Second Batch of Domestic TOP TENs List

Japan Industrial BAT List

BAT1: Optimum Control of High Efficiency Inverter Centrifugal Chillers Using a Heat Source Integrated Control System

1.Category of industry

Air conditioning

2.Category of technology

High efficiency next-generation air conditioning technology

3.Source of energy

Electrical equipment

4.Practical application

April 2010

5.Summary

This product is an optimizing controller that implements centralized control of heat source systems including the control of auxiliary equipment in order to realize the optimum energy conservation performance of inverter centrifugal chillers. By implementing optimized control,an energy conservation effect can be realized that is even greater than before,not only through applying high efficiency inverter centrifugal chillers as heat source equipment,but also by integrating air conditioning systems including auxiliary equipment such as pumps and cooling towers. In particular,the development of a plain control algorithm for overall optimization was outstandingly innovative,aiming to implement control of multiple centrifugal chillers and independently control the various auxiliary equipment to realize high COP values. Additionally,in contrast to the fact

that the heat source system control was previously an integral-style program optimized to the site,the use of a mass-produced-type standard built-in control program realized quality improvements and reductions in the introduction costs for each case. In an actual case of introducing this system,an annual average system COP of 7.7 was achieved (compared to COP 5.9 before the introduction),realizing a 23% reduction in electric power consumption (corresponding to 378 MWh/year).

6.Principle and operation

As a controller of the heat source system,the product has the following three features.

(1)Extraction of the best performance from the centrifugal chillers

By conducting communications with the chillers,operating data including the optimum load area is obtained. Using this acquired data,control of the number of units and distribution of the cooling water flow rates are implemented to enable operation of the equipment at a high COP. In addition,utilization of the chiller communications data will also help to make it unnecessary to mount sensors such as thermometers and flow meters on the equipment.

(2)Incorporation of various energy conservation control functions

Six main types of control software for heat source equipment are incorporated as a package,allowing customers to freely set combinations according to their needs. Further,whichever combination type is selected,the best energy conservation control is offered for that combination. This reduces the work load for the system design and equipment installation required for the realization.

<1> Multiple chiller unit control <2> Cooling water variable flow control <3> Chilled water variable flow control <4> Cooling tower control <5> Chilled water bypass valve control <6> Main pipe bypass valve control

(3)External communications functions

The product incorporates external communications functions (Internet LAN interface and programmable logic controller (PLC)) which makes it possible to easily monitor the status from remote locations. Communications are possible with upstream control systems,which also makes it convenient for use as a sub-system for large-scale heat sources.

7.Description of improvement

Before Improvement

(1) Control design and operation

Because the performance characteristics of inverter centrifugal chillers depend on the cooling water temperature setting,chilled water temperature,loads,and equipment models,it was very difficult for the facility designer to gain an understanding of these characteristics beforehand in order to plan the most suitable operation and also to apply the system according to the plan at the installation site.

(2) Product quality and cost

Control programs of heat source systems are often integral items that need to be set up by an engineer according to the connection conditions of the site equipment. This caused variations in the quality and increased the man-hours required.

After Improvement

(1)Methods were developed using engineering theoretical formulas for calculating the load region (optimum load area) under which the inverter centrifugal chillers achieve high COP values,and it became possible to aim to realize energy conservation easily by implementing control of multiple chiller units based on these calculated values. In addition,a plain control algorithm was developed,enabling overall control while maintaining individual control of each item of auxiliary equipment. Due to these developments,complicated design

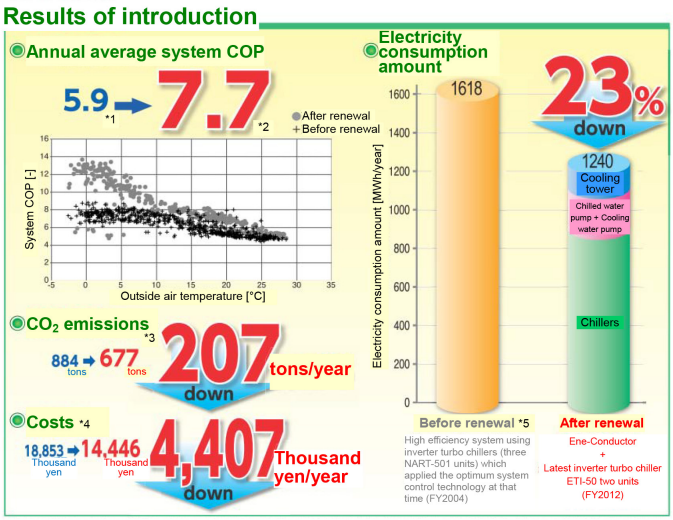
planning is no longer required before introduction,allowing large energy conservation to be made.

(2) This product is a standard control program which has only one pattern. By narrowing down to the targeted system configuration (by for example supporting less than six chillers,six types of control functions,a double pipe system,etc.),it has been incorporated as a standard built-in control program. The specifications of each system supporting the user and the differences in configurations are switched using the setting parameters. By changing from an integral type program optimized for each site to a mass-production-type program,it was planned to improve quality,reduce design costs,and lower the site work costs.

8.Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio).

In a customer's facility where this product was introduced during renovation work,the performance verification results realized an annual average system COP of 7.7 in FY2012. As a result of comparing with the system before the product introduction,energy conservation of 23% was achieved,and it is planned to achieve a reduction in CO_2 emissions of 207 tons/year and cost reductions of 4,407,000 yen/year.



*1 Source : Kuwahara and five others: 'Energy Saving Performance and Effective Operation Methods for a Heat Source System for Air Conditioning using Inverter Chillers',Report Part 1,Report Part 2,The Society of Heating,Air Conditioning and Sanitary Engineers of Japan,47th Academic/Technical Papers Chapter,2009

*2 Source : Tai (Kyushu University) and eight others: 'Development of Performance Evaluation Method for Optimal Controlled Heat Source System'Report Part 2: Analysis of Measurement Data in FY2013,The Society of Heating,Air Conditioning and Sanitary Engineers of Japan,2013

*3: CO_2 emissions amount calculated using the Tohoku Electric Power Company,Inc. FY2011 CO_2 emissions coefficient of 0.546kg-CO_2/kWh

*4: Calculated from the Tohoku Electric Power Company,Inc. high voltage electricity rate of 11.65 yen/kWh (summer period) (June 2013)

*5: The electric power amount before the introduction is based on the FY2012 data,and back-calculated using the FY2004 system COP of 5.9 before the product introduction (=FY2012 electric power x FY2012 COP / FY2004 COP)

9.Economic efficiency and its trend

(1) Equipment investment costs: Unknown

(2) Remodeling costs: Unknown

(3)Running costs:

18,853,000 yen/year → 14,446,000 yen/year

Saving of 4,407,000 yen/year (Based on the actual results at an introduction case site)

(4)Payback period:

3 years* Calculated from the suggested price of 12,500,000 yen (differs from the actual price) and the running cost improvement amount.

(5)Investment costs for energy conservation per unit: Unknown.

10.Trend in market

(1) Diffusion rate

From the start of sales in 2010,units have been introduced in a total of 41 cases (as of the end of August 2017)

(2)Prediction for 2018

Expected to reach a total of 50-60 cases

11.Reference information

(1) CO_2 reductions

Reduction of 207 tons/year (Based on the actual results at an introduction case site).

(2) Social impact

1)Awards

-FY2013 Energy Conservation Grand Prize for excellent energy conservation equipment (Minister Prize of Economic,Trade and Industry (Electricity-saving Award)).

Sponsored by: The Energy Conservation Center,Japan.

2） Documents,etc.

-FY2013 Energy Conservation Grand Prize for excellent energy conservation equipment Award-winning Entry Abstracts [Products and Business Models Category],The Energy Conservation Center,Japan,p20-21.

-Mitsubishi Heavy Industries Technical Review Vol. 51 No. 2 (2014),p4-9.

(3)Patents

Patents relating to control of multiple chillers: 4 patents,patents relating to controlling the auxiliary equipment: 8 patents,patents relating to attached functions: 4 patents,display screen design registrations: 2 registrations (Includes items under application).

12.Implementation sites

As of the end of August 2017,there were 35 cases of product introductions in Japan and 6 cases overseas (in Malaysia,Thailand,Singapore,United Arab Emirates,and Turkey)

13.Cited documents

(1)Tai (Kyushu University) and six others: 'Study on performance management methods of a heat source system using simulation : Part 2. Development of fault detection tool for refrigerators' ,The Society of Heating,Air Conditioning and Sanitary Engineers of Japan,20th Kyushu Branch Technical Research Paper Presentation,2013.

(2)Kuwahara and five others: 'Energy Saving Performance and Effective Operation Strategies of Cooling Plant System Using an Inverter Chiller for Building Air-Conditioning : Part2-A System Performance Evaluation Based on Model-Based Simulation Analysis and Effective Operation Strategies' ,Report Part 1,Report Part 2,The Society of Heating,Air Conditioning and Sanitary Engineers of Japan,47th Technical Papers Chapter,2009.

14.Contact information

Mitsubishi Heavy Industries Thermal Systems,Ltd. Air Conditioning and Refrigeration Division Machinery,Equipment & Infrastructure Domain.

13th Floor,Igarashi Building,2-11-5,Shibaura,Minato-ku,Tokyo,Japan ■

BAT2: Large–Capacity Storage Battery 'NAS Battery'

1.Category of industry

N/A

2.Category of technology

Large-capacity storage battery

3.Source of energy

N/A

4.Practical application

Since 2002

5.Summary

NGK Insulators,Ltd.,top manufacturer of ceramic products,is the first company in the world to provide sodium sulfur battery (NAS battery) which is capable for storing large amounts of electric energy. There are various types of applications such as load leveling,emergency power supply,compensation of fluctuating renewable power,stabilization of network,etc. and it contributes to energy savings and to reduce environmental load.

6.Principle and operation

NAS battery uses beta alumina as solid electrolyte,sulfur (S) for the positive electrode and sodium (Na) as the negative electrode. During discharge,the sodium ions pass through the solid electrolyte and generates sodium polysulfide at positive electrode. During charging,the opposite reaction occurs. NAS battery has following characteristics.

(1)Large-capacity: Capable of 6 hours discharge at rated power

(2)High energy density: Approximately three times greater than lead acid battery.

(3)High-speed response: Less than 1ms.

(4)Long life: 15 years or 4,500 fully discharged cycles.

(No limitation for simple short time discharge/charge cycle.)

(5)No self-discharge: No uniform charging required.

(6)High temperature operation type: Automatically temperature controlled by heater.

7.Description of improvement

See Figure 1 and Figure 2.

8.Benefit by NAS battery

(1)Reduction of CO_2 emissions by peak shaving

Decreasing the peak demand could result in stopping some thermal power plants using fossil fuel in the networks,which stand by for day time peak. In other words leveled demand could result in high efficiency operation of thermal power

plants,and in these way NAS battery could contribute to reduction of CO_2 emissions.

(2)Promotion of renewable energy

NAS battery compensates output fluctuation of renewable energy in the network. It helps further introduction of renewable energy with efficient use.

(3)Efficient operation of diesel generator in micro grid

In a remote island,fuel cost is very high and its micro grid is supported by old diesel generator. Introduction of renewable energy causes instability in the network,and gen sets should be operated irregularly sometimes at low output power to balance the power supply and demand,which results in low efficient operation. NAS battery can balance the power supply and demand with efficient operation of diesel generators and renewable energy. This will contribute to the reduction of energy costs and CO_2 emissions.

9.Economic efficiency and its trend

(1) Equipment investment costs in 2017:

40,000-50,000 yen/kWh

In 2020: 23,000 yen/kWh

* NAS battery system equipment costs only; variable according to individual specifications

(2) Remodeling costs Unknown

(3) Running costs Differs according to the usage method

(Operating expenses + repair expenses)

(4) Payback period Unknown

(5) Investment costs for energy conservation per unit:

Unknown

10.Trend in market

(1)Current diffusion rate of NAS battery: Approximately 200 locations worldwide,with a total output of 530,000 kW

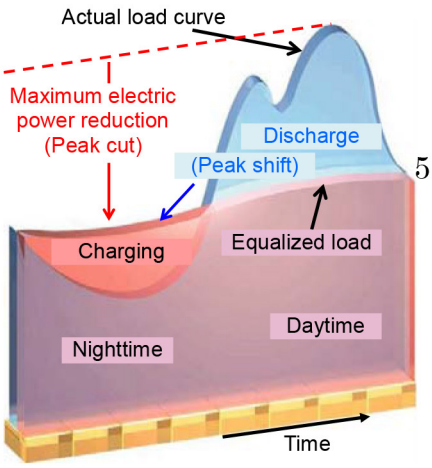


Figure 1 Peak shaving by load equalization

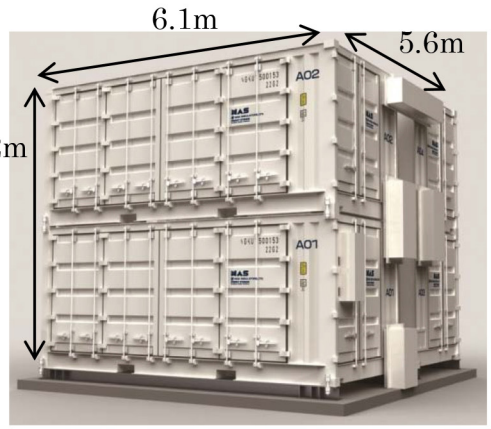


Figure 2 Exterior view of standard 800 kW NAS battery system

(2)Prediction for 2017 (or 2020): Unknown

11.Reference information

N/A

12.Implementation sites

N/A

13.Cited documents

N/A

14.Contact information

NGK Insulators,Ltd.

Tokyo Sales Office,Domestic Sales Department,Power Business Group.

BAT3: High-strength and Low Thermal Conductivity Heat Insulating Materials 'ROSLIM™Board GH'

1.Category of industry

Heat insulating materials

2.Category of technology

High-strength and low thermal conductivity heat insulating materials (energy conservation)

3.Source of energy

N/A

4.Practical application

2011

5.Summary

'ROSLIM™Board GH' is a high-strength and high heat insulating performance material made of a nanopore silica including a heat-resistant reinforcing fiber and a radiation scattering material. The product provides higher workability and handling performance than conventional low thermal conductivity heat insulating materials. The product has following features:

(1)Higher heat insulating performance than still air

(2) Excellent handling performance among low thermal conductivity materials

(3)Excellent workability dispensing with special tools

6.Principle and operation

The physical properties of 'ROSLIM™Board GH' are shown in Table 1 and the comparison of thermal conductivities of various heat insulating materials is shown in Figure 1. As shown in Figure 2,the structure of 'ROSLIM™Board GH' including microscopic airspaces smaller than the mean free path of still air suppresses the heat conduction through gas and provides the lower thermal conductivity.

In addition,the radiated heat is scattered and attenuated by the effect of the radiation scattering material in the high temperature regions,and the thermal conductivity of 'ROSLIM™Board GH' at 600°C is half of that of quiescent air,showing its excellence.

Figure 3 shows the workability of 'ROSLIM™Board GH'.

The conventional low thermal conductivity heat insulating materials are brittle and fragile and require careful handling on account of the strength degradation caused by the forming. The high bond strength among particles of 'ROSLIM™Board GH' owing to the original manufacturing process enhances the strength of the whole member and enables easy handling of even formed materials or large sheets (25mm in thickness x 600mm x 900mm). This strength facilitates the precise forming,dispensing with special tools even in the complex forming.

7.Description of improvement

(1)Energy conservation utilizing excellent heat insulating performance

'ROSLIM™Board GH' in equal heat insulating thickness to the conventional heat insulating materials (calcium silicate boards etc.) used in the industrial furnaces can reduce heat radiation from the furnace to drastically save the energy consumption. For example,as shown in Figure 4,'ROSLIM™Board GH' in 50 mm heat insulating thickness installed in the industrial furnace with the furnace temperature of 1000°C reduces the energy consumption by 50% compared with the conventional heat

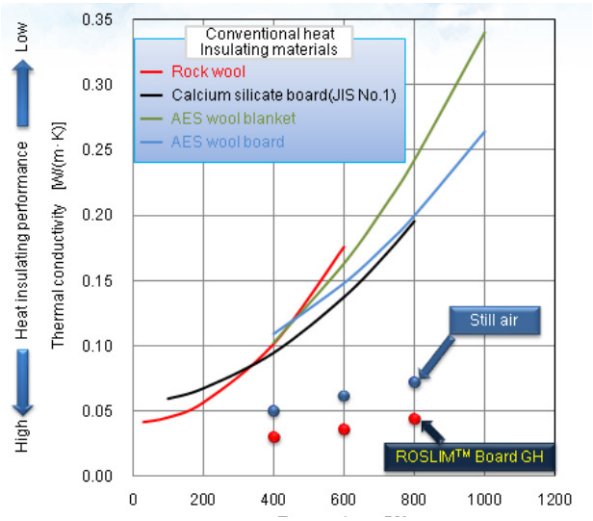


Figure 1 Thermal conductivities of heat insulating materials

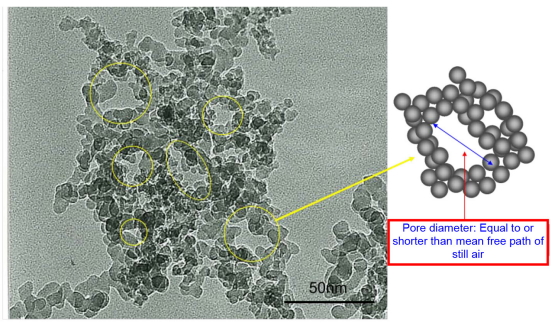


Figure 2 Inner structure of 'ROSLIM™Board GH' (TEM image)

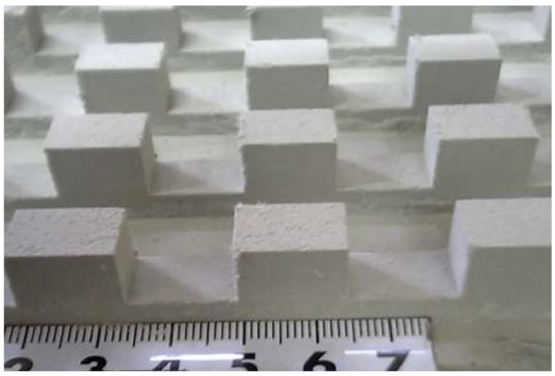


Figure 3 Example of complex forming

Table 1 Physical properties of 'ROSLIM™Board GH'

Density [kg/m³]	250
Thermal conductivity [W/(m·K)]	
at 400℃	0.030
at 600℃	0.036
at 800℃	0.044
Compressive strength [MPa] (10% Compressive strain)	1.02
Contraction factor in heating [%]	
at 800℃×24hr	0.6
at 1000℃×24hr	2.5
Highest heating temperature [°C]	1000

insulating materials.

(2)Downsized configuration utilizing excellent heat insulating performance

Figure 4 shows the example of the downsized heat insulating configuration. At equal outer surface temperature,excellent low thermal conductivity of 'ROSLIM™Board GH' can reduce the thickness of heat insulating materials and downsize the furnace and the devices. For example,as shown in Figure 5,'ROSLIM™Board GH' installed in the industrial furnace with the furnace temperature of 1000°C and the surface temperature of 57°C reduces the thickness by 200 mm compared with the conventional heat insulating materials.

8.Effect of improvement

See Figure 4.

9.Economic efficiency and its trend

The preliminary calculation results of the payback period for heat insulating installation under the conditions of the furnace temperature of 1000°C,the heat insulating thickness of 350mm and the surface temperature of 40°C (outside atmosphere temperature 25°C) are as follows:

(1)70% use of 'ROSLIM™Board GH': Payback period 2.2 years (preliminary)

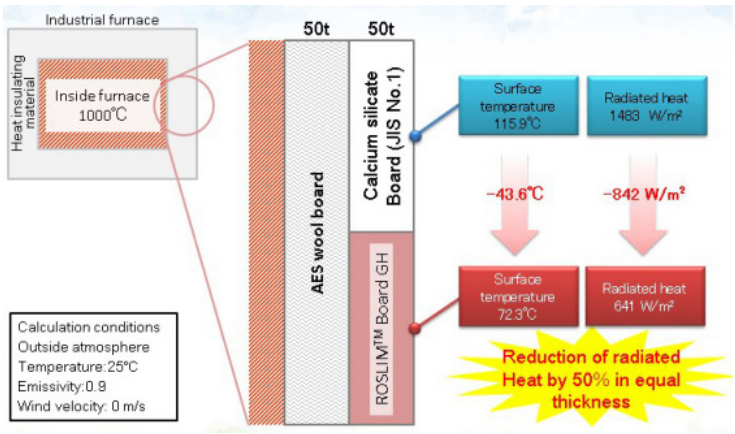


Figure 4 Example of energy-saving heat insulating configuration

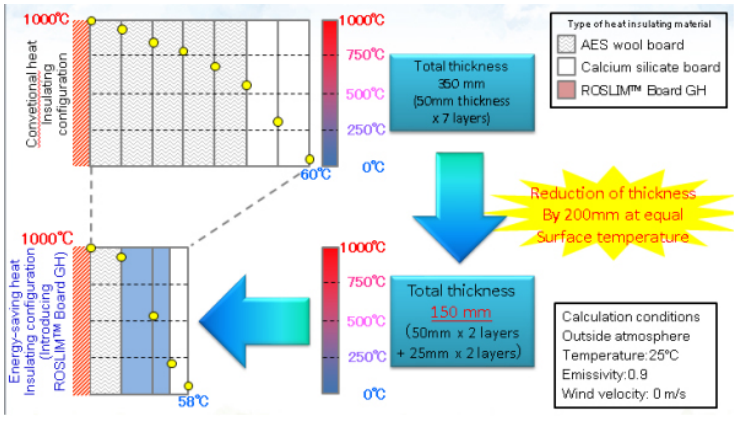


Figure 5 Example of the downsized heat insulating configuration

(2)45% use of 'ROSLIM™Board GH': Payback period 1.2 years (preliminary)

(3) 30% use of 'ROSLIM™Board GH': Payback period 0.6 years (preliminary)

10.Trend in market

(1)Current diffusion rate: 10%

(2)Prediction for 2020: 40%

11.Reference information

(1)Patents and utility models

1)Makio Naito,Yasuo Ito,Takahiro Ohmura:

Porous body coated particle,precursor for heat insulating material containing the porous body coated particle and heat insulating material,Japanese published patent application 2003-316772.

2)Makio Naito,Yasuo Ito,Takahiro Ohmura:

Porous body-coated fiber and heat-insulating material,Japanese published patent application 2003-152877

3)Makio Naito,Hiroya Abe,Yasuo Ito,Daiji Tahara:

Composite porous body,molded body of and thermal insulating material of this composite porous body,Japanese published patent application 2004-102578.

4)Yasuo Ito,Yoshihiko Goto,Shigeru Nakama,Takahiro Ohmura,Isami Abe: Thermal insulation and method of producing the same,Japanese published patent application 2009-239326.

5)Yasuo Ito,Yoshihiko Goto,Shigeru Nakama,Takahiro Ohmura,Isami Abe: Heat insulating material and method of producing the same,Japanese published patent application 2009-239327.

6)Yoshihiko Goto,Yasuo Ito,Ken Maeda,Akifumi Sakamoto,Thermal insulation material,Japanese published patent application 2010-187403.

7)Akifumi Sakamoto,Yasuo Ito,Ken Maeda:

Heat insulating material and method of manufacturing the same,Japanese published patent application 2010-231753

8)Akifumi Sakamoto,Yoshihiko Goto,Yasuo Ito,Ken Maeda: Heat insulating material and method for manufacturing the same,Japanese published patent application 2011-006475

9)Yasuo Ito,Yoshihiko Goto,Akifumi Sakamoto,Ken Maeda: Heat insulating material and method for manufacturing the same,Japanese published patent application 2011-088318

10)Yasuo Ito,Shigeru Nakama,Isami Abe,Jyunichi Numura: Method of producing heat insulating material for reformer,Japanese published patent application 2012-034214

11)Yasuo Ito,Ken Maeda:

Heat insulating material and method for producing the same,Japanese published patent application 2012-240721

12)Ken Maeda,Yoshihiko Gotoh,Kazuyuki Kii,Yasuo Ito:

Heat insulation unit,manufacturing method of heat insulation unit and heating furnace,Japanese published patent application 2013-175592.

(2)Awards

Chairman Prize of ECCJ in the Energy Conservation Grand Prize for excellent energy conservation equipment in FY2015 (Products and Business Models Category) Sponsored by: The Energy Conservation Center,Japan.

Supported by: Ministry of Economy,Trade and Industry.

(3)Documents

Presentations of papers and lectures

1)Hiroya Abe,Makio Naito,Yasuo Ito and Daiji Tahara: 'Design of Porous Materials by Dry Processing',The 8th IUMRS International Conference on Advanced Materials (Yokohama,October 2003).

2)Hiroya Abe,Makio Naito,Daiji Tahara,Yasuo Ito:

'Creation of nanoporous molded body by nanoparticle

bonding',The Ceramic Society of Japan Annual Meeting 2004,March 2004,Shonan Institute of Technology.

3)Isami Abe,Hiroya Abe,Makio Naito:

'Manufacture and structure of nanoporous fiber by nanoparticle bonding',The Ceramic Society of Japan 17th Fall Meeting,2004

4)Isami Abe,Kazuyoshi Sato,Hiroya Abe,Makio Naito:

'Effect of atmosphere in mechanical composition of silica nanoparticles and inorganic fiber',The Ceramic Society of Japan Annual Meeting 2005,March 2005,Okayama University.

5)Hiroya Abe,Isami Abe,Yasuo Ito,Kazuyoshi Sato,Makio Naito: 'Dry Powder Processing of High Porosity Microporous Composites',107th annual meeting id The American Ceramic Society (Baltimore,MI) Papers.

1)D. Tahara,Y. Ito,T. Ohmura,H. Abe and M. Naito,'Formation of Nano Structure on Glass Fiber by Advanced Mechanical Method,' Ceramic Transactions,Vol.146,p.173-177(2004).

2)H. Abe,I. Abe,K. Sato and M. Naito,'Dry Powder Processing of Fibrous Fumed Silica Compacts for Thermal Insulation,' Journal of American Ceramic Society,in press.

3)M. Naito and H. Abe,'Particle Bonding Technology for Composite Materials-Microstructure Control and Its Characterization,' Ceramic Transactions,Vol.157,p.69-76(2004).

12.Implementation sites

NICHIAS webpage: http://www.nichias.co.jp/

13.Cited documents

*'TOMBO' is a registered trademark or trademark of NICHIAS Corporation.

*'ROSLIM'is a trademark of NICHIAS Corporation.

*The measured values in this document are used only for reference and not guaranteed. The calculation results of the payback period are preliminary and do not warrant the payback period.

14.Contact information

NICHIAS Corporation. ■

BAT4: By–product Gas–fired Gas Turbine Technology

1.Category of industry

Thermal power Industry

2.Category of technology

BFG Fired Gas Turbine Technology

3.Source of energy

By-product gases from steel industry (BFG: Blast Furnace Gas,COG: Coke Oven Gas).

4.Practical application

Since 2004 (Application to high efficiency F class gas turbines).

5.Summary

In the global movement to realize environmental load reduction,the steel industry is also strongly required to reduce its CO_2 emissions as a countermeasure for global warming. Further,the global move to reduce consumption of primary energy resources represented by fossil fuels,BFG-fired gas turbines effectively utilizes by-product gases generated by the steel plants. The BFG fired gas turbines contributes for the reduction of CO_2 emissions,thereby achieving change to a higher efficiency and higher power output.

6.Principle and operation

Figure 1 shows the overview system of the BFG-fired gas turbine combined cycle plant. The primary equipment's consist of Gas compressor,Step up gear,Gas turbine,Generator and Steam turbine arranged on a single shaft configuration mode. The mixture of BFG gas and COG gas is compressed in the gas compressor and supplied as a fuel for the gas turbine. Due to the low calorific value of BFG gas,additional source of COG gas is supplied to increase the calorific value of mixed gas mixture to 4.4 MJ/m^3N-dry (LHV). The startup of gas turbine is driven by the steam turbine using steam from an existing boiler.

The BFG gas that is generated in the blast furnace (of steel plants) has the characteristics of having a lower calorific value than natural gas (LNG) which is generally known as a gas turbine fuel,and also that its combustion speed is low and combustion range is narrow due to the high proportion of inert gases comprising of nitrogen and carbon dioxide. With regards to fuel characteristics of BFG gas and to realize

high combustion efficiency over complete operation range,the combustor unit (refer figure 2) is designed to use same multi-can system with air bypass valve as used in dry low-NOx combustors thus allowing optimum utilization of fuel-air ratio. Further,the combustion efficiency is improved by mixing high calorie COG gas into the BFG gas using flow control method.

With regards to the air compressor and turbine where the turbine inlet temperature is constant,the amount of combustion gas passing through the low-calorie gas-fired turbines is higher than the normal high-calorie fuel-fired gas turbines due to the increase in the amount of fuel. In conventional low calorie gas-fired turbines using gases including BFG gas,the air compressor is made smaller than the standard machines and the air intake volume is reduced to realize a similar flow through the turbine as in the standard machines,which makes it possible to utilize the standard turbine blade lattice. Additionally,because BFG gas includes large amounts of dust than LNG,there is a concern regarding degradation over time and blockages. To prevent this an electrostatic precipitator (EP) is installed on the BFG supply line,thereby improving the reliability and availability.

7. Description of improvement

Figure 3 shows examples of the energy balance in a BFG-fired gas turbine combined .

cycle plant (GTCC) and in a conventional plant (known below as BTG). Additionally,

Figure 4 shows graphs comparing the plant efficiency and power output.

When the amount of heat input is set to be same as in BTG and GTCC plants,using BFG .

and COG mixed gas as the fuel,the plant heat efficiency is estimated to be 36% in the BTG plant and 45% in the GTCC plant on LHV basis. It can therefore be anticipated that there will be an increase of 29 MW in the power output in the GTCC plant compared to the BTG plant (Comparison using a 150 MW class plant).

8. Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio) .

The amount of CO_2 emission is mutually related to the amount

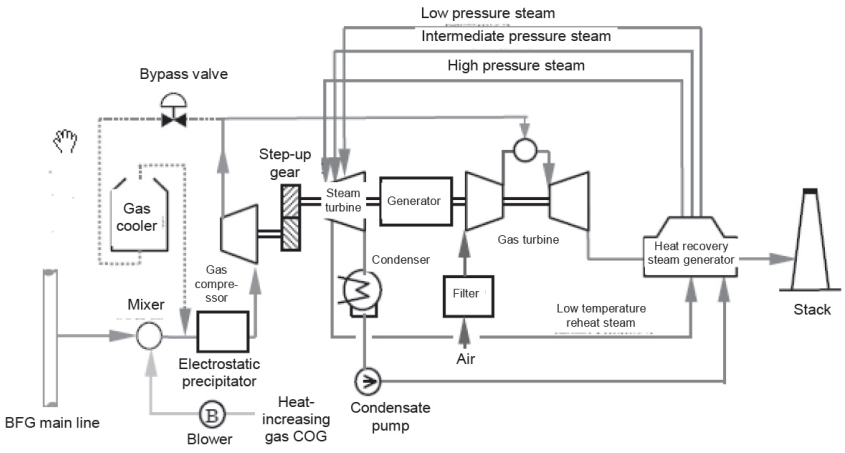


Figure 1 Overview system of a BFG-fired GTCC plant

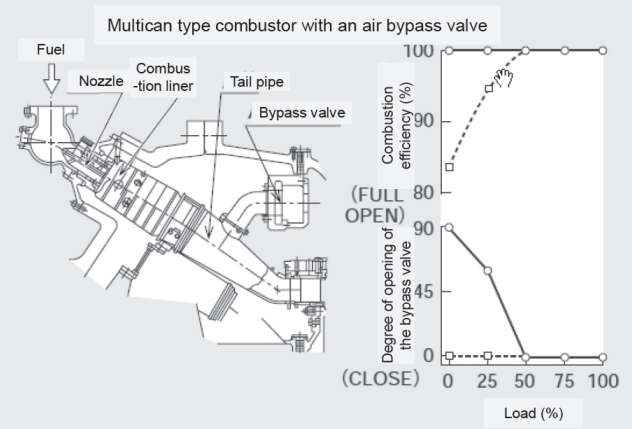


Figure 2 Multi-can type combustor with an air bypass valve

(After optimizing the pipe diameter and length,the welding at each stage was eliminated.)

of BFG/COG gas generated by the steel industry as by-product gases. To minimize the CO_2 emissions it is necessary to evaluate not only the power generating equipment utilizing these by-product gases,but also to include the surrounding facilities. The proposed evaluation Plant heat efficiency (%,LHV) Plant power generation end output (MW) is shown below.

In developing countries,BFG is not currently being used for power generation,and is being released into the atmosphere. A comparison between the current situation and the situation after introducing the BFG fired gas turbine combined cycle plant (GTCC) is shown in Figure 5. By generating 145 MW of electric power using the BFG fired GTCC,it will be possible to reduce 145 MW of the portion generated by the existing coal-fired boiler power plant (BTG). If the power is assumed to be generated for 8,000 hours annually,the CO_2 reduction of this coal-fired BTG is 1,040,000 tons of CO_2 per year. As shown in Figure 6,compared to building a new BTG,the GTCC will also be advantageous by an amount of approximately 210,000 tons of CO_2 year. In this way,it is possible to view the superiorities of

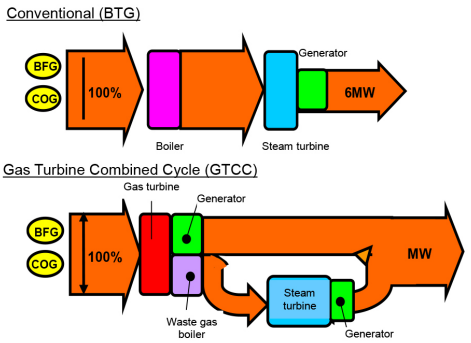


Figure 3 Energy balance diagram

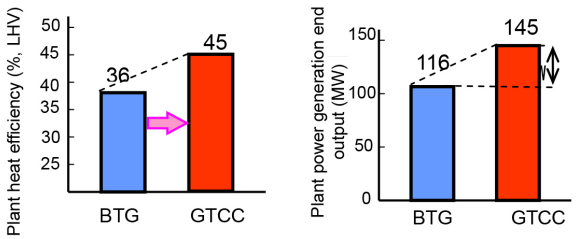


Figure 4 Comparison of BTG and GTCC plant efficiency and power output

GTCC plants as being the effective utilization of BFG from the viewpoints of realizing the high efficiency operation of plants and the control of CO_2 emissions.

9. Trend in market

Actual delivery results of low calorie gas-fired gas turbines (Since 1958) by MHPS include Japan: 28 units,China: 29 units,South Korea: 5 units,Netherlands: 4 units,Ukraine: 4 units. Total: 70 units .

10. Reference information

CO_2 reduction Refer to section 8 .

11. Implementation sites

[Before improvement] [After improvement]

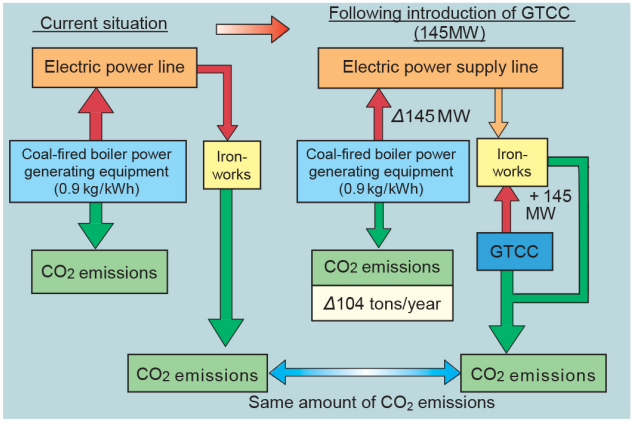


Figure 5 Figure showing an image of CO_2 reductions in a steel plant

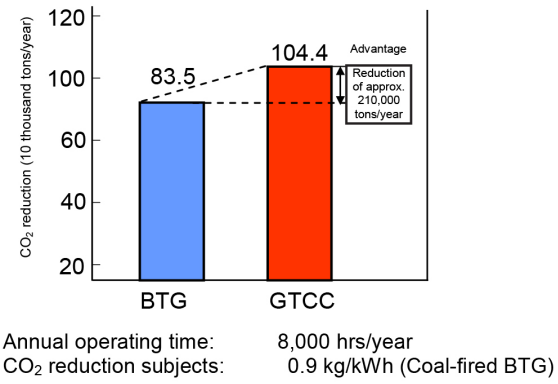


Figure 6 Comparison of CO_2 emissions

Refer to section 9 .

12. Cited documents

Mitsubishi Heavy Industries Technical Review Vol. 41 No. 5 (2004) .

Mitsubishi Heavy Industries Technical Review Vol. 44 No. 1 (2007) .

Mitsubishi Heavy Industries Technical Review Vol. 48 No. 3 (2011) .

Other

13. Contact information

Mitsubishi Hitachi Power Systems,Ltd. ■

BAT5: Matrix Converter U1000

1. Category of industry

Power converters

2. Category of technology

Regenerative energy utilization type

3. Source of energy

Electricity

4. Practical application

April,2014

5. Summary

Variable speed motor drives using inverters are becoming popular for energy conservation in the industrial field. However,there is a need to suppress power line harmonics based on the basic principles of the inverter and to process the regenerated energy created by the load side revolutions. In order to solve these problems,devices such as a regenerative power converter,an AC reactor,a harmonic filtering reactor,a condenser and others are coupled to the inverter.

On the other hand,these devices require much space for installation because of the increased number of components. This product enables both the suppression of the harmonics and utilization of the regenerated energy in a single unit,does not require additional space for the installation and drastically reduces cost. The product reduces workload drastically,improves the energy conservation rate in operation by 2%,and reduces the capacity of generator by 50% and the capacity of power supply unit by 20%. Thus,the product deserves to be called as the next-generation motor drive that solves the problems of the conventional general purpose inverters and contributes to the customer's energy conservation by its efficiencies which are higher than the inverters.

6. Principle and operation

The matrix converter U1000 comprises a circuit configuration shown in the right-hand figure,and supplies sine-wave voltage and current to a motor by direct PWM control of 3-phase AC voltage with 9 bidirectional switches located on a matrix between a power supply and the motor. Refer to Figure 1.

7. Description of improvement

Before improvement

Suppressing harmonics and utilizing regenerated energy used to require the regenerative power converter,the AC reactor,the harmonic filtering reactor and condenser. However,the additional components and wirings called for more space in the control panel,increasing the installation cost.

Refer to Figure 2.

After improvement

The product enables the suppression of harmonics and utilizing of regenerated energy in one unit,and drastically reduces space for installation. Not only the energy is saved by utilizing the regenerated energy of the surroundings but also the cost is estimated to be reduced drastically.

Refer to Figure 3.

8. Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio)

Utilizing regenerated energy,one of the features of the product,is very effective for large scale cranes and elevators.

In the case of single inverter,the regenerated energy during unloading is wasted as a heat from a braking resistor. The product allows recycling of the wasted regenerated energy at the power supply and utilization of the energy as an additional energy source. In the case of the 10ton-crane,110,000 yen is saved annually as converted to the electric power charge.

Refer to Figure 4.

9.Economic efficiency and its trend

(1) Equipment investment costs

-Reducing the installation cost by about 40% (in the case of 400 V 45 kW)

-Reducing the cost of the control panel by about 50%

-Reducing the cost of the generator and the power supply unit by about 50%

In the case of power supply to a generator,normally the generator requires capacity of about 4 times as much as the power capacity consumed at the inverter (with no reactor). On the other hand,in the case of the Matrix Converter,the generator requires only about twice the capacity for operation.

(2) Running costs

-In the case of the 10ton-crane,110,000 yen is saved annually as converted to the electric power charge.

(3) Payback period

The payback period depends on types of devices,capacity of the motor and the operation cycle. The payback period calculated based on the product cost was about 3 years at the earliest.

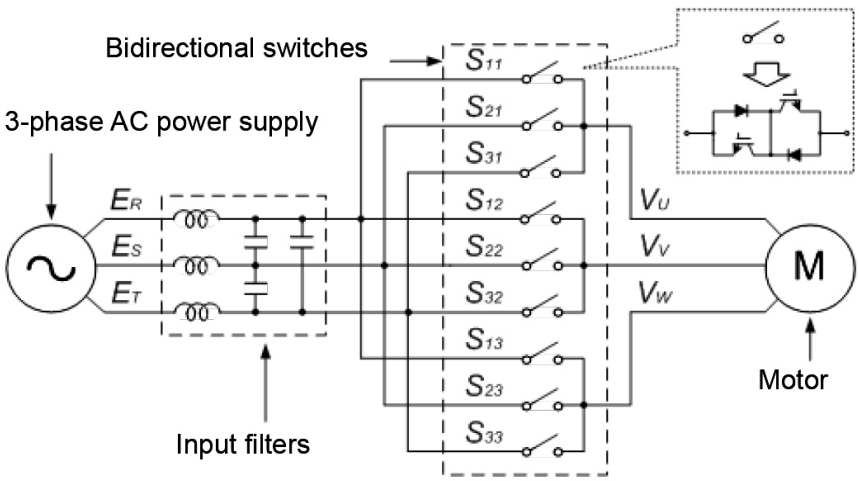


Figure 1

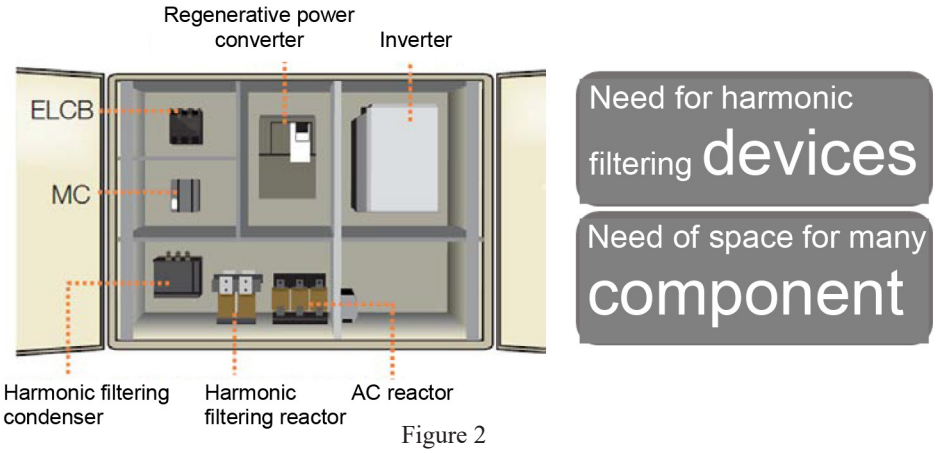
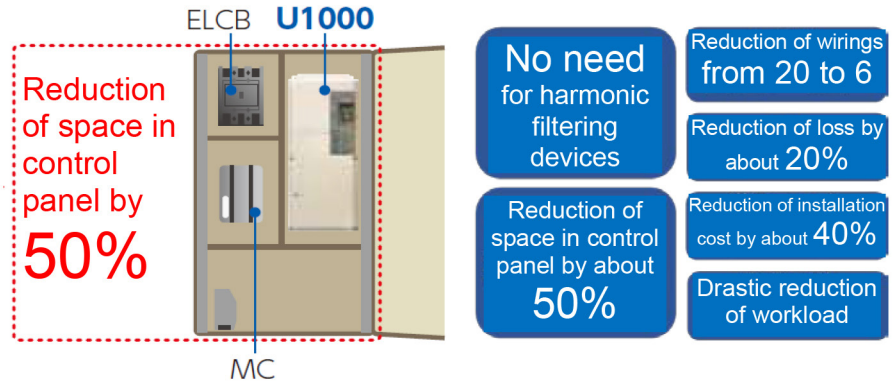


Figure 2



Example with installing and wiring space: 400 V 185 kW,efficiency: 400 V 15 kW,and installation cost: 400 V 45 kW

*Installation cost is calculated using market prices.

Figure 3

10.Trend in market

Number of shipments: Increasing at an annual rate of 150-200%.

11.Reference information

Social impact by CO_2 reduction

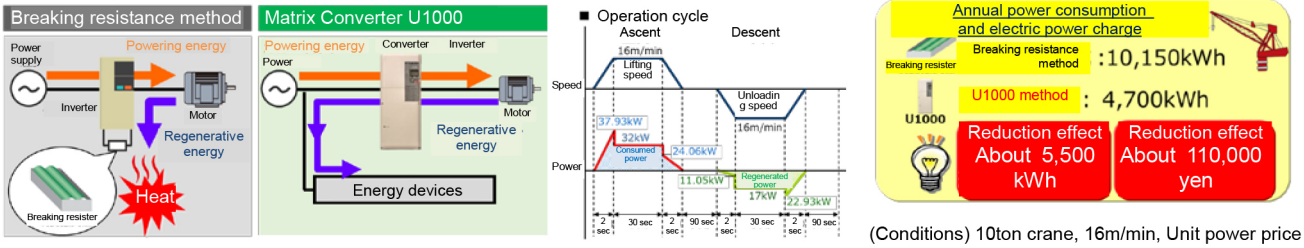
In the case of application to the overhead crane,the estimated energy conservation is 558,232 MWh/unit,and estimated CO_2 reduction is 111.5 million litters (crude oil equivalent). The CO_2 reduction is equivalent to annual CO_2 emissions by 133,000 people,assuming that a person emits 6 kg of CO_2 per day.

Refer to Table 1.

12.Implementation sites

-Cranes in seaports

-Cranes in steel works



(Conditions) 10ton crane, 16m/min, Unit power price

Figure 4

Table 1

Hanging weight	Number of installed overhead	Energy-savingeffect of U1000 [kWh/Unit]	Energy-saving effect of U1000[kWh/Unit]	Reduction of CO_2 [ton]
Total	95,550	1,363	558,232,000	292,000
3t or more and less than	16,581	2,725	22,592,000	11,800
5t or more and less than 10t or	32,943	5,450	89,770,000	46,900
more and less than 20t 20t or	26,399	10,900	143,875,000	75,200
more and less than 50t	15,428	21,800	168,165,000	88,000
50t or more and less than	2,887	43,600	62,937,000	32,900
100t or more and less than 200t	1,014	87,200	44.210.000	23,100
200t or more and less than 500t	290	174,400	25.288.000	13,200
500t or more and less than	8	348,800	1,395,000	700
1000t or more	0		0	0

*1: Figures in the table above are extracted from the data "Number of installed cranes by model" provided by Japan Crane Association.

-Cranes in waste disposal sites

13.Cited documents

-The Energy Conservation (August 2014)

-YASKAWA Technical Review Vol.78 No.4 Special issue for environment and energy (February 10,2015)

-The Energy Conservation (February 2016)

14.Contact information

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BAT6: High Efficiency Motor Control

1.Category of industry

Inverters

2.Category of technology

Motor control

3.Source of energy

Electricity

4.Practical application (Commercialization)

July 2014

5.Summary

In recent years,as measures for preventing global warming and against the exhaustion of energy resources,efficient energy use is required in various industries including the following: the strengthening of regulations on energy use through legal amendment of the Act on the Rational Use of Energy and the introducing regulations on motors for high efficiency. Interest in energy saving is also growing among energy consumers from the viewpoint of global environmental conservation and also of a cost reduction,and the demand for as driving motors with high efficiency using inverters energy saving is increasing. According to that,the technologies and engineering for energy saving in inverters have been progressing year after year.

6.Principle and operation

The electric power supplied by electric power companies is generally an alternating current,and the frequency and voltage are fixed. When a motor is driven by the commercial power supply,its rotation speed is constant. However,it is possible to change the motor rotation speed by using inverters,which is motor control engineering. By converting the commercial power into a direct current (in the converter unit),and temporarily re-converting it into a variable frequency alternating current (in the inverter unit),inverters change frequency and voltage in any magnitude.

Because the motor rotation speed is proportional to the frequency,motors can be operated at variable speeds by varying the frequency and voltage applied to the motor by using the inverter.

In the equipment of reduced torque load characteristics including fans and pumps,the load torque is proportional to

the square of the rotation speed (air volume),while the output is proportional to the cube of the rotation speed (air volume). For this reason,when an inverter controls an operation of reduced torque load equipment,a large energy saving effect can be anticipated compared to the commercial power operation (with damper control).

In addition,a variety of high-efficiency motor control technologies are incorporated in the latest inverters for realizing energy saving.

(1) High efficiency IPM motor driving

Recently,high efficiency interior permanent magnet (IPM) motors have received attention for a reason that they produce higher energy conservation effects than induction motors. IPM motors are synchronous motors that have permanent magnets embedded inside the rotor. Induction motors generate magnetic flux by passing current through the rotor conductor to obtain the rotary force (torque),which causes a loss (secondary copper loss) occurrence in the rotor. In contrast,because current does not pass through the rotor in IPM motors which utilize magnets,loss (secondary copper loss) does not occur,and the efficiency will be better than that of induction motors.

(2) Optimum excitation control (Induction motor high efficiency control)

High efficiency control system was also devised for induction motors. V/F control is generally used,which fixes the ratio of the output frequency and output voltage to the motor. However,in optimum excitation control,the excitation current and the torque current are diverted from the motor current. The excitation current is controlled so that the motor efficiency reaches its maximum efficiency and the output voltage is determined.

7.Description of improvement

(1)Mitsubishi Electric Corporation developed the technology to control IPM motor with high performance and high efficiency,and achieved the operation of the IPM motor with our general-purpose inverter.

Controlling the operation of the IPM motor with high efficiency attains,approximately 10% more efficiency than operating the induction motor by the inverter in a 5.5 kW motor example due to product integration. Additionally,it allows to replace only the conventional motor with the IPM motor at the timing if renewing motors in the future,which brings about advantages to facilitate the adoption of further energy saving.

The actualization of operation of the IPM motor as well as induction motor by the general-purpose inverter contributes to the simplification of customer’s stock control. Additionally,our development of the auto-tuning function which can measure the circuit constant of IPM motor as well as conventional induction motor enables optimal operation of motors,increasing the range of suitable applications for motors

(2) Mitsubishi Electric Corporation developed and as in actual use the control method (optimum excitation control) that maximizes the efficiency of induction motors.

For the fan and pump applications,because the low-speed torque is not required,the motor excitation current is controlled for maximization of motor efficiency to give higher priority on the improvement of the motor efficiency than the torque generation.

With a small load torque,further energy saving is enabled. In example of a freezer operation,at 10% motor load torque which is common torque level for a normal operation,the motor efficiency under optimum excitation control is about 15% higher than the motor efficiency under V/F control.

During the newly developed advanced optimum excitation control,it is possible to generate a large starting torque while maintaining the motor efficiency under the optimum excitation control. This is applicable to the cases when a large torque is required at startup,such as for the fan with large inertia.

8.Effect of improvement

Improvement of energy consumption intensity (Option for improving energy conservation ratio)

(1) IPM control

Refer to Figure 1.

(2) Induction motor optimum excitation control

Refer to Figure 2.

9.Economic efficiency and its trend

Economic efficiency: IPM motor life cycle cost (LCC) simulation (Comparison with general-purpose motor driven by the commercial power supply).

[Usage conditions] Motor capacity: 15 kW,Air Volume: 70%

Operation time: 16 hours/day x 250 days/year = 4,000 hours/year.

Refer to Figure 3.

10.Trend in market

Inverter installation rate: 26% ("Progress in Inverters 2016") Japan Electrical Manufacturers'Association)

11.Reference information (Application example)

Refer to the attached appendix documents (1) Air conditioning in buildings,and (2) Water-cooling pump.

12.Implementation sites

Mitsubishi Electric FA website www.mitsubishielectric.co.jp/fa

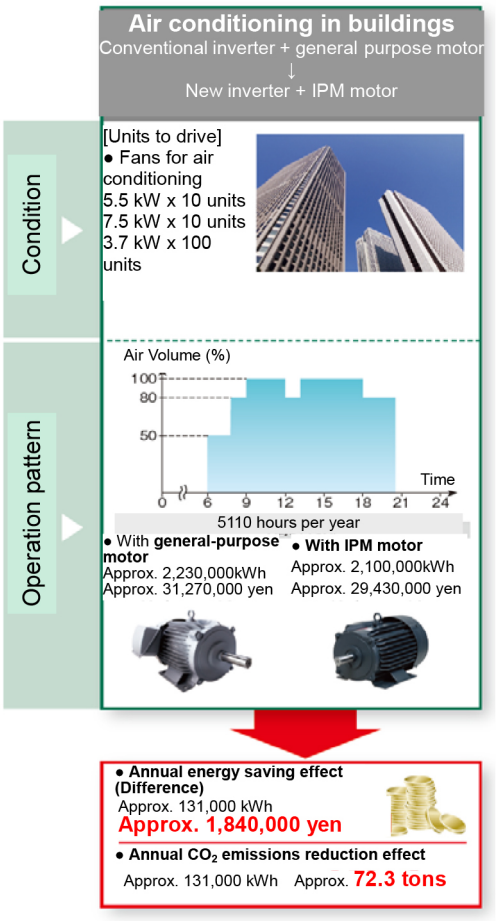

Figure 1

13.Cited documents (Reference information)

-The Japan Electrical Manufacturers'Association bulletin “Denki” February 2014,"Progress in Inverters 2016"The Japan Electrical Manufacturers'Association

-Mitsubishi Electric Technical Review,April 2014,Mitsubishi Electric Corporation

14.Contact information

Mitsubishi Electric Corporation. ■

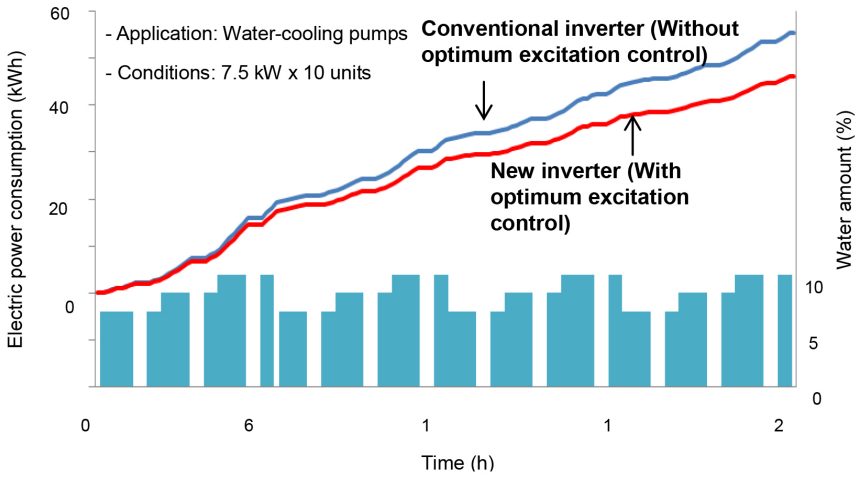

Figure 2

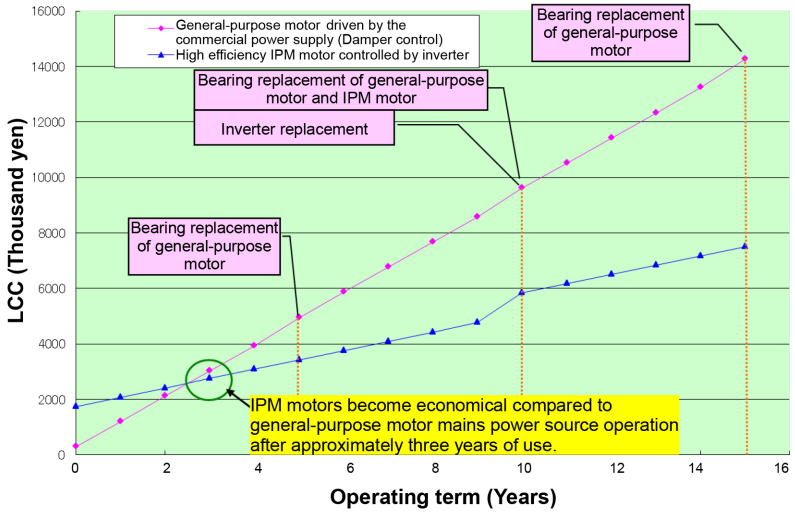

Figure 3

BAT6–1: Air Conditioning in Buildings

1.Category of industry

Fans

2.Principle and operation (Features and advantages)

In recent years,the energy-saving tendency has been increasing,which is promoting the introduction of laws and regulations in countries worldwide making it obligatory the manufacture and sale of high-efficiency motors. In particular,because interior permanent magnet (IPM) motors operate at higher efficiency than induction motors,their high energy-saving effect has been attracting attention.

Mitsubishi Electric Corporation developed the technology to control IPM motor with high performance and high efficiency,and achieved the operation of the IPM motor with our general-purpose inverter.

Controlling the operation of the IPM motor with high efficiency attains,approximately 10% more efficiency than operating the induction motor by the inverter,and 5% more efficiency than operating the high efficiency induction motor by the inverter,in a 5.5 kW motor example.

The actualization of operation of the IPM motor as well as induction motor by the general-purpose inverter contributes to the simplification of customer's stock control. Additionally,our development of the auto-tuning function which can measure the circuit constant of IPM motor as well as conventional induction motor enables optimal operation of motors,increasing the range of suitable applications for motors.

Refer to Figure 1.

3.Effect of improvement

Refer to Figure 2.

4.Reference information

(1)Awards

-Good Design Award 2014 Organizer: The Japan Institute of Design Promotion

(2)Documents,etc.

-The Japan Electrical Manufacturers' Association bulletin "Denki" February 2014,The Japan Electrical Manufacturers' Association

-Mitsubishi Electric Corporation Technical Review,April 2014,Mitsubishi Electric Corporation

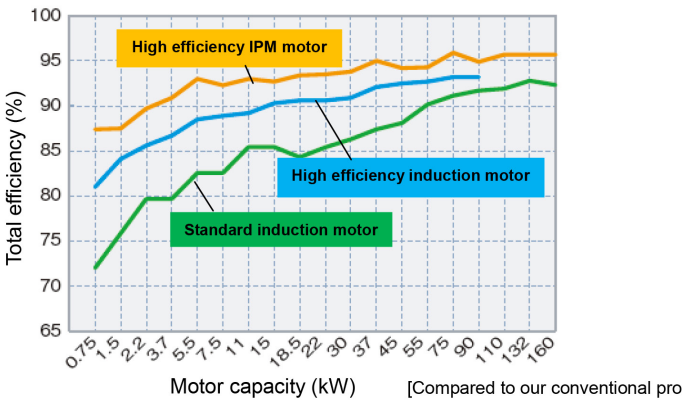

Figure 1 Comparison example in total efficiency of motors

5.Contact information

Mitsubishi Electric Corporation ■

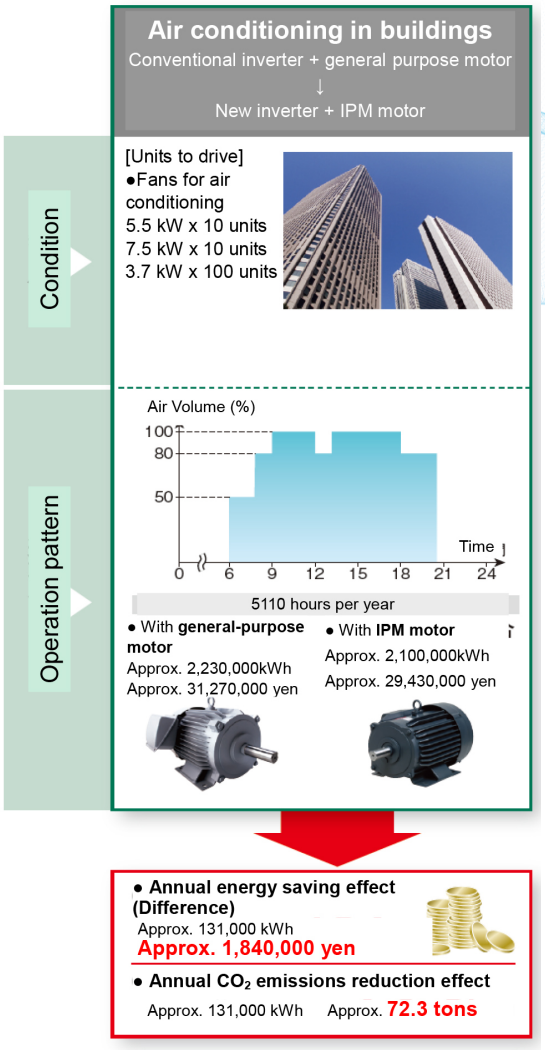

Figure 2

BAT6-2: Water-cooling Pump

1.Category of industry

Pumps

2.Principle and operation (Features and advantages)

Mitsubishi Electric Corporation developed the control method (optimum excitation control) that maximizes the efficiency of induction motors.

For the fan and pump applications,because the low-speed torque is not required,the motor excitation current is controlled for minimization of motor loss to give higher priority on the improvement of the motor efficiency than the torque generation.

With a small load torque,further energy saving is enabled. In example of a freezer operation,at 10% motor load torque which is common torque level for a normal operation,the motor efficiency under optimum excitation control is about 15% higher than the motor efficiency under V/F control. (Figure 1)

During the newly developed advanced optimum excitation control,it is possible to generate a large starting torque while maintaining the motor efficiency under the optimum excitation control. This is applicable to the cases when a large torque is required at startup,such as for the fan with large inertia.

3.Effect of improvement

-Application: Water-cooling pump

-Conditions: 7.5 kW x 10 units

Refer to Figure 2&3.

4.Reference information

(1)Awards

-Good Design Award 2014 Organizer: the Japan Institute of Design Promotion

(2)Documents,etc.

-The Japan Electrical Manufacturers' Association bulletin "Denki" February 2014,The Japan Electrical Manufacturers' Association

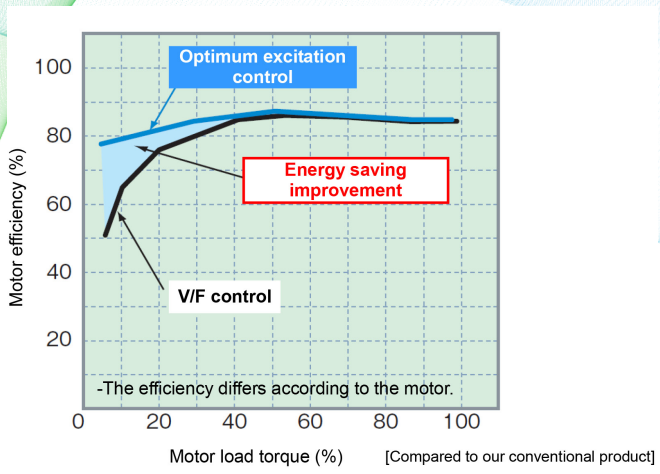

Figure 1 Motor efficiency during optimum excitation control (Example when an inverter running frequency is 60 Hz and a 3.7 kW motor is used.)

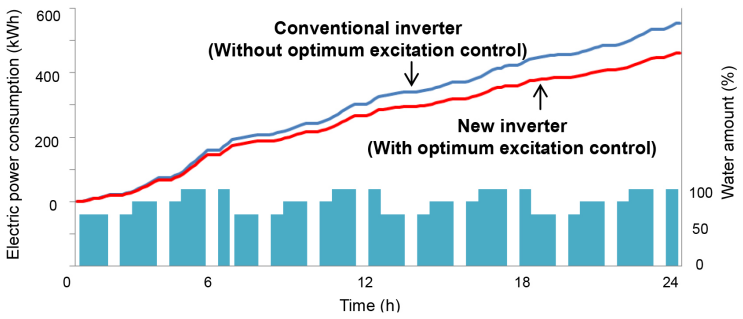

Figure 2

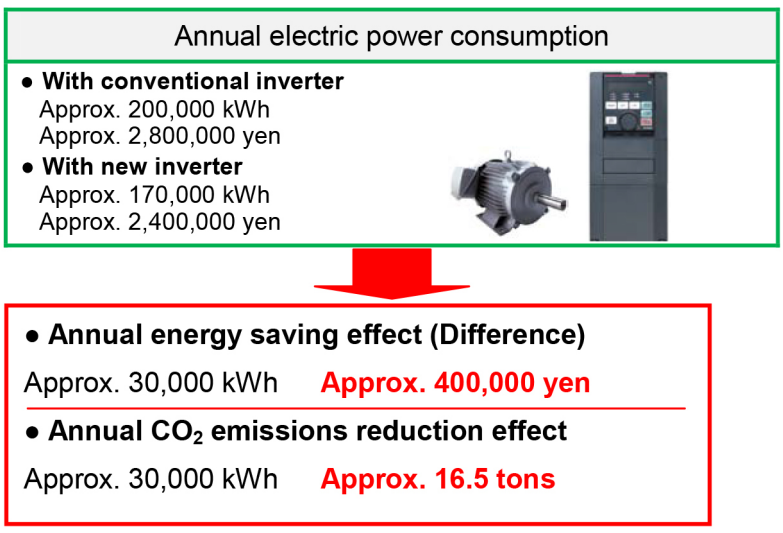

Figure 3

-Mitsubishi Electric Corporation Technical Review,April 2014,Mitsubishi Electric Corporation

5.Contact information

Mitsubishi Electric Corporation ■