Kawasaki responds to a great variety of energy needs with its system solutions

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Preface

The Great East Japan Earthquake was one of the greatest earthquakes in the history of Japan, being accompanied by large-scale tsunamis that caused unheard-of damage. The accident at the Fukushima Daiichi Nuclear Power Plant of the Tokyo Electric Power Company and shutdown of thermal power plants forced the utility company to resort to rolling blackouts in its service areas. In addition, an unprecedented situation in which all nuclear power plants in Japan were brought to a shutdown has caused a shortage of electric power on a scale involving the entire nation in addition to the disaster-stricken areas. The exposure of the vulnerability in the steady supply of energy has forced Japan to re-evaluate its energy policy as an urgent challenge.

In the meantime, the world economy continues to advance, with energy consumption growing increasingly in emerging countries such as China and India. According to a report from the International Energy Agency (IEA), China will account for about one-fourth of the world's energy consumption in 2030, becoming the world's largest energy consumer. For the purpose of preventing global warming, countries have raised the reduction of greenhouse gas emissions as a strategy in their energy policies. In addition, the accident at the Fukushima Daiichi Nuclear Power Plant following the Great East Japan Earthquake has created a trend toward abandoning or reducing nuclear power generation, as restructuring is being urged with energy strategies around the world. At the same time, environmental problems have worsened, and a move is growing to use fossil gas fuels of lesser CO_2 emissions than coal or petroleum. In the future, the importance of distributed power generation based on gas will further increase.

In August 2012, the Ministry of Economy, Trade and Industry established the Combined Heat and Power Promotion Office and a contact in charge of this matter in each Bureau of Economy, Trade and Industry. The Ministry says that the creation of a responsible office will reinforce administrative functions aimed at the accelerated introduction of cogeneration systems (energy systems supplying both heat and power, abridged to CHP* in the following) with the aim of expanding the introduction of CHPs.

We have a rich assortment of generator sets such as gas turbines, gas engines, diesel engines, and steam turbines, as well as products for exhaust heat utilization such as heat recovery steam generators (HRSG) and absorption chillers. We also have a good track record of delivering them in the form of CHPs. This special issue of the Kawasaki Technical Review presents our system solutions and products related to distributed power generation systems that respond to a wide variety of customer needs.

*CHP: Combined Heat and Power

1 Offering system solutions in response to customer needs

We respond to a variety of energy needs of customers with solutions that optimize life cycle costs and environmental performance.

For example, steam obtained from CHPs can be used as a heat source for processes, painting, industrial ovens, paper drying processes in paper mills, hot water supply and space heating, while adding an absorption chiller to a system allows low-temperature exhaust heat to be used to produce chilled water that is used for general air conditioning or for inlet air cooling for increasing gas turbine power generating output in summer. And, if this low-temperature exhaust heat is recovered and used by a binary turbine, the thermal efficiency of the system can be improved. Furthermore, combining exhaust heat recovery steam with various types of steam turbines will allow variable heat-electricity systems that follow the seasonal and time zone variations in steam demand to be built. Combining various machines and devices in this way and using heat in a cascade configuration (multi-stage use) from high to low temperatures allow a high overall efficiency to be attained, which greatly contributes to energy conservation and CO_2 reduction.

To suggest such a solution to the customer, it is very important to be able to quickly present a system configuration that will maximize the benefit of investment, as well as a method of running that system. Since the ongoing acceleration of the introduction of CHPs is expected to be accompanied by the sophistication of system configurations arising from the diversification of customer needs, we will further strengthen our ability to propose solutions so that we can respond to customer needs quickly.

2 Standby gas turbine generator sets

We started developing industrial gas turbines using our own technologies in 1972, and since delivering Japan's first all-made-in-Japan turbine generator set in 1977, we have manufactured and delivered a number of gas turbine generator sets. Making the most of the features of gas turbines, to note their light weight, small size, and high starting reliability, we have serialized all 21 models covering 150 to 4,800 kW class products. In addition, the 1974 revisions to the Fire Services Act made stricter the obligation for buildings and large-sized stores to install standby generator sets for times of emergency. Recognized for their advantages of a compact size, light weight, no need for cooling water, and low vibrations in comparison with emergency diesel generator sets, gas turbine generator sets have rapidly penetrated the market.

With financial and IT enterprises having established large-sized data processing centers in the recent years, gas turbine generator sets have become widespread as backup power supplies for such data processing centers (Fig. 1).

In the Great East Japan Earthquake, Kawasaki's gas turbine generator sets showed their 99.9% starting reliability, and contributed to support efforts in the disaster-stricken areas.

After the Great East Japan Earthquake, users requested extended operation as a measure to cover the power shortage. Additionally, dual fuel specifications, in which liquid fuel is used for starting under a power service interruption and then gas fuel takes over, have been increasingly requested. Moreover, requests for mobile power supply vehicles have grown as they can demonstrate their capabilities as emergency power supplies in a disaster or a large-scale service interruption or as temporary power supplies used during wiring construction work or inspections.

Fig. 1 3,500 kVA standby gas turbine generator set for data processing center

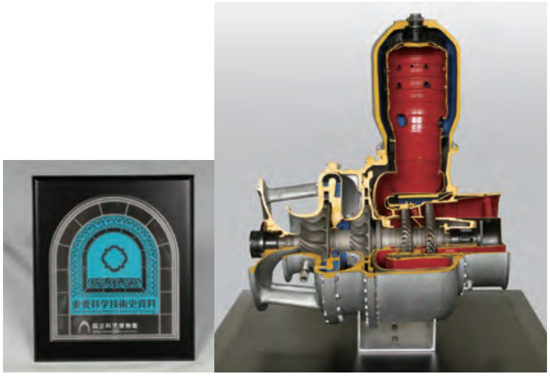

Fig. 2 Forerunner of gas turbines that became widely used as emergency generators (Essential Historical Materials for Science and Technology)

Since we entered the emergency power supply market in 1977, our gas turbine sales achieved a landmark as the 10,000th unit was delivered in February 2011. In September 2011, the 150 kW class S1A-01 gas turbine developed by us in 1975 was registered as the "forerunner of gas turbines that became widely used as emergency generators" and placed amongst the Essential Historical Materials for Science and Technology (Future Technology Heritage) at the National Museum of Nature and Science (Tokyo) (Fig. 2).

3 Industrial gas turbine generator sets

In response to society's energy conservation needs, we, making the most of the experience acquired through emergency generator sets, developed a CHP composed of a gas turbine and a HRSG, delivering the first CHP unit of this kind with a 1,000 kW output in 1984. Furthermore, we made in-roads into the market of combined cycle power generation that improves the power generation efficiency by combining a gas turbine with a steam turbine. Following this, we developed and put on the market increasingly larger gas turbines one after another, such as the M7A (7 MW class) and L20A (18 MW class). Following this, we developed a still larger model in the L30A (30 MW class), with operation of the first commercial unit started in October 2012 (Fig. 3). This has helped us serialize a wide variety of models with an output range of 650 to 30,000 kW.

In the past, the introduction of CHPs aimed at energy conservation or the reduction of greenhouse gas emissions in most cases. Since the Great East Japan Earthquake, however, a move has begun to study the introduction of CHPs from the viewpoint of business continuity in preparation against the risks of power shortages and service interruptions.

From the viewpoint of protecting the global environment, the needs for clean exhaust gas properties (reduction in CO_2 emissions and NOx emissions) have grown. We have already commercialized a gas turbine with an NOx emission level of 15 ppm (density equivalent at O_2 = 15%), with a similar product with an NOx emission level of less than 10 ppm having been developed and now under a demonstrative operation. In addition, we are engaged in developing combustion systems capable of running on a variety of fuels such as low-calorie gas, hydrogen, and by-product gas.

In terms of after-sales services, we have built a remote monitoring system called "Technonet" using a gas turbine

Fig. 3 30 MW class PUC300 cogeneration facility

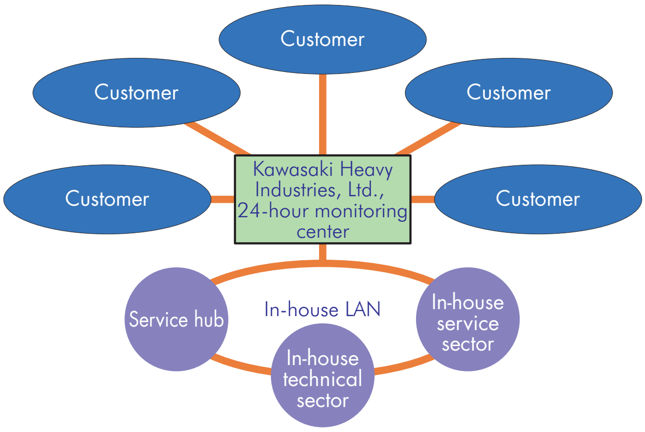

Fig. 4 Technonet system (Conceptual diagram)

developed by us and our own telecommunications network, to grasp the state of operation of each customer 24 hours a day. This allows us to provide preventive maintenance, operational support, instant response to potential nonconformance, and quick specific services (Fig. 4).

4 Lean methane-fueled gas turbines

Coal is widely used as a power generation and industrial fuel and as a raw material for steelmaking. The demand for coal is increasing rapidly in emerging countries like China and India, mainly for power generation.

On the other hand, mining coal releases methane gas contained in coal layers. With a greenhouse effect about 21 times that of CO_2, methane gas causes, after CO_2, the second greatest environmental load on the global environment. Among the kinds of coal methane, in particular, ventilation air methane (VAM), which has a dilute methane content of less than 1%, has no way of being used and is currently being released into the atmosphere.

Fig. 5 Lean methane-fueled gas turbine generator set

Yet, we have developed a gas turbine running on lean methane such as VAM (Fig. 5). We will sell gas turbines of that type to coal producing countries to contribute to the prevention of global warming.

5 Diesel generator sets

We have a long history as a diesel engine manufacturer, and since entering into a technical tie-up with the German firm MAN in 1911, we have provided a number of excellent engines for use in merchant ships, warships and land facilities. And, in 2011, we feted our 100th anniversary of technical tie-ups with MAN.

The Kawasaki-MAN 4-stroke diesel engine comes in L and V types that are light in weight, small in size, and high in power. These engines are capable of extended operation on heavy oil without major maintenance and are designed for simple maintenance and servicing, and, therefore, are used widely as main marine engines and in power generating plants.

These MAN-type engines and S.E.M.T. Pielstick PA6CL type 4-stroke engines, completed in 1993, are used in land-based power generation. We have a history of delivering utility-use generator sets for remote islands, emergency generator sets for nuclear power plants, and industrial generator sets, all of which have been given a favorable reception (Fig. 6).

Fig. 6 Diesel generator set destined for the Okinawa Electric Power Company

Fig. 7 7.8 MW Kawasaki green gas engine

6 Gas engines

We developed the world's highest performing gas engine with an 8 MW class generating output (Fig. 7). In 2007, we completed an 18-cylinder demonstrative machine and achieved the world's highest generating efficiency of 48.5%, and, at the same time, it materialized the world's highest level of environmental performance in terms of NOx emissions (density of 200 ppm or less at O_2 = 0%) . This gas engine is characterized not only by the optimized combustion chamber shape but also by its ability to control the incident of knocking and the cycle efficiency obtained through individual control of cylinders. Its overall efficiency reached about 85% when built into a CHP using exhaust heat. In the course of engaging in the development of various products, we installed a gas engine generator set with an output of 5 MW at our Kobe Works, equipped it with a variable nozzle turbocharger and succeeded in increasing the generating efficiency to 49.0% in 2010. An order for the first unit was received in February 2011. Recently, needs have been growing rapidly in Japan for small- and medium-sized power plants and captive power plants for the purpose of steady supply of electric power. We received an order from Central Motor Co., Ltd. (now Toyota Motor East Japan, Inc.) for a gas engine for its Miyagi plant in July 2011, and another order in September 2011 from a new electric utility company, Nihon Techno Co., Ltd., for the construction of Japan's first gas engine power plant composed of 14 gas engines with a total power generating capacity of 110,000 kW. The project is called the "Nihon Techno's Sodegaura Green Power Project." Both power plants have started full commercial operation.

Nihon Techno's Sodegaura Green Power Plant is operated at a generating efficiency of 49.5% and applies low-viscosity lubricant and other measures. In the meantime, overseas inquiries have increased rapidly due to an increase in electric power demand resulting from economic development. In December 2011, we received an order for two gas engines to be installed in a Singapore LNG terminal, the first order from overseas. Orders for more than 30 gas engines have been received from both Japan and foreign countries.

We started developing marine gas engines and land-use gas engine of the world's highest power generation efficiency. This is the first attempt in Japan to develop marine gas engines fired exclusively by gas for use as main engines that can deliver a large output (2 MW or more). Another feature of this engine is its compliance with the International Maritime Organization (IMO)'s Tier Ⅲ regulations without relying on a DeNOx system. We will develop not only technologies to minimize knocking due to load fluctuations but also technologies that are applicable both to direct propulsion systems, by which engine output is used to drive the propeller directly, and to indirect propulsion systems, by which engine output is used to drive a propulsion motor and then drive a propeller (electric propulsion).

We will complete a demonstrative (six-cylindered) marine engine with an output of about 2.5 MW and obtain ship classification in fiscal 2013, and then successively put on the market engines with an output range of 2 to 8 MW (5 to 18 cylinders).

7 Generator-use steam turbines

Land-use steam turbines are classified into those for power generation and those for mechanical drive. We have serialized a reduction geared type (models RP and RC) and a direct coupling type (models DP and SC) for power

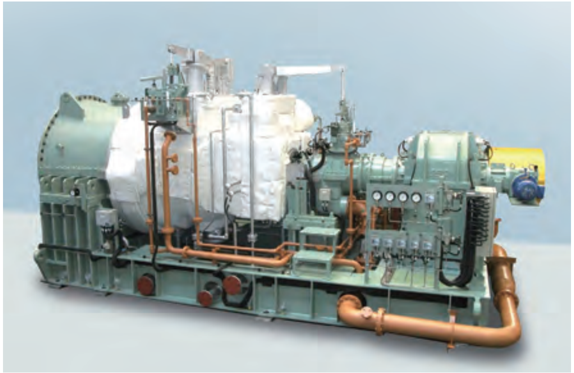

Fig. 8 Generator-use steam turbine

Fig. 9 Green binary turbine

generation use, and HP and HC models for mechanical drive use (Fig. 8). Their output range extends from 1,000 kW to 150,000 kW.

For power generation use, in particular, we have an extensive track record in the field of steam plants such as exhaust heat recovery plants using exhaust heat from plants, refuse incineration plants, biomass power generation plants, and geothermal power plants, in addition to conventional in-house power generation plants consisting of fossil fuel-fired boilers, turbines, and generators. At the same time, we produce high-efficiency turbines with axial flow exhaust that are suitable for combined cycle power generation plants as they aim at the effective use of energy in combination with gas turbines.

8 Top pressure recovery turbines

A top pressure recovery turbine is a machine that recovers the pressure energy of blast furnace gas produced by a blast furnace in a steel plant in the form of electric energy. Top pressure recovery generator sets allow blast furnace gas to be used effectively and exhibit a high energy-saving effect. In addition, they are equipped with environmental functions for reducing fluid noise from blast furnace gas flow and removing dust. For this reason, they are installed in all large-scale blast furnaces in Japan.

Our top pressure recovery turbines do not adopt conventional governor valves to regulate blast furnace gas pressure, but variable stator blades by which the pressure is controlled by freely changing the angle of the inlet stator blades. For this reason, low-noise, high-efficiency power generation is allowed even under conditions in which the quantity and pressure of the gas passing through the turbine varies. As the top-ranking manufacturer of top pressure recovery generator sets, we have a track record of delivering about 50 units both in Japan and foreign countries, including the Republic of Korea, Taiwan, the Unites States, China and Brazil. In addition, inquiries for replacement projects in Japan are brisk.

9 Binary turbines

Binary power generation is an electricity-producing energy-saving system, by which energy is taken from a low-temperature heat source by means of a low-boiling-point medium to drive a turbine generator set. Binary power generation produces electric power by effectively using waste hot water (80°C to 120°C) or exhaust gas that was not used in the past, geothermal heat, or hot spring water, thus contributing to a reduction in CO_2 emissions. The green binary turbine (Fig. 9), whose manufacture and sale started in June 2010, materializes excellent environmental performance and high cost-effectiveness owing to technologies accumulated with CFC turbine generator sets, similar systems, and by adopting a new low-boiling-point medium.

Jointly with Kyushu Electric Power Co., Inc., furthermore, the demonstration tests on a geothermal binary generator set (250 kW) will be started on the premises of the electric power company's Yamagawa Geothermal Power Station, to confirm and verify heat recovery technologies, cost-effectiveness, durability, and similar factors under geothermal conditions.

Closing

Today's trends toward the abandonment or reduction of nuclear power plants, expanded use of renewable energy, global environment conservation, introduction of CHPs, and expanded use of distributed power generation have spurred intensive reviews of energy policies the world over.

With the aim of contributing to the preservation of the global environment and the stable supply of electricity, we will continue improving our technologies and proposing to customers efficient practical energy systems and energy-related equipment that meet their diversified energy needs.