Conservation Rate)

'Conditions for Comparison'

(1) Treated material: Weight of treated material per charge is 800 kg.

(2) Hours of operation: Annual operation is set at 7,200 hr.

(3) Annual amount of treatment: Amount of treatment is 3,000 Charges/year.

(4) CO_2 emissions: Conversion value to power consumption is set to 0.555 kg/kWh.

(5) Electricity charge: JPY15/kWh.

(6) Cost of petroleum solvent: JPY250/L.

Power consumption/Charge: 31.1 → 19.7 kWh

-11.4 kWh

After Improvement

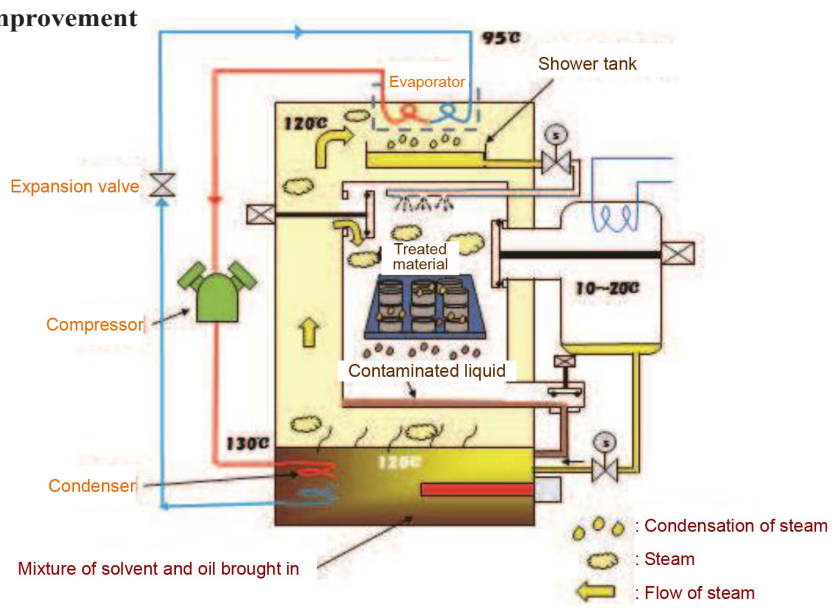


Fig. 1 The heat-pump heat-recovery system

After Improvement

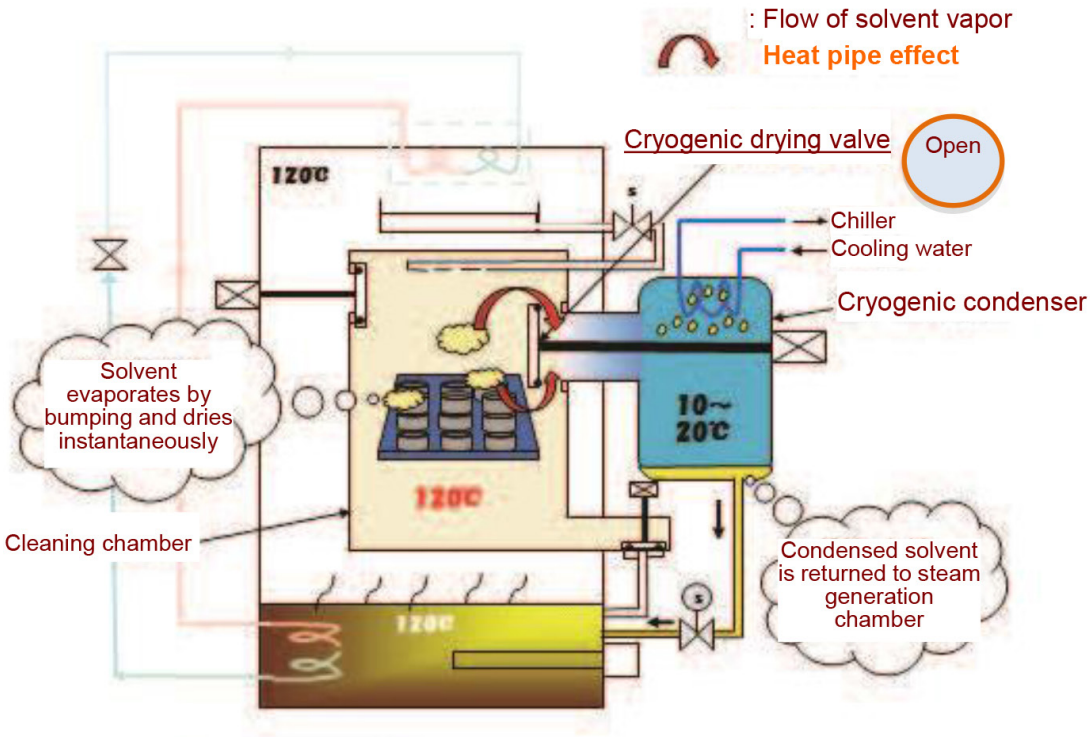


Fig. 2 Cryogenic drying system

Energy conservation rate:44.4%

See Table 1.

9.Economic Efficiency and Changes

Energy Conservation (Cost of solvent is not included)

(1)Initial equipment investment cost: Not available.

(2) Remodeling cost.

(3) Operation cost:3,990,000 JPY/year → 2,218,000 JPY/year, Around −1,772,000 JPY/year.

(4)Years Needed for Recovery of Investment:Not available

see Table 2.

10.Market Situations and Conditions

In the future,IHI Machinery and Furnace Co. plans to build a network of operations in China and Europe,and to undertake sales activities aimed at increasing sales of EvaCryo degreasers inside and outside of Japan,to a target of JPY 2,000 million in 2015.

11.Additional Information for Reference

(1)CO_2 emission reduction 168 tons/yr reduced.

(2)Social impacts and other factors.

1)History of Awards Received.

•Recipient of 2013 Excellent Energy Conservation Equipment Award presented in the name of the Minister of Economy,Trade and Industry sponsored by the Japan Machinery Federation.

Table 1 Comparison of energy conservation performance

	Conventional HWV degreaser	EvaCryo	Difference	Reduction Rate
Power consumption for shower liquid regeneration/Charge	16.8 kWh	4.3 kWh	12.5 kWh	75%
Power consumption /Charge	31.1 kWh	19.7 kWh	11.4 kWh	36.7%
Annual power consumption	265,986 kWh	147,849 kWh	118,137 kWh	44.4%
Annual CO_2 emissions	148 tons of CO_2/yr	82 tons of CO_2/yr	66 tons of CO_2/yr	44.4%
Annual electricity charge	JPY 3,990,000/yr	JPY 2,218,000/yr	JPY 1,772,000/yr	44.4%

Table 2 Comparison of economic efficiency

	Conventional HWV degreaser	EvaCryo	Difference	Reduction Rate
Solvent consumption /Charge	0.9 L	0.4 L	0.5 L	55%
Annual consumption of solvent	13,500 L	6,000 L	7,500 L	55%
Annual cost of solvent	JPY 3,380,000	JPY 1,500,000	JPY 1,880,000	55%

12.Bibliography and Reference Information

Japan Machinery Federation

2013 Excellent Energy Conservation Equipment Award

[Award in the name of the Minister of Economy,Trade and Industry]

13. For More Information,Please Contact:

IHI Machinery and Furnace Co.,Ltd.

BAT1–3: Heat Pump System for High–efficiency Steam Supply

1.Business Categories Adopting This Technology

Biofuel manufacturers

2.Classification of Technology

Recovery of low-temperature waste heat (uses a high-efficiency heat pump)

3.Energy Source

Waste heat

4.Year of Commercialization

February 2013

5.Overview

Spurred by the requirements of energy conservation in face of global warming,there has been a demand for a highly efficient technology that produces high-temperature steam in excess of 120°C by way of a heat pump. Until now,high-temperature steam in excess of 120°C could only be supplied by boilers that use steam in processes such as sterilization,condensation,drying ,and distillation. However,a heat pump system (Steam Grow Heat Pump) for providing steam supply with high efficiency at temperatures in excess of 120°C has now been developed. In this respect,Model SGH120 has a mounted heat pump and is capable of supplying steam of 120°C,and Model SGH165 has an additionally mounted steam compressor onto the heat pump and can supply steam at a maximum temperature of 175°C.

6.Principles and Operation

Up until the present day,heat pumps could provide high temperatures of more than 100°C but could supply either high-temperature water and steam simultaneously or only hot air. Kobe Steel has now developed the following technologies to supply only saturated steam at a temperature in excess of 120°C.

For developing this technology,the design of gaps and openings in various parts ofthe compressor were first reexamined,taking thermal deformation at a high temperature into consideration. A method used to directly atomize a refrigerant liquid into the motor (to cool the motor) was also adopted to prevent the motor overheating even when the compressor is operating under a high suction temperature. This achieved both compressor reliability,and the maintenance of compressor performance.

A high-efficiency operation was then achieved by using a different screw compressor in accordance with the

compression ratio. For instance,a dual-stage compressor is used in Model SGH120 and a single-stage compressor is used in Model SGH165.

Third,R245fa,which is a type of hydrofluorocarbon (HFC),was used as a refrigerant for the heat pump unit. It is also a low-pressure refrigerant with a high critical temperature (154.0°C),and can be used as a base refrigerant. The selection of an optimal refrigerant component ratio using R134a (critical temperature 101.1°C) was then achieved at a high efficiency.

Through the development of the foregoing technologies,the rated performance of SGH120 has been enhanced to a supply an amount of steam equivalent to 0.51 t/h and COP3.5,and SGH165 to deliver an amount of 0.84t/h and COP2.5. By recovering heat from the following areas: the cooling water of the water-cooled chiller,the high-temperature waste water from the production process,and the unutilized heat-source water inside the plant,steam can therefore now be supplied at a high efficiency.

7.Improvements Made

See Figure 1&2.

8.Effects of Improvement - Improvement in Energy Consumption Rate (Option for Improvement of Energy Conservation Rate)

See Figure 3&4.

9.Economic Efficiency and Associated Changes

(1)Initial equipment investment cost:

Data currently unavailable

(2)Remodeling cost:

(3)Running costs:95,000,000 JPY/year → 42,000,000 JPY/year, Approximately 50,000,000 JPY/year.

(4)Number of years required to recover investment：

Data currently unavailable.

10.Market Condition

(1)Penetration rate at present: Data not currently available.

(2)Forecast of penetration in 2017 (and 2020):

Before Improvement

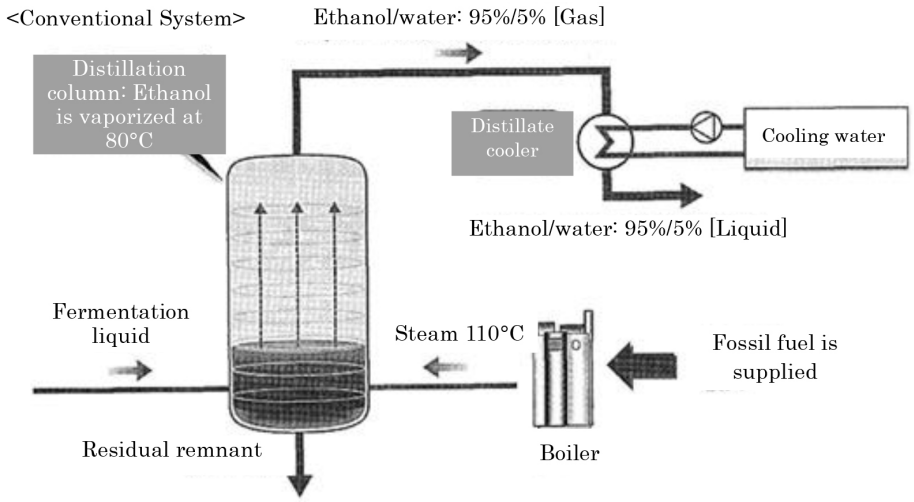


Figure 1

After Improvement

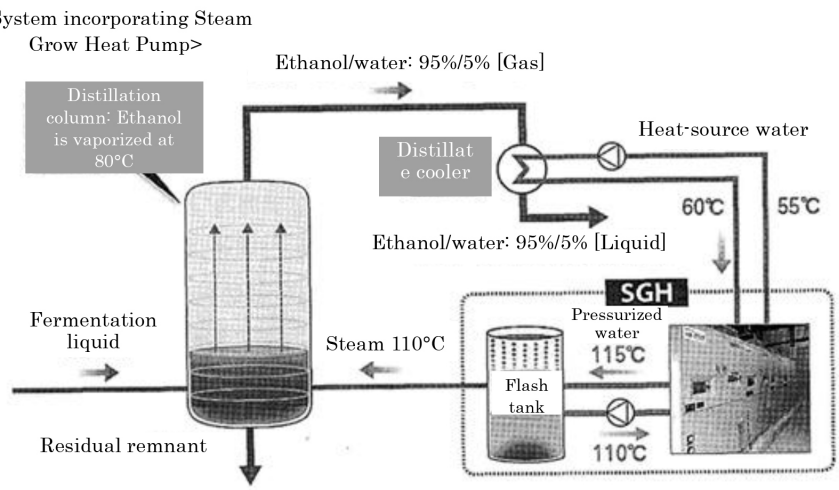


Figure 2 Image of system incorporating Steam Grow Heat Pump

Data currently unavailable.

11.Additional Relevant Information

(1)CO_2 emission reduction: 1,290 tons/year.

(2)Social impacts and other factors.

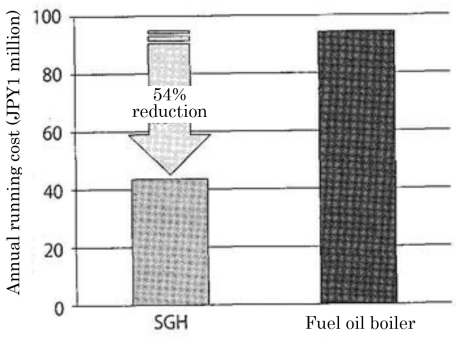


Fig. 3 Comparison of annual running costs

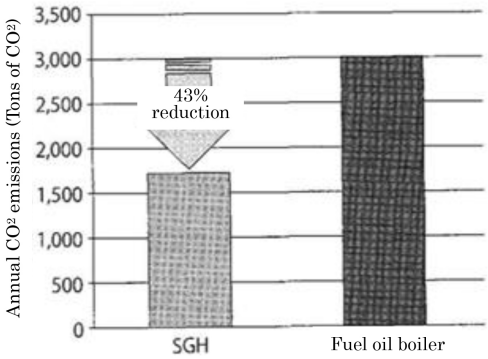


Fig. 4 Comparison of CO_2 emissions

1)Literature:

•Monthly publication of Energy Conservation (June 2014),pp 42–45,(special edition for heat pumps).

12.Bibliography and Reference Information

'Heat Pump System for Supply of Steam at High Efficiency and Examples of System Installations,' Monthly publication Energy Conservation,Vol. 66,No. 6,June 2014,pp 42–45,The Energy Conservation Center,Japan.

13.For More Information,Please Contact:

The Machinery Division of Kobe Steel,Ltd. ■

BAT2: High Efficiency Boilers

1. Introduction

Industrial steam boilers can be categorized as: (a) those that directly supply heat to users,and (b) those that generate power by rotating a turbine,from which the exhaust gas is used as a heat source for factories. This article describes boilers that do not generate power.

See table 1.

(1) Boiler Classification

In general accordance with the Industrial Safety and Health Law of Japan,boilers are classified as: simplified boilers,small boilers,and boilers.

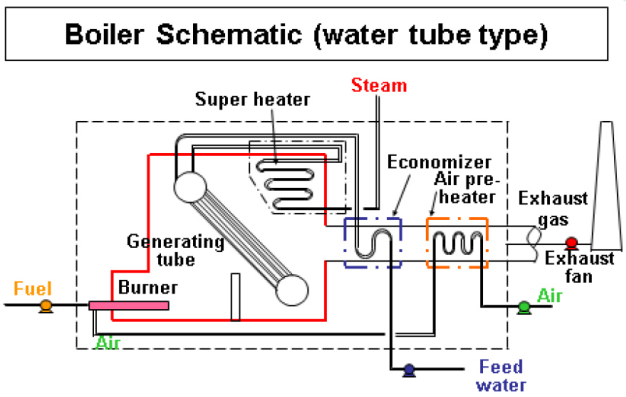


Fig. 1

(2) Energy Conservation Measures of Boilers.

The general energy conservation options for boilers are as follows:

a.Optimizing air ratio.

b.Reducing heat lost via exhaust gas.

c.Reinforcing heat insulation (adiabatic insulation).

d.Preventing heat loss caused by intermittent boiler operation.

e.Recovery of steam drain.

f.Improving FDF/IDF (forced draft fan/induced draft fan) efficiency under partial load.

g.Preventing losses from steam trap and blow water.

2. Technical Trends of Once-through Boilers

Among steam boilers operating in Japan for general industrial purposes excluding power.

generation,it is estimated that about 65% of the steam requirement is supplied by once-through boilers,while about 20% and 15% are supplied by flue and smoke tube boilers and water tube boilers respectively. In recent years,newly manufactured boilers are predominantly of the once-through type. The features and technical trends of once-through boilers are summarized in the following.

See Figure 2.

Table 1

Boiler Classification		Steam Boiler*1	Hot Water Boiler	Once-through Boiler*4
Simplified Boiler		Boiler pressure <= 0.1 MPa, with heat transfer area <= 0.5 m²	Boiler pressure <= 0.1 MPa, with heat transfer area <= 4 m²	Boiler pressure <= 1 MPa, with heat transfer area <= 5 m² *2, *3
Small Boiler		Boiler pressure <= 0.1 MPa, with heat transfer area <= 1 m²	Boiler pressure <= 0.1 MPa, with heat transfer area <= 8 m² Boiler pressure <= 0.2 MPa, with heat transfer area <= 2 m²	Boiler pressure <= 1 MPa, with heat transfer area <= 10m² *2, *3
Boiler	Small in scale	Heat transfer area <= 3 m², regardless of pressure	Heat transfer area <= 14m², regardless of pressure	Heat transfer area <= 30m², regardless of pressure*3
		Boilers that do not comply with the above definitions	Boilers that do not comply with the above definitions	Boilers that do not comply with the above definitions

*1) Some steam boilers are classified by drum dimensions.

*2) Once-through boilers classified as simplified boilers and small boilers have internal header diameter <= 150mm.

*3) A dimensional limit is placed on the steam separator of once-through boilers of small-scale boilers or smaller

*4) The Industrial Safety and Health Law of Japan classifies water-tube boilers that have a steam separator and that subsequently return hot water to a heating tube as once-through boilers in cases where the total amount of water at the inlet of the heating tube is not greater than twice the maximum volume of feed water.

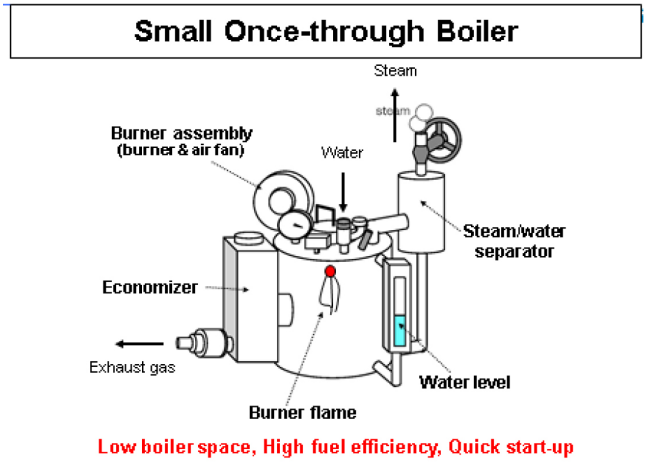


Fig. 2

(1) Increased Evaporation

The evaporation achieved by small once-through boilers was initially around 350 kg/h,but some .

models presently manufactured in Japan can achieve evaporation of 2 t/h to 2.5 t/h.

(2) Higher Boiler Efficiency

The use of an economizer (waste heat recovery equipment) has increased boiler efficiency from .

approximately 70% to as much as 95%–96%. Boilers with efficiency greater than 100% (on the basis of lower heating value) are also available,by installing economizers to recover latent heat from water vapor in exhaust gas.

(3) Improved Combustion Burner

Burners have been developed that respond better to fluctuations in load,such as a low-NOx burner.

burners with a high turn-down ratio. those designed for combustion at a low air ratio. and those with a turn-down ratio of 6:10 from low and high combustion loads.

(4) Improved Control of Boiler Operation and Optimal Number of Boilers

Remote monitoring and control (control of the number of boilers for efficient operation in low-load zone) has

improved operational efficiency.

(5) Energy Conservation through use of Inverter with Exhaust Fan

3. Introduction of Energy Conservation Cases with High-efficiency Once-through Boiler

The following cases show the application of energy conservation technologies previously listed in section 2.

(1) Once-through boiler featuring wide combustion zone with burner for fully-premixed surface-stabilized combustion and condensing (Hirakawa Corporation)

Energy conservation technology 1-(2)-a,b,c

(2)System comprising multiple compact once-through boilers,combined with optimal-efficiency monitoring (Miura Co.,Ltd.)

Energy conservation technology1-(2)-a,b,c,d,e

(3)Compact,gas-fired once-through boiler with jet-film combustion,featuring low air ratio(Nippon Thermoener Co.,Ltd. and Takuma Co.,Ltd.)

Energy conservation technology1-(2)-a,b,c ■

BAT2-1: Once-through Boiler Featuring Wide Combustion Range with Burner for Fully-premixed Surface-stabilized Combustion and Condensing

1.Business Categories Adopting this Technology

General

2.Classification of Technology

High-efficiency boiler

3.Energy Source

City gas

4.Year of Commercialization

2011

5.Overview

This is a once-through boiler featuring low NOx emissions and high efficiency,incorporating the FPSCC technology (fully-premixed surface-stabilized combustion and condensing). Fuel gas and combustion air are fully premixed before feeding to the burner,achieving surface-stabilized combustion and condensing,which forms short,stabilized flames uniformly across a relatively large flame-forming surface of the burner,and for 'recovery of latent heat.'

Using this type of burner enables stable combustion across the entire burner surface,via which the once-through boiler can modulate burner output and control combustion over a wide range up to a low firing area(turn-down ratio 10:1).

6.Principles and Operation

(1) Wide Combustion Range

Conventional once-through systems meet the heat demand by operating multiple boilers that use three-stage control after ignition,namely: high firing,low firing,and stop. The combustion control widths (turn-down ratios) of conventional boilers are about 3:1,in some cases requiring frequent starts and stops when the heat demand is low. Post-purging and pre-purging are performed to release both unburned gases and high-temperature air from within the boilers,resulting in start- and stop-losses due to cooling of the boiler and lowering of the efficiency.

In order to optimize the burner devices and peripheral equipment,the boiler features modulating combustion control at a wide turn-down ratio of 10:1,allowing continuous combustion down to 10% of the rated capacity. Compared

with conventional once-through boilers,the newly-developed boiler reduces start–stop heat losses,resulting in improved boiler efficiency.

(2) High Efficiency

The boiler structure features an enlarged heating surface that maximizes absorption of heat input,and its waste-heat recovery unit is equipped with a feed-water preheater (economizer) that can recover even latent heat. Additionally,a good match is attained between the boiler itself and the burners,to maintain stable efficiency across the entire combustion range described in (1),thereby achieving a high boiler efficiency of more than 102% (on the basis of lower heating value) over the entire combustion range.

(3) Low NOx Emissions

Featuring metal fibers that have a sufficiently large surface area,the fully-premixed surface-stabilized combustion and condensing burner achieves uniform lean combustion of premixed air and fuel gas with short flames so as to control the locally generated high-temperature parts that create thermal NOx in the flames,thereby reducing NOx emissions (O_2 = 0% conversion) to less than 25 ppm across the entire combustion range.

7.Improvements to Boiler Structure

See Figure 1.

8.Effects of Improvement on Energy Consumption Rate (Option for improvement in energy conservation Rate)

See Table 1.

9.Economic Efficiency and Changes

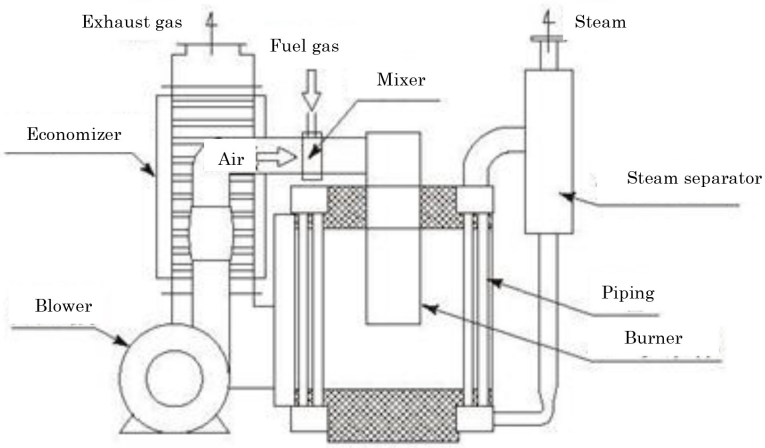
(1) Initial investment cost	Not available
(2) Remodeling cost	Not available
(3) Operational costs	9,088,000 JPY/year → 24,744,000 JPY/year -4,344,000 JPY/year
(4) Investment recovery (years)	Not available

10.Market Conditions and Conditions

(1) Present market penetration rate

Not available

After Improvement



Figule 1 Boiler Structure

(2) Forecast market penetration in 2017 (or 2020)

Not available

11.Additional Information for Reference

(1) CO_2 emission reduction 130 t/year

(2) Social impacts and other factors

1) History of awards received

•2011 Excellent Energy Conservation Equipment Award,on behalf of the president of the Japan Machinery Federation

2) Literature

•Monthly publication: 'Energy Conservation,' May 2012,page 60.

12.Bibliography and Reference Information

(1)'2011 Excellent Energy Conservation Equipment,' Monthly publication: 'Energy Conservation,' Vol. 64,No. 5,May 2012,page 60,The Energy Conservation Center,Japan

(2) Information from Hirakawa Corporation

13.For More Information,Please Contact:

Mr. Hiroshi Matsumoto,Director,Planning Office,Management Division,Hirakawa Corporation

Telephone: +81-6-6458-8687

email: h_matumoto@hirakawag.co.jp

Table 1 Comparative Economic Efficiencies of Conventional and Newly Developed Boilers

			Conventional Boiler	Newly Developed Boiler	Difference
Equivalent evaporation		Kg/h	2,500	2,500	-
Boiler efficiency (LHV)		%	96	102	+6
Feed water temperature		°C	15	15	-
Operational efficiency		%	86.9	100.6	+13.7
Fuel (City gas 13A)					
	Fuel consumption	m^3N/h	144.7	136.0	-8.7
	Unit price of fuel	JPY/m^3N	70	70	-
	Annual fuel charge	JPY/Year	28,198,017	24,324,262	-3,873,755
Electricity					
	Power consumption	kWh	5.3	2.5	-2.8
	Unit price of electricity	JPY/kWh	20	20	-
	Annual electricity cost	JPY/Year	894,000	420,000	-470,400
Total fuel and electricity costs		JPY/Year	29,088,417	24,744,202	-4,344,155
CO_2 emissions		$t\text{-}CO_2$/Year	910	780	-130

* The operating conditions are based on a 30% load factor and boiler operating 24 hours per day,350 days per year.

BAT2–2: Multiple Installation (MI) System of Small Once–through Boilers with Optimal–efficiency Operation Function

1. Business Categories Adopting This Technology

General

2. Classification of Technology

High-efficiency boiler

3. Energy Source

City gas, LPG

4. Year of Commercialization

2010

5. Overview

According to the result of a load analysis made by Miura Co.,Ltd,the average load factor of steam systems is about 20% to 50%. However,the new SQ boiler series drastically improves the system efficiency in this load region. The efficiencies of boilers vary with operating conditions,and boilers have a combustion point known as the 'Eco-Operation Point,' at which the efficiency shows the highest values in accordance with the operating conditions. In relation to this,boiler system efficiency significantly improves when boilers preferentially perform combustion at the 'Eco-Operation point.'A system efficiency of 100% has been achieved in the case where even latent heat in exhaust gases has been recovered.

6. Principles and Operation

(1) Development of New Combustion Control System 'High Speed Multi-Position Step Control'

The efficiency of a boiler varies with its operating conditions (boiler load factor,feed-water temperature,and steam pressure),and boilers have a combustion point at which the efficiency shows the highest values in accordance with the operating conditions. Miura Co.,Ltd. named the combustion point at which the efficiency becomes the highest,the 'Eco-Operation point,' and have developed 'High-speed multi-position control' technology that features a combustion output tailored to the eco-operation point.

Expanding the turn-down ratio to 1:5,combustion outputs of 0%–20%–45%–100% have been achieved. The rated efficiency (boiler load factor 100%,steam pressure 0.49 MPa,feed water temperature 15°C,and an air supply temperature of 35°C) has attained an efficiency of

98%,thereby delivering an improvement of 2% compared with conventional models manufactured by Miura Co.,Ltd.

(2) Development of New MI Control System

Miura Co.,Ltd. has developed a new system to control the number of boilers (patented),known as the 'MI control system,'which maximizes the eco-operation point effect. The new system controls the number of boilers in order to maximize how many boilers are operating at the eco-operation point,resulting in the drastic increase of system efficiency. An increase in the number of boilers combusting at the eco-operation point reduces power consumption through the inverters (which are installed as a standard specification).

(3) Development of New Economizer

A new economizer (of the down-flow type) that enhances the latent-heat recovery effect has been developed.

7. Improvements Made

Before Improvement

(1) Development of New Combustion Control System

(2) Development of New Economizer

See Figure 1.

After Improvements

(1) New combustion control system

(2) Development of new MI control system

(3) Economizer of new type

See Figure 2&3.

8. Effects of Improvement - Improvement in Energy Consumption Rate (Option for Improvement in Energy Conservation Rate)

See Table 1.

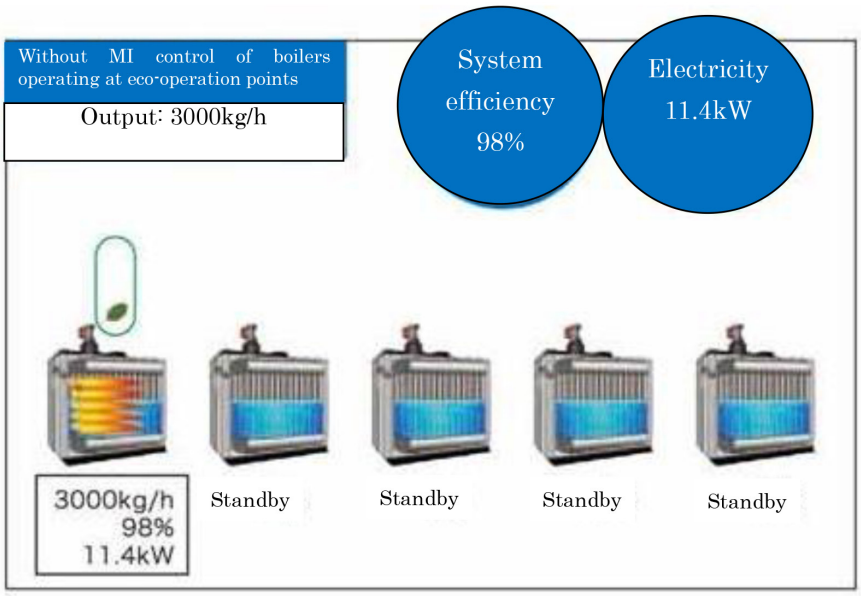


Figure 1

9. Economic Efficiency and Changes

(1) Initial investment cost: 40 million to 50 million JPY

(2) Remodeling cost:

(3) Running costs: (5 units)

Fuel:	-8,254,000 JPY/year
Electricity:	-579,000 JPY/year
Total for 5 units:	-8,833,000 JPY/year

(4) Number of Years Required to Recover Investment: Approximately 5 years

10. Market Situations and Conditions

(1) Penetration rate at present:

46% (actual rate achieved in 2013)

(2) Forecast of penetration in 2017 (or 2020):

Data not currently available

11. Additional Information for Reference

(1) CO_2 emission reduction: 304 tons/yr (for 5 units)

(2) Social impacts and other factors

1) History of Awards Received

• Recipient of the 2010 Excellent Energy Conservation Equipment Award

(Japan Machinery Federation):awarded by the president of the Japan Machinery Federation.

2) Literature

• Monthly publication of 'Energy Conservation,' (April 2011),pp. 70–71.

12. Sites Adopting This Technology

Nara Plant of Taihei Food Co.,Ltd.

Change from a flue and smoke tube boiler to 7 units of SQ-3000AS + BP-201ST

(1) Higher boiler efficiency: 84.8% → 96.5%

(2) CO_2 reduction: 37% reduction

(3) Labor-saving: Daily management is outsourced to maintenance servicing of Miura Co.,Ltd. (program ZMP-SL)

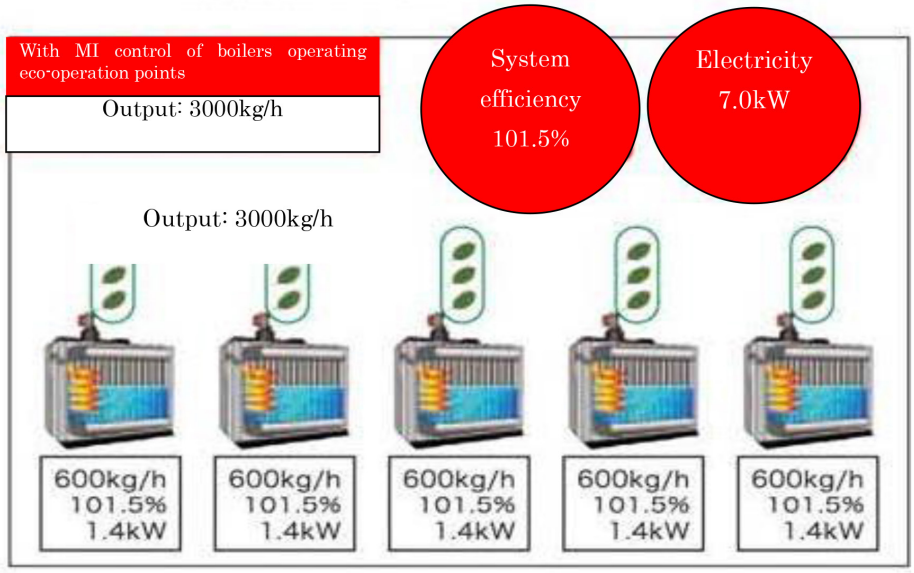


Figure 2

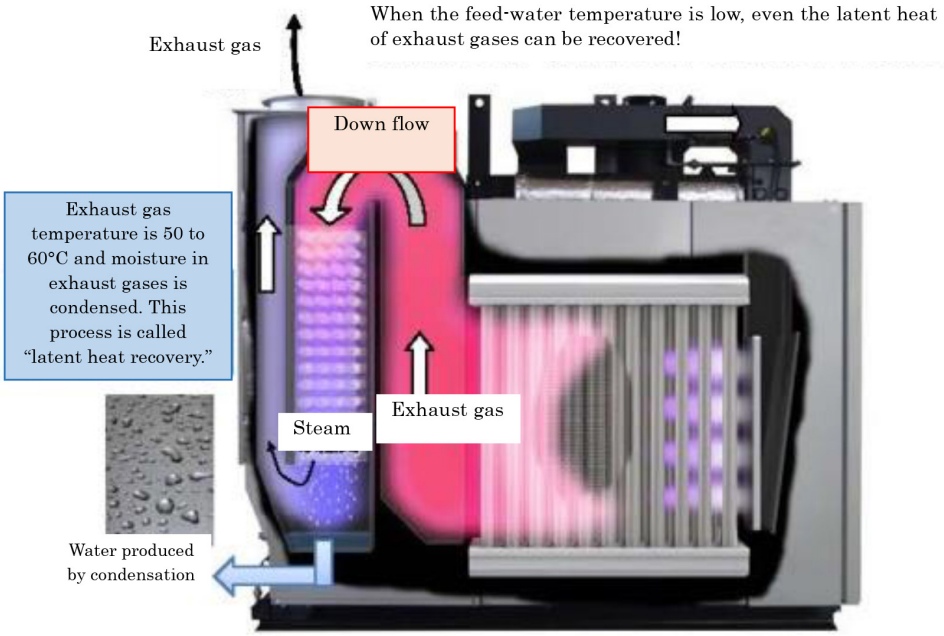


Figure 3

Table 1 Calculation of an Example of Fuel Costs and CO^2 Emissions for a Steam System with a Total Capacity of 15 t/h

System	Conventional System	New SQ-3000 model x 5 Units	Difference
Amount of Steam [t/Year]	26,280	26,280	—
System Efficiency [%]	92 (Estimated)	100	+8 points
Fuel Consumption [m^3N]	1,587,000	1,460,000	-127,000 m3N
Fuel Cost [Thousand JPY/Year]	103,173	94,919	-8,254,000 JPY
Electricity Consumption [kWh]	99,864 kWh	61,320 kWh	-38544 kWh
Electricity Charge [Thousand JPY/Year]	1,498	919	-579,000 JPY
CO_2 Emissions [t-CO_2/Year]	3,668	3,364	-304 t-CO_2/Year

Calculation Conditions: System load factor 20%,fuel city gas 13A (JPY65/m^3N,2.29kg-CO_2/m^3N)Electricity Charge: JPY 15/kWh,0.339kg-CO_2/kWh

(4) Saving of floor space: Approximately 50% space saved by changing the flue and smoke tube boiler to a small once-through boiler.

13. Bibliography and Reference Information

'2010 Excellent Energy Conservation Equipment,' Monthly publication 'Energy Conservation',Vol. 63 No. 4,April 2011,pp 70–71,The Energy Conservation Center,Japan.

14. For More Information,Please Contact:

The Maintenance Service Sales Promotion Department Miura Co.,Ltd.

7 Horiecho,Matsuyama,Ehime Prefecture 790-2696 Japan

Telephone +81-89-979-7000.

Fax +81-89-978-2321

http://www.miura.co.jp

BAT2-3: Small Gas Fired Once-through Boiler

1.Business Categories Adopting This Technology

General

2.Classification of Technology

High-efficiency boiler

3.Energy Source

City gas

4.Year of Commercialization

January 2009

5.Overview

Using conventional technology simultaneous control of CO and NOx at a low air ratio has been difficult in compact once-through boilers with a large thermal load to the combustion chamber. Air ratios of about 1.3 (exhaust gas O_2: 4.9%) have been the limit. In general,the heat transfer area of the economizer has been increased to achieve a high efficiency.

Aiming to achieve both high efficiency and low power consumption through combustion at a low air ratio,the new type of small,gas-fired boiler uses a once-through design with a unique,independently developed jet-film burner to simultaneously control CO and NOx. The new boiler redefines performance expectations for both high-efficiency combustion and low environmental load at an ultra-low air ratio of 1.17 (O_2 concentration in exhaust gas = 3%),which could not be achieved by the conventional technology.

6.Principles and Operation

A unique jet-film combustion technology has been developed to simultaneously control CO (complete combustion) and NOx (control of high-temperature combustion) while the burner and combustion chamber have been optimized tosimultaneously accomplish low CO and NOx emissions.

Figs. 1 and 2 illustrate the cross-sections of the burner and combustion chamber,respectively.

7.Improvement Made

Sweep filter dust and to form a flow at high speed and the upstream side of the burner into the combustion chamber,to form a self-recirculating gas flow. this is mixed with thin-film flames thereby controlling the flame temperature and thermal NOx emission.

High-speed jetting accelerates the mixing of fuel gas and

air,allowing control of CO even at low air ratio.

8.Effects of Energy Consumption Rate (Option for Improvement of Energy Conservation Rate)

By changing the air ratio (which was previously limited to 1.3) for combustion to an ultra-low ratio of 1.17 (O_2 concentration in exhaust gas = 3.0%),the rated boiler efficiency has been improved from 96% in the past to 98%. Additionally,by improving the turn-down ratio,the efficiency at low load and significantly improved by 20% at a 20% load.

The power consumption of the blower has been reduced by between 22% and 45% by operating at low air ratio and installing an inverter with the blower.

Refer to Figure 3,4 & table 1.

High-efficiency operation is feasible with this boiler through four-stage control of combustion under the following conditions: stop (0% load),low combustion (20% load),medium combustion (50% load),and high combustion (100% load). Compared with boilers of the conventional type (three-position control at 0,50,and 100% loads),operational efficiency is dramatically increased,especially within the low load region of 20%–50%.

By installing multiple units of this boiler,and by controlling the number of boilers in combustion,large capacities can be

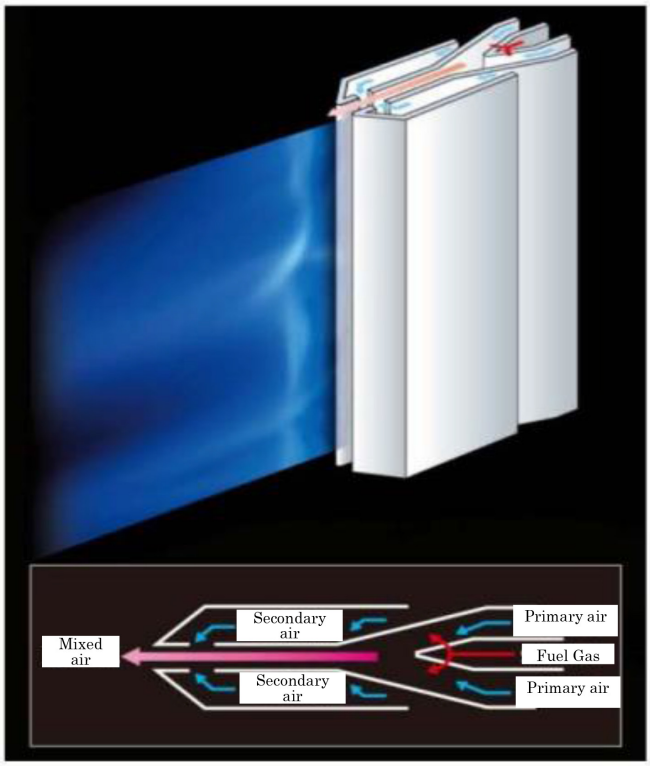


Fig. 1 Cross section of burner

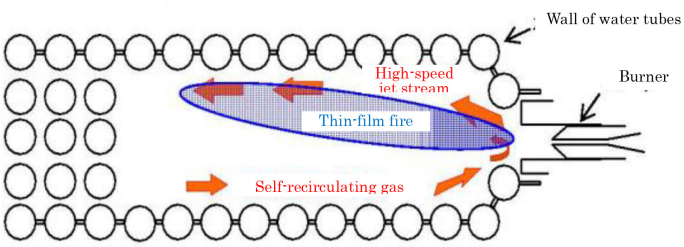


Fig. 2 Cross section of combustion chamber

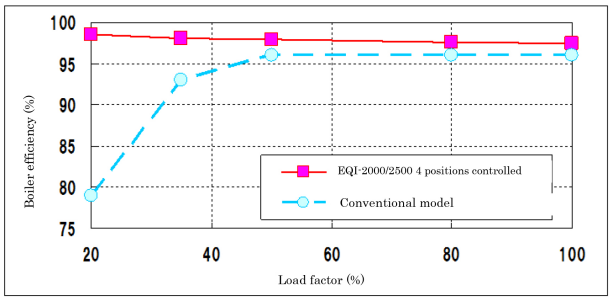


Fig. 3

Table 1 Comparison of efficiency between conventional and new boilers

Load factor	Boiler Efficiency (%)		Efficiency Improvement Ratio
	EQi	Conventional model	
20%	99.0	79.0	20%
35%	98.0	93.0	5%
50%	98.0	96.0	2%
80%	98.0	96.0	2%
100%	98.0	96.0	2%

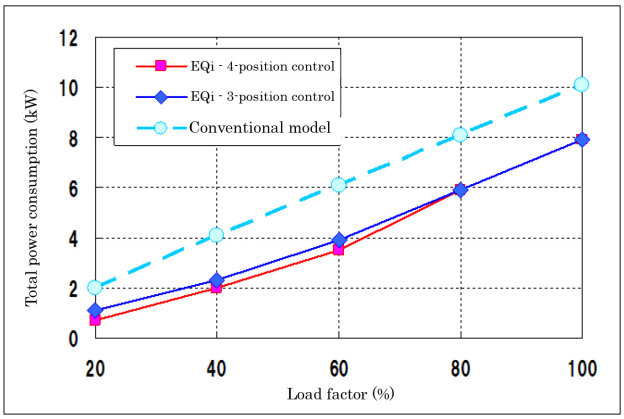


Fig. 4 Comparison of power consumption between conventional and new boilers

achieved. In this operational mode,settings are established to increase the number of boilers operating at low-to-medium load,because operation within this load range gives high boiler efficiency and low power. ow power consumption .

See Figure 5.

9.Economic Efficiency and Changes

(1)Initial investment cost: Not available (Cost is lower than conventional boilers)

(2) Remodeling cost: Not available

(3) Operating costs Fuel -420,000 JPY/year

Electricity -110,000 JPY/year

Total -530,000 JPY/year

(4)Repayment period 0 year

See Table 2.

10.Market Situations and Conditions

(1) Current market penetration rate for new boiler type:

Total number of boilers shipped (from 2009 to first half of 2014) = 350 units.

A: Annual shipment of new boiler type = 85 boilers/year (2011 to 2013 average) .

B: Annual shipments of small,once-through boilers = 4,000 boilers/year (2011 to 2013 average).

C: Markey penetration ratio of new boiler type = A/B = 2%

(2)Forecast total shipments of new boiler type to 2017 = 800 units.

Forecast annual shipments of new boiler type = 135 units/year

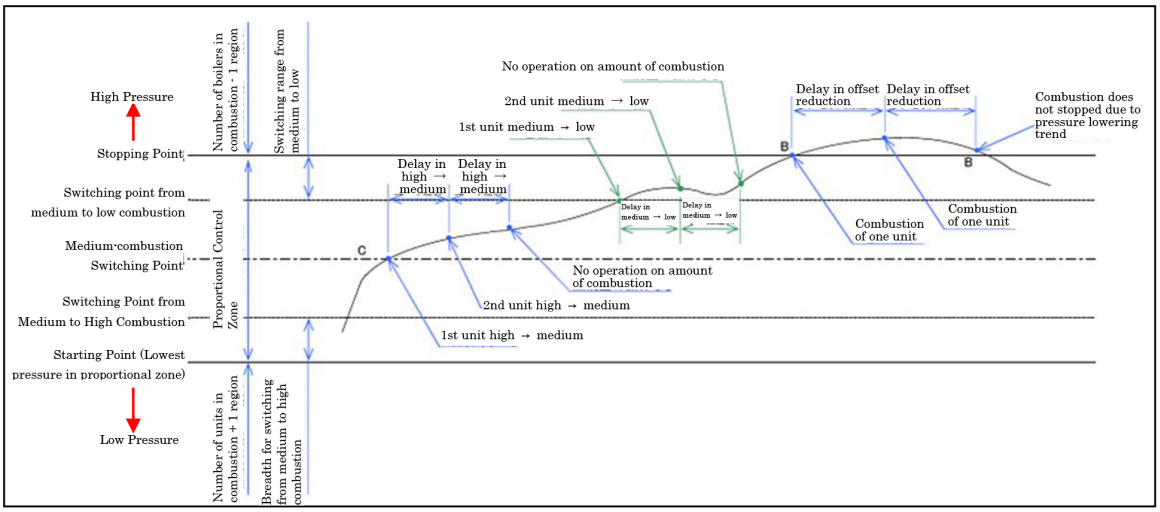


Fig.5 Example of number of units in combustion in 4-position multi-stage operation in pressure control consumption.

Table 2 Comparative operating costs of conventional and new models

Parameter	Conventional Model	New boiler
Heat output	1,250 kW	
Annual load factor	50%	
Boiler efficiency	96%	97.5%
Annual fuel saving	7,000 m^3(N)/year	
Annual fuel cost advantage	Approximately 420,000 JPY/year	
Rated power consumption	5.1 kW	2.8 kW
Annual electricity saving	10,000 kWh	
Annual electricity cost advantage	Approximately 110,000 JPY/year	
Annual reduction of CO_2 emissions	Approximately 20 t-CO_2/year	

(penetration rate 3%).

Forecast total shipments of new boiler type to 2020 = 1,300 units.

Forecast of annual quantity of this boiler shipped = 180 units/year (penetration rate 5%).

11.Additional Information for Reference

(1)CO_2 emission reduction

20 t/year (heat output = 1,250 kW)

(2) Social impacts and other factors.

1) History of Awards Received

•Recipient of 2010 Excellent Energy Conservation Equipment Award (on behalf of the president of the Japan Machinery Federation).

•2011 Excellent Technology Award (Combustion Society of Japan).

•2011 Excellent Environmental System Award (on behalf of the president of the Japan Society of Industrial Machinery Manufacturers).

2) Literature

•'Industrial Machinery,' No. 698 (Nov. 2008,page 15)

•'Environment and Energy,' (April–May 2010,page 47)

•'Boiler Research,' No. 361 (June 2010,page 16)

•Monthly publication 'Energy Conservation,'N(April 2011,page 74)

•'Industrial Machinery,' No. 733 (Oct. 2011,page 19)

•Journal of Combustion Society of Japan,Vol. 54,No. 167 (Feb. 2012,page 6)

•'Industrial Machinery,' No. 746 (Nov. 2012,page 44)

12.Sites Adopting This Technology

Sales networks deployed in Thailand and Japan

13.Bibliography and Reference Information

'2010 Excellent Energy Conservation Equipment,' Monthly publication 'Energy Conservation,' Vol. 63,No. 4,April 2011,pages 74 and 75,The Energy Conservation Center,Japan

14.For More Information,Please Contact:

Nippon Thermoener Co.,Ltd. and Takuma Co.,Ltd.

BAT3: Cogeneration System

1.Business Categories Adopting This Technology

N/A

2.Classification of Technology

N/A

3.Energy Source

Natural gas

4.Year of Commercialization

December 2007

5.Overview

• The power generation efficiency of standard type engines (KG series) is 48.5%. The power generation efficiency of the high-efficiency type (KG-V series) is 49.0% (LHV-base).

• NOx emissions are low at 200 ppm or less (converted at O_2 = 0%) and environmental performance is high.

• The continuous operation range is wide,ranging from 30% to 100% load. The engine uses the spark ignition method and does not require a liquid pilot fuel. The output range is 5 to 7.8 MW^2 and covers varied output requirements.

• Power generation can be started within three minutes after starting the engine. The rated output can be reached within ten minutes.

• The engine is completely developed by in-house technology and manufactured in the mother factory in Japan. Therefore,the engine can flexibly meet various customer requirements. The engine has better power-to-weight ratio and excels in transportability and installability. Refer to table 1.

6.Principles and Operation

• The engine is ignited by the spark ignition method using a spark plug. The pre- and main-combustion chambers are independent in supplying gas,and optimum gas injection is achieved by a high-speed solenoid valve.

• The structure of the combustion chamber is designed with high anti-knocking performance. Ignition timing and gas amounts for each cylinder are individually controlled by the Knocking Analyzer and the Main Control Unit in order to maintain the performance of the engine at a maximum.

• In the KG-V series,suction pressure is controlled by a variable nozzle system,instead of the conventional bypass system,in order to achieve high efficiency through effective utilization of exhaust energy.

• Cogeneration system is applied using waste heat energy,making energy conservation feasible.

See Figure1&2

Table 1

Type		KG-12	KG-18	KG-12-V	KG-18-V
No. of Cylinders		12	18	12	12
Power Generation Output kW	50Hz/750rpm	5,200	7,800	5,200	7,800
	60Hz/720rpm	5,000	7,500	5,000	7,500
NOx		200 ppm (O_2 = 0% equivalent) or less			
Power Generation Efficiency		48.5%		49.0%	

(On ISO 3046, 13A Gas Basis)

7.Improvements Made

See Figure 3&4

8.Effects of Improvement —Improvement in Energy Consumption Rate (Option for Improvement of Energy Conservation Rate)

See Figure 5&6.

9.Economic Efficiency and Changes

Assuming a gas charge of 50JPY/Nm^3 to 70 JPY/Nm^3 for projects in Japan (cogeneration system,power generation + steam supply)

• Economical merit in installing cogeneration system: 3.8JPY/kWh to 6.9 JPY/kWh

• Payback period: 3 to 6 y.

10.Market Situations and Conditions

(1)Penetration rate at present: Record of engines delivered as of September 30,2014:

• Japan: The market share of Green Gas Engines in the large gas engine market of Japan is nearly 100%.

• Outside Japan: Green Gas Engines have been delivered to Singapore,India,and the United States

(2) Forecast of penetration in 2020: 300 engines as a cumulative total.

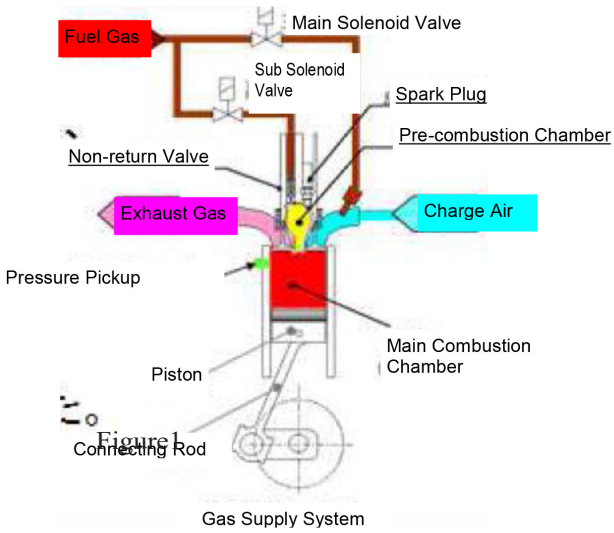


Figure1

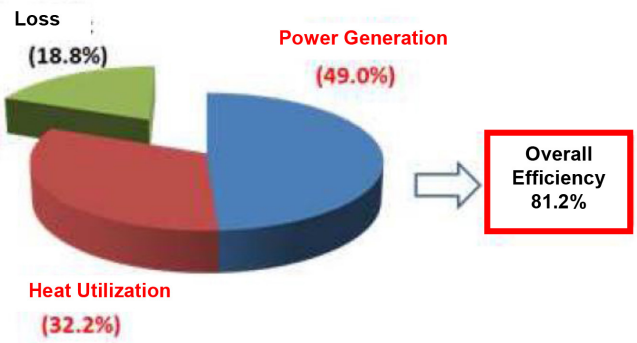


Figure2

Before Improvement

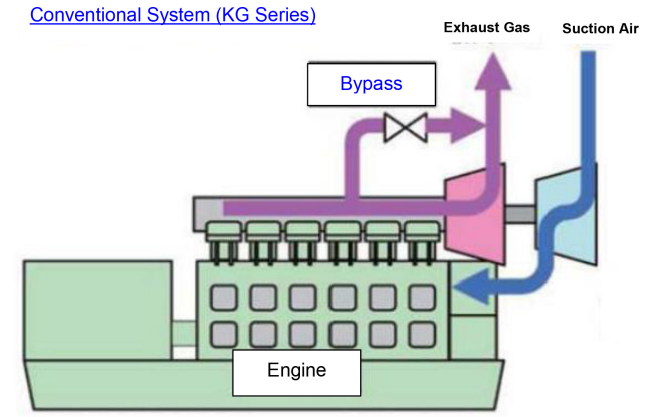


Figure3

After Improvement

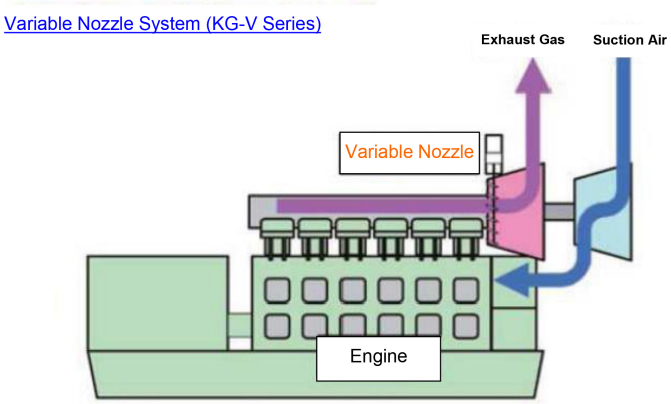


Figure4

11.Additional Information for Reference

(1)CO_2 Emission Reduction

The overall efficiency varies in accordance with the waste-heat recovery applications. The specifics of the efficiency are as follows:

Power generation + Steam + Hot water: 77.1%

Power generation + Hot water: 81.2%

Power generation + Cold water: 74.7%

(2)Social Impacts

Green Gas Engines have been put into operation at the Kobe Works of the Kawasaki Heavy Industries since January 2010. The engines were initially used for research,development,and demonstration purposes. The engines contributed to cutting the peaks in power demand loads as on-site power generation equipment. Thus,they contributed to the prevention of rotating blackouts within the service areas of the Kansai Electric Power Co.

12.Sites Adopting This Technology

A power plant has been installed on the premises of the Kobe Works of the Kawasaki Heavy Industries.

13.Bibliography and Reference Information

JASE-World,Collection of Technologies Used at International Sites (F-22)

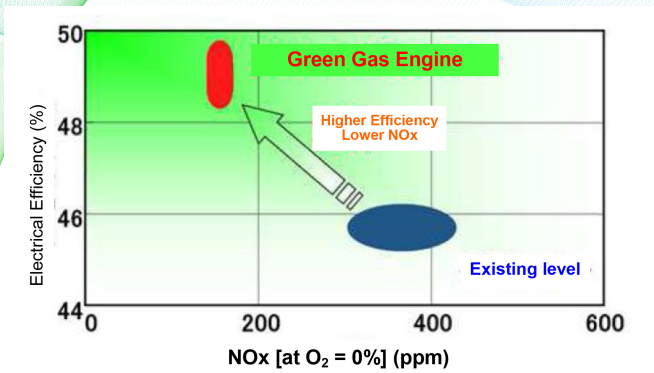


Figure 5

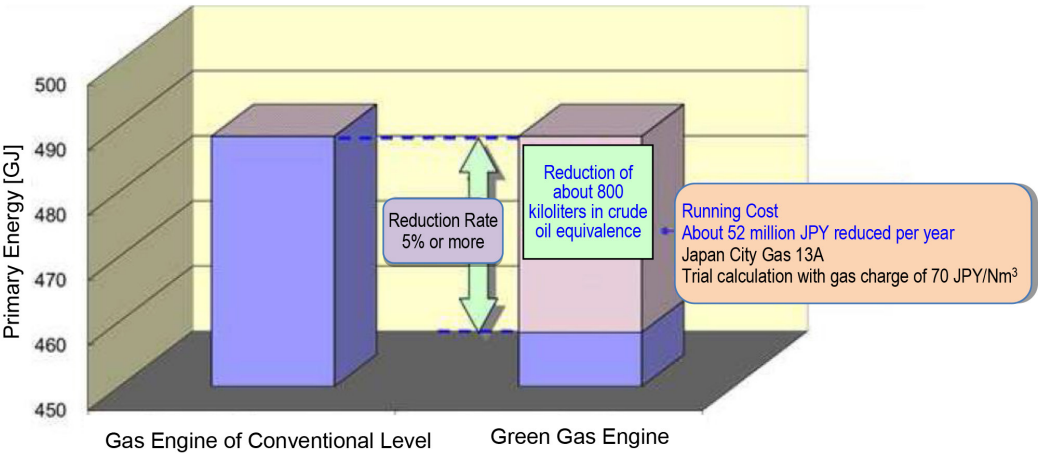


Figure 6

14.For More Information,Please Contact

Energy Solution Division,Gas Turbine & Machinery Company,Kawasaki Heavy Industries,Ltd.

Telephone: +81-3-3435-2211,Fax: +81-3-3435-2022

http:///www.khi.co.jp/

BAT4: High–performance Industrial Furnace (Regenerative Burner)

1.Business Categories Adopting This Technology

Iron and steel,nonferrous metals

2.Classification of Technology

Waste heat recovery (medium to high temperature)

3.Energy Source

Fuel gas

4.Year of Commercialization

1992

5.Overview

The technology is applied to industrial furnaces and other heating facilities. The system consists of a pair of regenerative burners. Each regenerative burner unit comprises a burner portion and a regenerator made of heat-resistant ceramic. The two burners are fired alternately. As one burner is fired,the other idling unit recovers sensible heat from the firing regenerator's high-temperature exhaust gas,which preheats the combustion air in the idling unit to a high temperature,thereby achieving a significant reduction in fuel gas consumption when the idling unit is switched to the combustion mode.

In addition,the high-temperature combustion technology based on this technology also realizes a drastic reduction in thermal NOx generation.

6.Principles and Operation

(1)The high-temperature exhaust gas generated by combustion in one unit of a pair of regenerative burners is passed into the regenerator of the other idling regenerative burner,heating the latter regenerator. After transferring heat to the regenerator,the lower-temperature exhaust gas is discharged to the flue. (See Fig. 1)

(2)Next,the burner of the idling unit begins combustion with high-temperature combustion air that was highly preheated by passing through the heated regenerator. At the same time,the other regenerative burner stops burning fuel and is switched to idling mode to heat its own regenerator by recovering sensible heat from the firing unit's exhaust gas passing through its regenerator. (See Fig. 2)

Thus,as described above,combustion with high-temperature preheated air and the recovery of sensible heat from exhaust gas to preheat the combustion air are performed alternately by each unit.

(3)Preheating the combustion air drastically reduces fuel consumption. Moreover,this high-temperature combustion with an improved burner design creates burning conditions that mitigate a thermally intensified combustion spot,which

results in lowering the maximum flame temperature and hence reducing thermal NOx generation.

7.Improvement Made

Before Improvement

In the case of a conventional steel reheating furnace for steel slabs etc.,the combustion exhaust gas is discharged from the charging side of the furnace and passes through a metal recuperator. After preheating the combustion air in the recuperator,the exhaust gas is discharged through a stack. Due to the conditions of the metallic recuperator,including the thermal constraints of its materials,the temperature of the preheated air is limited to several hundred °C (See Fig. 3).

After Improvement

The ceramic regenerator of the regenerative burner drastically increases the upper temperature limit of the preheating air relative to a metal recuperator,allowing combustion air to be preheated to over 1,000°C in the high-temperature heating zone (soaking zone).

Heat is recovered by each unit of a pair of burners so that heat can be recovered by selecting a desired heating zone. (See Fig. 4)

8.Effects of Improvement - Improvement in Energy Consumption Rate (Option for Improvement of Energy Conservation Rate)

The improvement effect varies greatly depending on the type and size of the furnace. According to data collected at the integrated steelworks of JFE Steel Corporation,after installing the regenerative burners on steel reheating furnaces,fuel consumption was reduced by 9 to 56% and the annual total amount of energy saved was 29 to 294 TJ.

See table1.

9.Economic Efficiency and Changes

Published data or information on monetary amounts is not available.

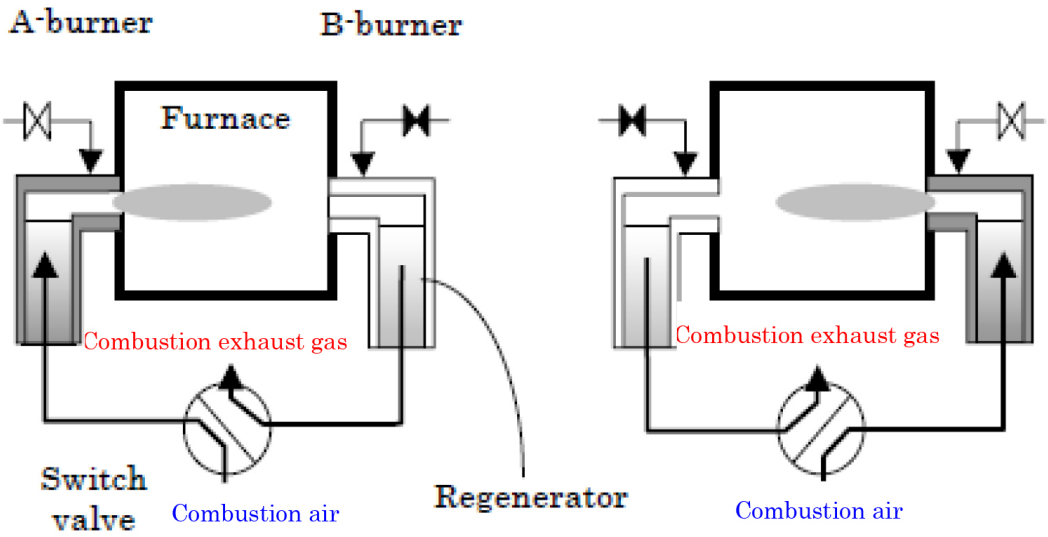


Figure 1 Figure 2

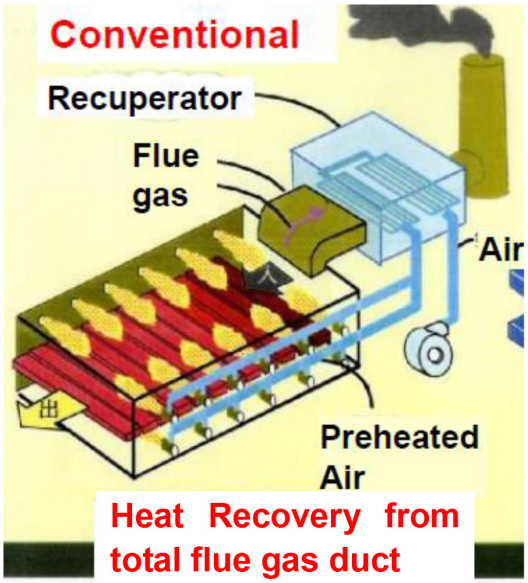


Figure 3

(1)+(2) Equipment investment cost and modification cost:

Published information is not available. However,these costs vary greatly depending on the equipment type and the size and scope of modification. They are estimated to typically range from approximately 10 million JPY to several hundred million JPY. In the case of Item No. 1 shown in Table 1 (Reheating Furnace #3 of Hot Strip Mill #1,Fukuyama Steel Works),the initial investment level is estimated to be approx. 600 million JPY,whereas the annual energy conservation advantage is estimated to be approx. 150 million JPY based on the typical energy price level at the time when the regenerative burners were installed.

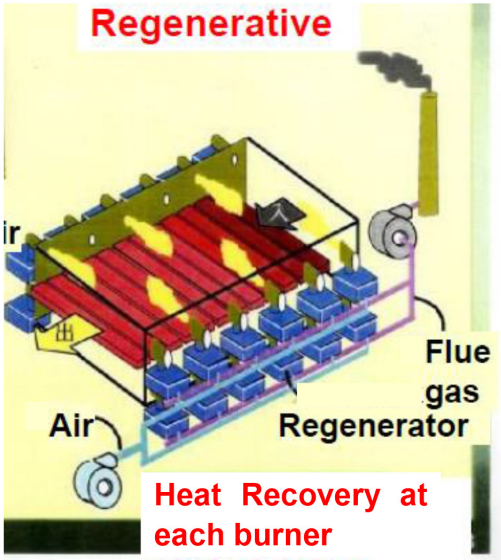


Figure 4

(3) Running costs:

As shown in Table 1,specific reductions in fuel amounts or operating costs achieved through the installation of regenerative burners vary greatly in accordance with the type and size of the facilities. The running costs include the cost of electric power to drive switch-over valves and other devices.

(4) Maintenance costs:

The increased maintenance costs compared with conventional burners include the repair costs of switch-over valves and the regenerators. However,the total maintenance cost is normally less than 3% of an investment amount.

(5)Payback years:

Available information indicates that compared to conventional burners,the cost difference of constructing a new reheating furnace equipped with regenerative burners can normally be recovered within approx. three years.

Energy prices such as the price of natural gas are increasing,and the potential for introducing/disseminating regenerative burners is high in India and other developing countries where steel mills are expected to be newly constructed or expanded.

10.Market Situations and Conditions

(1)Current dissemination rate

•In Japan,the new regenerative burners are installed in almost all reheating furnaces that are in continuous operation.

• In countries outside of Japan,Europe,and the USA,regenerative burners are not installed in most heating facilities for iron- and

Table 1 Summary of Effects

NO	Furnace	Burners	Reduction in Fuel		NO_x
			▼%	▼TJ/Y	
1	Reheating Furnace #3, Hot Strip Mill #1, Fukuyama Steel Works	76	25	294	80
2	Ladle Heater for Electric Arc Furnace, Keihin Steel Works	2	56	29	
3	Batch-type Reheating Furnace #1, Steel Plate Mill, Fukuyama Steel Works	12	40	111	60
4	Reheating Furnace #1, Steel Plate Mill, Keihin Steel Works	16	13	212	31
5	Reheating Furnace #2, Hot Strip Mill #1, Fukuyama Steel Works	76	25	294	80
6	Batch-type Reheating Furnace #3, Steel Plate Mill, Fukuyama Steel Works	6	37	51	53
7	Reheating Furnace #1, Steel Plate Mill, Fukuyama Steel Works	30	9	65	44
8	Reheating Furnace #2, Steel Plate Mill, Fukuyama Steel Works	30	9	65	44

steel-making and nonferrous industries.

(2) Forecast of dissemination after 2017:

• It is expected that this technology will be well-disseminated because more manufacturers in the ferrous and non-ferrous industries could utilize regenerative burners if information on best practices could be collected and disseminated through this program. In particular,the potential to disseminate the ladle heater will be high because the investment required is relatively small and the modification is easy.

• The strong ability of this technology to drastically reduce thermal NOx makes the potential for dissemination higher,especially in developing countries where regulations on pollution control are expected to become stricter in the future.

•Introduction and dissemination of the regenerative burners is also possible in nonferrous industries such as processing and manufacturing plants that feature an ingot melting process,including the process to re-melt aluminum ingots and recycled scrap.

11.Additional Information for Reference

(1) Reduction of CO_2 Emissions

Depending on the energy balance and operation (energy mixture) of steel mills,the reduction of CO_2 emissions will be 55 tons/TJ in case of a reduction in consumption of purchased fuel (natural gas) through a reduction in fuel consumption through energy conservation.

(2) Social Impact

This technology reduces the consumption of fossil fuels through higher efficiency alone and is extremely effective both in stable energy supply and in reducing the emission of greenhouse gases. Additionally,the technology is also effective in improving atmospheric environmental quality through reducing the generation of thermal NOx in exhaust gases.

12.Sites Adopting This Technology

Integrated steel works and the other steel mills in Japan including the Fukuyama and Keihin Steel Works of JFE Steel Corporation

13.Bibliography and Reference Information

(1)NKK Technical Journal No. 178 (August 2002) 'Eco-friendly Regenerative Burner Heating System Technology Application and Its Future View' (http://www.jfe-steel.co.jp/archives/nkk_giho/178/06.html)

(2)'Regenerative Burner,' Nippon Furnace Co.,Ltd.

14.For More Information,Please Contact

JFE Steel Corporation

Nippon Furnace Co.,Ltd.

Chugai Ro Co.,Ltd.

Japan Industrial Furnace Manufacturers Association

BAT5: High Efficiency Inverters

1.Progress of inverter energy savings

In recent years,measures have been introduced for the prevention of global warming and depletion of energy resources,such as the Energy Conservation Law. As a result,energy use is under careful consideration in various fields. With the development of global environmental preservation and the growing interest in cost reduction through energy savings,the demand for saving energy through the use of inverter drives is increasing. Consequently,the technology associated with energy saving inverters has also progressed every year.

2.Energy savings from inverters

Power supplied from energy providers generally has an alternating current (AC) with fixed frequency and voltage. Therefore,when motors are driven by a commercial power supply,the rotational speed is fixed. However,the use of an inverter will allow the rotational speed of the motor to vary.

The inverter converts the commercial power supply to a direct current (DC) (converter),followed by a return to an AC of variable frequency (inverter). The frequency and the voltage can be changed arbitrarily (Figure 1).

The rotational speed of the motor is proportional to the frequency. By varying the frequency and voltage applied to the motor by the inverter,the motor can be operated at variable speeds.

The load torque of fans and pumps is proportional to the square of their speed (air flow),and the output is proportional to the cube of their rotational speed (air volume). Therefore,if a machine with a variable load torque is controlled with an inverter,significant energy savings can be expected in comparison with the commercial operation (damper control*2) (Figure 2).

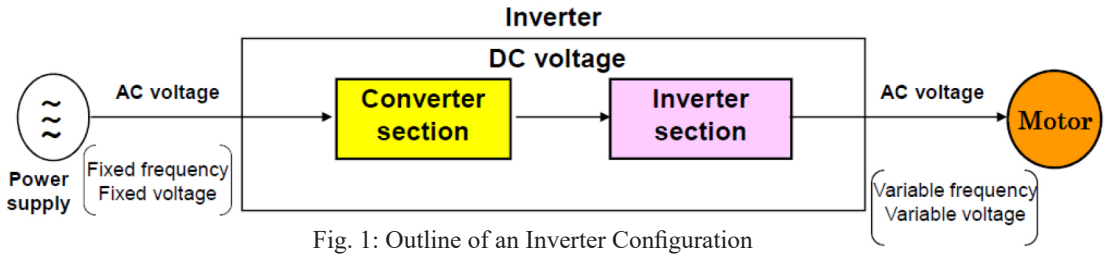


Fig. 1: Outline of an Inverter Configuration

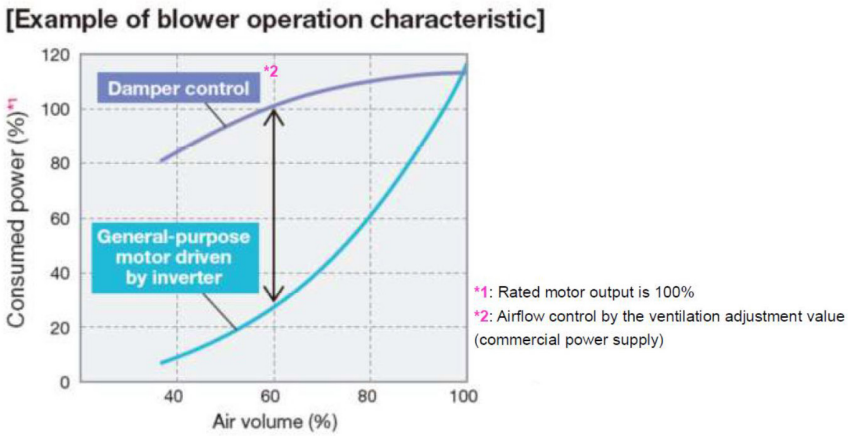


Fig. 2: Outputs with variable torque

3.Energy-saving technology of inverters

Modern inverters are equipped with energy saving technologies.

(1)Driving high-efficiency motors

As a recent highly effective method of energy saving,the Interior Permanent Magnet (IPM) motor has deterred attention away from induction motors. The IPM motor is a synchronous motor with embedded permanent magnets in the rotor. Induction motors apply a current to the rotor conductor in order to obtain a rotational force (torque). This generates a magnetic flux,which leads to a loss in the rotor (secondary copper loss). Because the IPM motors contain magnets,loss current does not flow in the rotor and secondary copper loss does not occur. The efficiency is improved compared with the induction motor.

IPM motors that are driven by a general-purpose inverter simplify inventory management through product integration. It is possible to change only the motor to an IPM motor at the time of motor renewal,and consequently,achieve further energy saving benefits.

(2) High-efficiency control of induction motors

A suitable efficiency control scheme has also been devised for the induction motor. Typically,V/F control is a constant ratio of the output frequency and the output voltage to the motor. By utilizing high-efficiency control to improve motor efficiency,it can be increased by more than 10%.

(3) Standby power reduction

By using DC24V externally,it is possible to only operate the

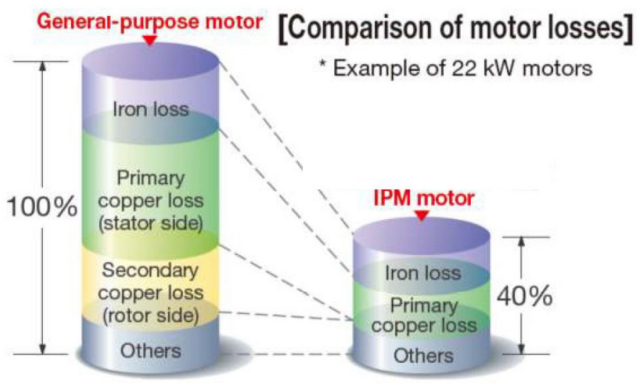


Fig. 3: Efficiency comparison

control circuit. While maintaining the parameter settings or communication,it is possible to turn off the main power supply to the circuit. This makes it is possible to reduce standby power. Additionally,the operation of the cooling fan is controlled according to the temperature of the cooling fin of the inverter. This allows a reduction in the standby power by decreasing unnecessary fan operation.

4. Application examples

In the following examples,the energy-saving effects of the inverter are shown:

(1)Cooling water pump

(2)Air conditioning for buildings

BAT6: Application Expansion of High Efficiency Lighting

1.Evolution of LED Lighting Technology

The emergence of LEDs has extended the interest in lighting to a wide range of fields including design engineers involved in architectural facility design,architectural designers,lighting consultants,organizations promoting energy conservation,and general consumers. The trend even involves engineers in industries not directly related to lighting,and people across a wide range of business sectors,including light-applied sectors.

1.1 LED Features with regard to Lighting Application

Features that cannot be found with other light sources,such as energy efficiency,long life,small size,and compactness.

1.2 Evolution of Technology

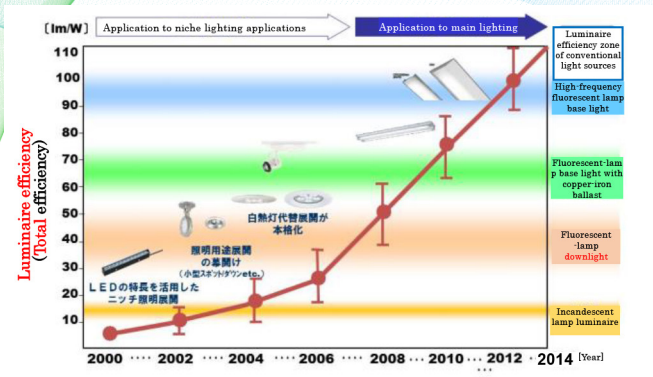
An LED chip is a directional point light source,and was originally suitable for use in spot-lighting and down-lighting. LED lamp manufacturers have repeatedly launched products with unique light dispersion characteristics,in order to provide luminosity with similar intensity of distribution to that of fluorescent lamps so that they can be used as general purpose lighting and base lighting,such as fluorescent lamps. Thus,the debut of LEDs has further spurred the development of new lighting design techniques such as variance in color of light and enhancement of color rendering properties. Overviewing the changes of LED products in lighting in architectural facilities,the luminaire efficiency has already reached the level of high-frequency fluorescent lamps.

Incandescent lamps cannot exceed approximately15 lm/W and are being replaced by fluorescent and LED lighting. The luminous efficiency of general fluorescent lamps had been leveling-off until high-frequency inverter fluorescent lamps were introduced,after which efficiency started to increase again. The efficiency of high-pressure sodium vapor lamps has saturated at a high level. When white LED lamps were developed in the second half of the 1990s,their efficiency was less than that of incandescent lamps. However,efficiency has increased significantly each year since the technology was commercialized.

Refer to the figure on the next page.

1.3 Toward Market Penetration of LED Lighting

High expectations are placed on the future of LED lighting. Technological development of LED lighting is advancing toward market penetration and expansion by incrementally resolving the following challenges.



•Comparison of service lives of conventional light sources and LED lamps

LED lamps have long service life of up to 40,000 hours,compared with 12,000 hours for high-frequency fluorescent lamps and high-intensity discharge lamps.

• Enhanced luminosity efficiency of various light sources

(1) Higher energy efficiency

(2) Better quality of light

(3) Higher color-rendering properties

(4) Control of dispersion characteristics

(5) Cost reduction per luminous flux

(6) Quality

2.LED Lighting and Energy Conservation

The crucial matter for energy conservation in lighting is a reduction in power consumption during lighting. Delamping and lowering of illuminance levels are hardly primary methods of energy conservation. The energy consumption of a lighting system is obtained by multiplying the power of the luminaire by the number of luminaires by the lighting duration. Therefore,the points for energy conservation are as follows:

• Power consumption: low loss of ballast (inverter ballast)

• Lighting duration: sensor control and timer control

• Area: optimal control of lighting for each area

• Lamp luminous flux: use of high-efficiency lamps

• Utilization factor: luminaire of high efficiency and high interior reflectance

• Maintenance factor: lamps with high luminous flux retention rate. cleaning and maintenance of luminaires and lamps

Additionally,wide-ranging technologies are currently being developed,including: higher efficiency,larger luminous flux,more products for each color temperature,higher color rendering index,better luminous intensity distribution characteristics,development of light-color control and dimming functions,and improved light-color and color-rendering properties for each application.

The following two examples are taken from the aforementioned examples,to demonstrate recent developments in energy conservation.

(1) Hitachi Appliances,Ltd.

Promotion of improvement of LED lamps and ceiling lighting,aimed at achieving both larger luminous flux and higher efficiency by improvement of heat radiation performance.

(2)Toshiba Lighting & Technology Corp.

Development of technologies for LED lamps compatible with incandescent bulb dimmers to achieve smooth and stable control for full-range dimming. ■

BAT6-1: High-efficiency LED Lighting

1.Business Categories Adopting This Technology

Lighting equipment

2.Classification of Technology

High-efficiency lighting

3.Energy Source

Electricity

4.Year of Commercialization

2014

5.Overview

The proportion of energy consumed for lighting purposes is high,comprising approximately 13% in ordinary households,and approximately 21% in office buildings.

There is an increasing demand for LED lighting with a high output of light and high efficiency,as an alternative source of light. As the LED temperature and heat emission increases,its luminous efficacy decreases. One of the major challenges associated with LED lighting is to achieve both a high output of light and high efficiency at the same time. In recognition of its efforts to address this challenge,Hitachi Appliances Ltd. was awarded the 2013 Energy Conservation Grand Prize for its creation of residential LED ceiling lights and LED light bulbs. These ceiling lights and light bulbs have a high output of light and high efficiency,through a structural design featuring compactness and high-heat radiation efficiency,and an optical design to improve the luminous intensity distribution with minimal loss.

Additionally,the performance of LED ceiling lights and light bulbs are significantly enhanced through the continuous development of core technologies,and Hitachi Appliances has expanded the application of its high-efficiency LED lighting technology to LED lamps (E39 cap) for commercial facilities. Hitachi Appliances is accelerating the commercialization of high-efficiency LED lighting products as itscontribution to energy conservation in a variety of locations,without sacrificing brightness.

6.Principles and Operation

With LED lighting,Hitachi Appliances is continually developing a common core technology that disperses and efficiently radiates heat emitted by LED modules to achieve both a high output of light and high efficiency at

the same time. By fully employing structural design expertise and material utilization technology to enhance heat transfer performance,optical design technology to minimize optical losses while ensuring a luminous intensity distribution,and a design process using high-accuracy thermal analysis and optical simulation,the design of high-efficiency LED lighting products can be optimized within a short time period. The developmental power of these technologies allows the creation of products with excellent performance in the wide-ranging field of LED lighting. Specific examples of these technologies are described below:

(1)Technology for High Output of Light and High Efficiency for LED Ceiling Lights

1) Dispersed arrangement of LED modules to lower temperature increases Many high-efficiency LED modules are mounted almost uniformly on a largecircuit board to disperse the heat generated by the emission of a large quantity of light.

2) Optics technology to distribute lighting with minimal losses

Each LED module has a specially designed dome-shaped lens that efficiently distributes the light emitted by the LED module with minimal reflection loss. Therefore,the entire surface of the LED Ceiling Light can emit light uniformly and clearly. This results in excellent light distribution and contributes to an increase in brightness throughout the room.

3) Automatic dimming control with illuminance sensors for additional energy conservation

The Eco-illuminance Sensor detects room brightness,and automatically adjusts the brightness of the room to a preset level. The sensor automatically reduces light output to minimize surplus power consumption when the room brightness is high due to natural light,or other light sources.

(2)Technology for High Output of Light and High Efficiency of LED Light Bulbs.

The size of the circuit board for the light source,on which LED modules are mounted,is increased in order to enhance the heat radiation performance of the board,and to disperse the heat of the LED modules. By increasing the contactarea with the aluminum heat sink,heat is effectively transmitted to a heat sink of a new design featuring a large surface area,thereby providing high heat radiation performance.

(3)Technology for High Output of Light and High Efficiency for LED Lamps in Commercial Facilities (E39 cap)

An optimal shape for the heat radiation fin has been developed through repeated simulations using an original heat-conduction analysis method to radiate heat. This heat is generated by emitting a large quantity of light,in excess of 20,000 lumens,using a compact heat sink that can be mounted on existing luminaires. High efficiency is achieved through a unique concept involving the arrangement of LED modules aligned to individual radiation fins.

7.Improvement Made

Before Improvement

LED ceiling lights for 13 m^2 (LEC-AHS810B) to 30 m^2 (LEC-AHS1810BC) LED light bulbs of compact bulb type (LDA6L-H-E17/S) to general bulb type (LDA17L-G)

After Improvement

Hitachi Appliances has developed the following technologies for high-efficiency LED lighting aimed at achieving both a high output of light and high efficiency.

The LED ceiling lights optimize the number of LED modules for each room area class,and feature a dispersed placement of the LED modules. The lightsincorporate a dome-shaped lens that effectively distributes light with minimal optical loss. See Figure 1.

The LED light bulbs have LED modules mounted

dispersively on a large circuit board to disperse heat generation. The bulbs also have a newly developed compact and fin-shaped body with a large surface area to effectively radiate heat.

LED lamps used for commercial facilities have a large aluminum circuit board,featuring a structure that directly transmits heat to a body with a large surface area,achieving a high-efficiency performance paired with a high light output of 21,500 lm.

8.Effects of Improvement - Improvement in the Energy Consumption Rate (Option for the Improvement of the Energy Conservation Rate)

(1) LED Ceiling Lights

A comparison of the total luminous flux (lm) and luminaire efficiency (lm/W) of products from major manufacturers for each room area class is shown in the following table. The LED ceiling lights of Hitachi Appliances feature the highest illuminance and the highest energy conservation performance.

See Table 2.

(2) LED Light Bulbs

A comparison of the luminaire efficiency (lm/W) of products from major manufacturers for each brightness level is shown in the following table. The LED light bulbs by Hitachi Appliances,including those under development,show the highest efficiency the highest compared to all other products in this class.

See Table 3.

(3)LED Lamps for Commercial Facilities (E39 Base)

A comparison of the luminaire efficiency (lm/W) of products from major manufacturers in each class is shown in the following table. The efficiency of LED lamps from Hitachi Appliances is the highest out of all three classes.

See Table 4.

9.Economic Efficiency and Changes

(1) Market Potential

According to statistical data compiled by the Japan Lighting Manufacturers Association,the number of LED ceiling lights shipped to the Japanese market amounts to about 17 million as of April 2014. As LED ceiling lights could be installed in multiple rooms in 50 million households in Japan,the market is anticipated to expand further in the future. Based on statistics of light bulb shipments compiled by the Japan Lighting Manufacturers Association,Hitachi Appliances estimates that the present penetration rate of LED light bulbs is about 28%,and that this percentage will increase further. The debut of LED lamps with the E39 cap will accelerate the replacement of

Table 1

Objective	Technology Developed	Residential LED Ceiling Light	LED Light Bulb E26 and E17 Bases	LED Lamp for Commercial Facilities E39 Base
Control of Generated Heat	Use of high-efficiency LED modules	◎	◎	◎
Heat Dispersion	Large circuit board	○	◎	◎
	Dispersed placement of LED modules	◎	◎	◎
High Heat Radiation Performance	Direct heat radiation	○	○	◎
	Radiator body with a large surface area	○	○	◎
Minimum Loss	High-efficiency drive circuit	○	○	○
	Reduction of optical losses	◎Dome-shaped LED unit	◎Light-diffusion cover	◎Reflector

◎ denotes technology developed in 2014 FY

Table 2

	Eco-illuminance Sensor Western type							Western type				
Room Floor Area	Up to 30 m² Color LED ring	Up to 30 m²	Up to 23 m²	Up to 20 m²	Up to 17 m²	Up to 13 m²	Up to 10 m²	Up to 30 m²	Up to 23 m²	Up to 20 m²	Up to 17 m²	Up to 13 m²
Model (beginning with a prefix LEC)	AHS1810CC	AHS1810C	AHS1410C	AHS1210C	AHS1010C	AHS810C	AHS610C	AH1800C	AH1400C	AH1200C	AH1000C	AH800C
		AHS1816C	AHS1416C	AHS1216C		AHS816C		AH1811C	AH1411C	AH1211C	AH1011C	AH811C
								AH1815C	AH1415C	AH1215C	AH1015C	AH815C
								AH1850C	AH1450C	AH1250C		AH850C
Rate Luminous Flux (lm)	8,000	8,000	6,099	5,499	4,899	4,299	3,699	8,000	6,099	5,499	4,899	4,299
Rated power consumption (W)	63.6	63.6	49.5	44.6	39.8	34.8	30.0	63.3	49.2	44.3	39.5	34.5
Luminaire Efficiency (lm/W)	125.8	125.8	123.2	123.3	123.1	123.5	123.3	126.4	124.0	124.1	124.0	124.6
Luminaire Efficiency of the conventional model of Hitachi Appliances (lm/W)	84.8 AHS1810BC	-	104.8 AHS1410B	103.0 AHS1210B	103.1 AHS1010B	102.4 AHS810B	-	-	104.8 AH1400B	103.0 AH1200B	103.1 AH1000B	102.4 AH800B

fluorescent and incandescent lamps in the LED lamp market for commercial facilities. The LED product lineups featuring a high,top-class output and a high efficiency in various product groups are considered to be predominant in the market.

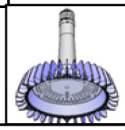
(2) Economic Efficiency

Calculations of the annual reduction in electricity charges in the case of replacement of conventional light sources with LED lighting are shown below. The table does not include luminaire purchasing and installation costs. The calculations are based on a standard household with a living room,dining room,kitchen,and three rooms,while assuming that four ceiling lights and five light bulbs are lit 2,000 hours per year. The trial calculations for factory lighting are based on 30 metal halide lamps of 400-W class,lit 3,000 hours per year while assuming a medium-sized area of 640 m2 as an example. The calculations show that approximately 19,000 JPY (69%) is saved per year for a residential house,and approximately 480,000 JPY (61%) for a factory,indicating that LED lighting can offer high economic efficiency in various facilities and living spaces.

Table 3

Type	General Bulb Type (E26 Base) Wide Light Distribution Type								General Bulb Type (E26 Base) For dimmer control device		Compact Bulb Type (E17 Base) Wide Light Distribution Type		Compact Bulb Type (E17 Base) Lower Part Light Distribution Type				Beam Lamp Type (E26 Base)		
Date Launched	Sep. 10 2014		Sep. 10 2014		July 10 2014		Feb. 10 2014		Sep. 10 2014		Sep. 10 2014		Sep. 10 2014		Sep. 10 2014		Oct. 10 2014 (scheduled)		
Product Full View																			
Model	LDA13L-G/100C	LDA11D-G/100C	LDA10L-G/80C	LDA10D-G/80C	LDA9L-G/60HC	LDA9D-G/60HC	LDA8L-G/60A	LDA7D-G/60A	LDA9L-G/D/60C	LDA7D-G/D/60C	LDA5L-G-E17/S/40C	LDA5D-G-E17/S/50C	LDA7L-H-E17/S/60C	LDA6D-H-E17/S/60C	LDA4L-H-E17/S/40C	LDA4D-H-E17/S/40C	LDR14L-W/150C	LDA11L-W/100C	LDA7L-W/75C
Light Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Daylight Color	Electric Lamp Color	Electric Lamp Color	Electric Lamp Color
Total Light Flux (lm)	1,520		1,160		1,000		810		810		500	600	760		440		1,550	1,100	800
Approx. Brightness	Equivalent to 100 W Class		Equivalent to 80 W Class		Equivalent to 60 W Class		Equivalent to 60 W Class		Equivalent to 60 W Class		Equivalent to 40 W Class	Equivalent to 50 W Class	Equivalent to 60 W Class		Equivalent to 40 W Class		Equivalent to 150 W Class	Equivalent to 100 W Class	Equivalent to 75 W Class
Rated power consumption (W)	13.3	11.4	10.3	9.5	9.3	8.7	8.1	7.3	9.0	7.3	5.0	5.2	6.9	5.8	4.4	4.0	14.4	11.0	7.3
Luminaire Efficiency (lm/W) (Top Runner Standard FY2017 Achievement Percentage)	114.2 (115%)	133.3 (121%)	112.6 (114%)	122.1 (111%)	109.0 (109%)	114.9 (104%)	100.0 (101%)	111.0 (100%)	90.0 Not Covered Under Top Runner Program	110.9	100.0 (101%)	115.3 (104%)	110.1 (111%)	131.0 (119%)	100.0 (101%)	110.0 (100%)	107.6 Not Covered Under the Top Runner Program	100.0	109.5
Luminaire Efficiency of the Conventional Model of Hitachi Appliances (lm/W)	91.0 LDA17L-G	101.3 LDA15D-G	77.3 LDA15L-G	101.8 LDA11D-G-A	-	-	71.1 LDA11L-G-A	92.0 LDA9D-G	-	-	72.9 LDA7L-G-E17/S	88.6 LDA7D-G-E17/S	-	108.6 LDA7D-H-E17/S	81.5 LDA5L-H-E17/S	-	-	-	-
Mass (g)	140	140	120	120	100	100	105	105	125	125	45	45	55	55	35	35	325	325	325
Size: Outer Diameter	60	60	60	60	60	60	60	60	60	60	35	35	40	40	35	35	121	121	121
Size: Overall Length (mm)	123	123	123	123	112	112	112	112	112	112	74	74	67	67	67	67	132	132	132

Table 4

	Product Full View		Metal Halide Lamp 400 W Class	Mercury Vapor Lamp 400 W Class	Mercury Vapor Lamp 250 W Class
Hitachi Appliances		Model	LME2101MN	LME1601MN	LME1101MN
		Rated Luminous Flux (lm)	21,500	16,800	11,600
		Luminaire Efficiency (lm/W)	134.4	138.8	139.1
		Date Launched	July 2014	July 2014	July 2014

Note: The preconditions for the calculations of reductions in electricity charges are 27 JPY/kWh for residential houses,and 21 JPY/kWh for industrial facilities.

See Table 5&6.

10.Market Situations and Conditions LED Ceiling Lights

LED Ceiling Lights

(1) Penetration at present: Approximately 17 million lights (as of April 2014)

(2) Forecast of penetration in 2017 (or 2020): Not available

LED Light Bulbs

(1) Penetration at present: Approximately 28%

(2) Forecast of penetration in 2017 (or 2020): Not available

11.Additional Information for Reference

(1)Patents and Utility Models

•Applications for patents planned

(2) History of Awards Received

N/A

12.Sites Adopting

This Technology Throughout Japan

13.Bibliography and Reference Information

N/A

14.For More Information,Please Contact:

Hitachi Appliances,Ltd. ■

Table 5

Trial Calculation of the Electricity Charge for Residential Houses	Fluorescent Ceiling Lights and Incandescent Bulbs	LED Ceiling Lights and LED Bulbs
Example of Luminaires	One ceiling light for each 23, 17, 13, and 10 m² room Light bulbs: 4 60 W-class bulbs, 1 100 W-class bulb	
Power Consumption (W/household)	666 W	207 W
Annual Power Consumption (kWh/year)	1,332	414
Annual Electricity Charge (JPY/year)	About 36,000 JPY	About 11,200 JPY
Reduction in Electricity Charges	Reduced by approximately 24,800 JPY (69%)	

Table 6

Trial Calculation of the Electricity Charge for Factories	Metal Halide Lamp, 400 W Class	LED Lamp, 400 W class
Example of Luminaires	30 metal halide lamps 400 W class	
Power Consumption (W/factory)	12,450	4,800
Annual Power Consumption (kWh/year)	37,350	14,400
Annual Electricity Charge (JPY/year)	About 785,000 JPY	About 303,000 JPY
Reduction in Electricity Charges	Reduced by approximately 480,000 JPY (61%)	

BAT6–2: Premium Dimming Technology

1.Business Categories Adopting This Technology

Lighting equipment

2.Classification of Technology

High-efficiency lighting

3.Energy Source

Electricity

4.Year of Commercialization

2014

5.Overview

LED lamps have been widely accepted for use in recent years in relation to their high-efficiency performance and long life. Nevertheless,it is evident that the public is not entirely satisfied with the dimming application of LED lights,which causes light flickering and difficulties using the dimming function at a low level of lighting. These common problems are obstructing widespread change from use of incandescent lamps to LED lamps. Although some LED lamp manufacturers are developing new dimming technologies and dimmers,users of existing dimmers will need to pay additional costs to replace current dimmers with the ones being newly developed. However,Toshiba Lighting & Technology Corp. has developed its own technologies and commercialized LED lamps that can be used with conventional dimmers. This technology ensures a minimal flickering of the light,and the bulbs can be dimmed in the range of 0 to 100%,which is the same range as that of incandescent lamps. The company further aims to expand the use of LED lamps with the use of this newly developed technology.

6.Principles and Operation

Toshiba Lighting & Technology Corp. organized project teams to address various technical challenges,enabling a developmental policy for each elemental technology. The technical challenges were then overcome through cooperation between relevant departments.

(1)Premium Dimming Control Program

Conventional dimmers were designed to dim incandescent lamps,and problems such as flickering or extinguishing of the light occur if a general LED lamp is used with a conventional dimmer. This is because the electrical characteristics of LED

lamps are different from those of an incandescent lamp and the dimmer cannot therefore function effectively.

The LED lamp introduced here can be controlled without the occurrence of light flicker,even when used with a conventional dimmer. This is achieved through the unique digital processing of a built-in microcomputer. The principal functions of the built-in microcomputer are as follows:

1)To determine the type of dimmer and to optimally control the LED lamp accordingly.

2)To monitor the waveform of the dimmer and to estimate its output.

3)To inform the lighting circuit of the current used in the LED.

4)To suppress any light output fluctuations,even when the dimmer operation is unstable or when the power supply voltage fluctuates.

Such installed functions enable LED lamps to be used with various types of dimmers. The microcomputer can suppress light flicker near the lower limit of dimming,which is caused by drops in voltage when an electric home appliance of a large capacity such as a hair dryer,vacuum cleaner,or induction heating equipment is used,or by distortion of the voltage waveform caused when a dimmer of other system is used. Smooth dimming is possible from full lighting to extinction,and fluctuations of light output can be controlled even near the lower limit of dimming. Furthermore,when combined with the dedicated dimmer for LED lamps manufactured by Toshiba Lighting & Technology,the buzzing sound generated by the dimmer can be mitigated.

See Figure1.

(2) Optical Design and Structural Design

LED lighting products require a combination of optical and thermal designs. In the optical design,thermal conditions are taken into consideration when selecting LED elements and their physical placement. The function of heat radiation provided by the LED elements is delivered by the lamp's housing,and the design structure that retains the form of an incandescent bulb has been sought in simulations. Such designs have enabled LED lamps to be mounted in closed apparatus,where it has not been

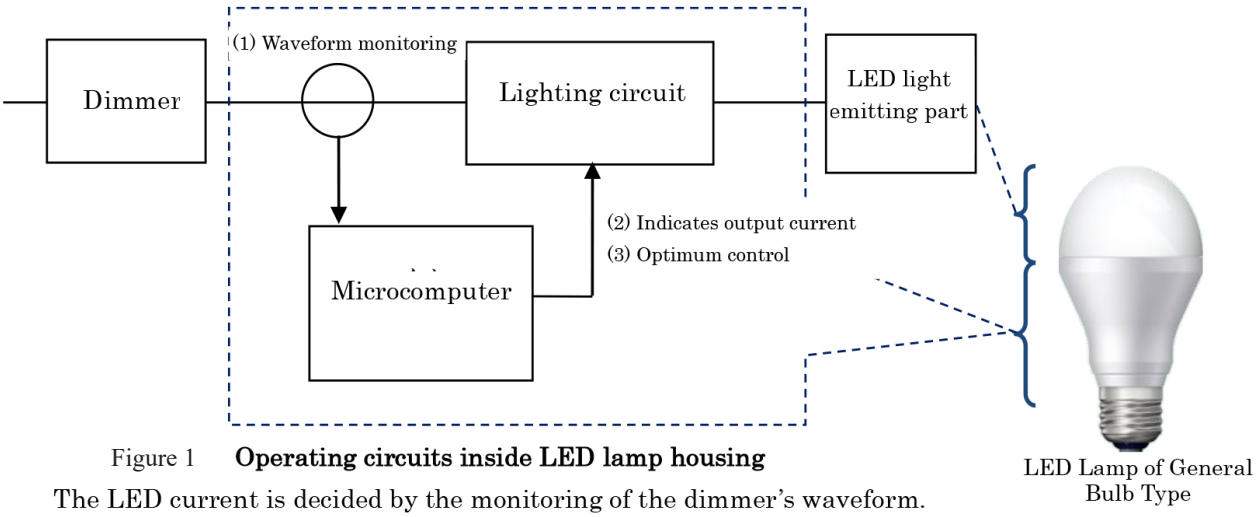


Figure 1 **Operating circuits inside LED lamp housing**

The LED current is decided by the monitoring of the dimmer's waveform. Light flickering is controlled automatically by the microcomputer, even if there is a fluctuation of the power supply voltage.

possible to install conventional LED lamps.

7.Improvements Made

Before Improvement

Model No. LW100V54W55

Incandescent lamp manufactured by Toshiba Lighting & Technology in 2010

After Improvements

Model No. LDA8L-G-K/D/50W

LED lamp manufactured by Toshiba Lighting & Technology (Color: Warm white,Equivalent to 50W incandescent lamp)

Model No. LDA8N-G-K/D/60W

LED lamp manufactured by Toshiba Lighting & Technology (Color: Neutral white,Equivalent to 60W incandescent lamp)

Specifications:

See Table 1.

Principal Features:

(1)To be used with conventional dimmers for incandescent lamps (phase-control dimmer of 2 wire type) with PREMIUM Dimming Technology

(2)Energy saving of 85% in comparison with that of an incandescent lamp

(3)Wide light distribution angle of 180 degrees

(4)Compatible with enclosed fixtures

(5)Long service life of 40,000 hours

Full View and Package:

Refer to Figure 2.

8.Effects of Improvement - Improvement in Energy

Figure2 Full View and Package:LED LAMP-General Bulb Type

Consumption Rate (Option for Improvement of Energy Conservation Rate)

A comparison of the energy consumption of LED lamps with that of incandescent lamps is shown below,demonstrating that power consumption can be reduced by 85%. Additionally,further energy conservation can be expected by using the dimming function.

See Table 2.

9.Economic Efficiency and Changes

(1)Market Potential

By suppressing the light flicker caused by drops in voltage when an electric home appliance of a large capacity such as a hair dryer,vacuum cleaner,or induction heating equipment is used,or by distortion of the voltage waveform caused when a dimmer in another system is operated,the newly developed LED lamps can now be used in markets such as hotels and

Table 1 Specifications

Model	Light Source Color	Dimensions (mm)		Base	Total Luminous Flux (lm)	Rated Power Consumption (W)	Energy Efficiency (lm/W)
		Outside Diameter	Total Length				
LDA8L-G-K/D/50W	Warm white	60	113	E26	640	8.2	78.0
LDA8N-G-K/D/60W	Neutral white	60	113	E26	810	8.2	98.8

Table 2

	LED Lamp Under Application		Comparable Product	Reduction of Power Consumption (%)
Type and Model	Equal to 50W class LDA8L-G-K/D/50W	Equal to 60W class LDA8N-G-K/D/60W	LW100V54W55	
Energy Consumption Efficiency (lm/W)	78	98.8	15	-
Power Consumption (W)	8.2		54	-85

theaters (which were not previously able to adopt LED lamps). The total market is conservatively estimated at about 15 million lamps. (Lamps with the dimming function with an E26 base represent about 10% of total E26-base lamps in Japan. Source: Toshiba Lighting & Technology Corp.)

(2)Economic Efficiency

Compared with incandescent lamps,the newly developed LED lamps can reduce the energy consumption currently used by approximately 85%. By the end of 40,000 hours of rated life,a total of approximately JPY 50,300 would have been saved in electricitycosts. As illustrated below,the total expenses will equal that of one incandescent lamp when the LED lamp is used for about 4,200 hours,which is equal to approximately one year if the LED lamp is lit for ten hours per day.

Refer to Figure 3.

10.Market situations and Conditions Market volume (Estimated)

(1)2014:Approx. 15 million lamps

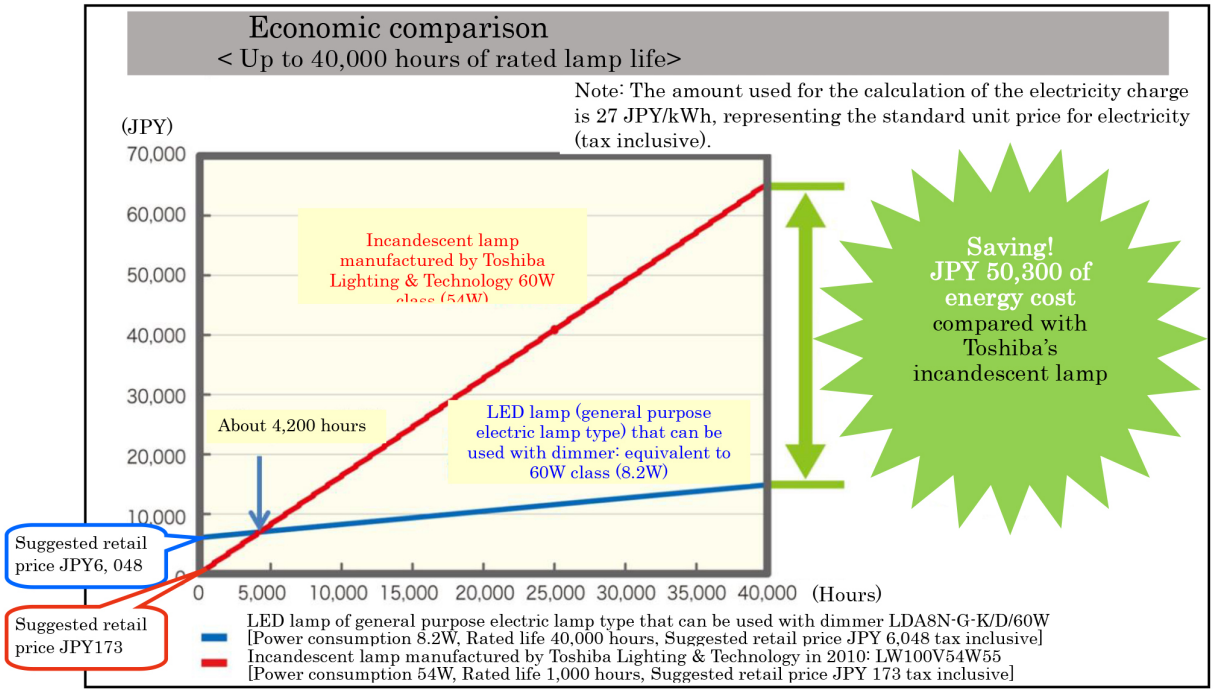


Figure 3

(2)2017 (or 2020) : Data not currently available

11.Additional Information for Reference

(1)Patent Applications and Patents Acquired under Development of This Technology

• Patent registration: 23 registrations (Applications filed)

• Trademark registration: 1 registration (Already registered) 'E-CORE'

(2)Status of External Evaluation such as Citations

• None

(3)Release of Information to Academic Societies and Press

• Press release made on February 26,2014 (for the general purpose electric lamp type)

12.Bibliography and Reference Information

N/A.

13.For More Information,Please Contact :

The Toshiba Lighting & Technology Corp. ■