Standby gas turbine generator set for stable supply of electric power

After the Great East Japan Earthquake, the need for systems that can stably supply power in an emergency is openly evident. We internally develop, manufacture and sell power generation facilities powered by gas turbines for a wide variety of output ranges, as standby backup power supplies to be used by hospitals, communications facilities, IT-related datacenters and other facilities that need to run 24 hours a day.

This paper presents the features of our standby gas-turbine power generation facilities as well as their operating track records in disasters such as the Great East Japan Earthquake.

Preface

The Great East Japan Earthquake that hit Japan in March 2011 caused immense damage over an extensive region covering one metropolis and 15 prefectures. In the areas where power service was interrupted, Kawasaki's standby gas turbine generator sets operated fully up to the time of service resumption or the exhaustion of fuel, proving their worth as standby equipment. Fig. 1 shows the localities in which Kawasaki's standby generator sets operated during the power service interruption caused by the earthquake.

It is essential for a standby generator set to start up without fail in an emergency and to supply electric power. And, a gas turbine used as the prime mover must be characterized by high startup reliability and a short transient time from the startup to the start of power feeding. For this reason, the plain-structured simple open cycle single-shaft type gas turbine (Fig. 2) is the mainstream product, which is adopted by Kawasaki too. A gas turbine is self-air-cooled and does not need cooling water, allowing itself to be installed in space-restricted locations such as a rooftop or a basement. Fig. 3 shows a typical indoor installation of a gas turbine generator set. Like a routine gas turbine generator set, a standby gas turbine generator set must not only be high efficiency but also meet different characteristics requirements from those of a routine use set because of the different purpose of use.

Table 1 shows the main specifications of Kawasaki's standby gas turbine generator sets of the Kawasaki PU series.

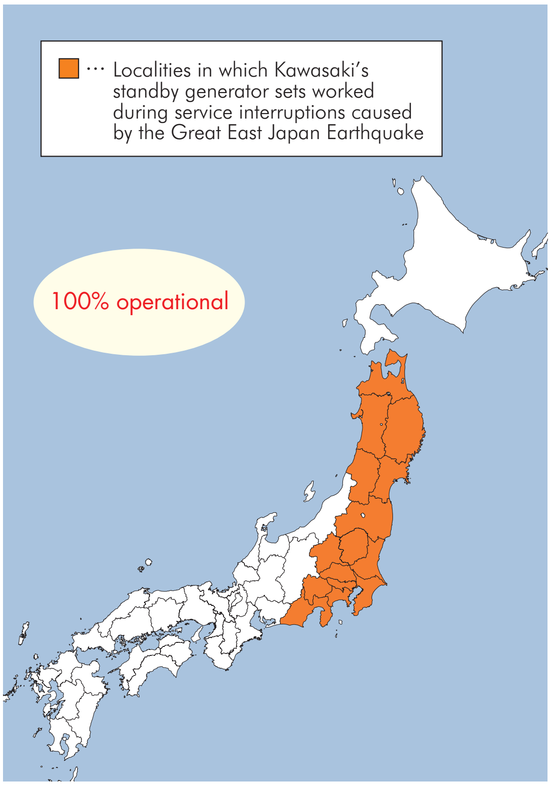

Fig. 1 Localities with working standby generator sets

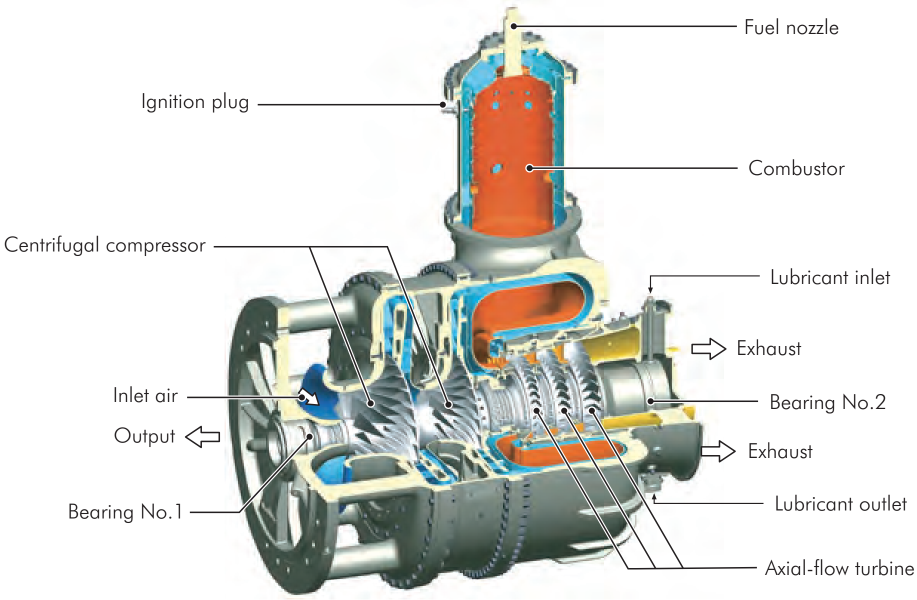

Fig. 2 Simple open cycle single-shaft type gas turbine

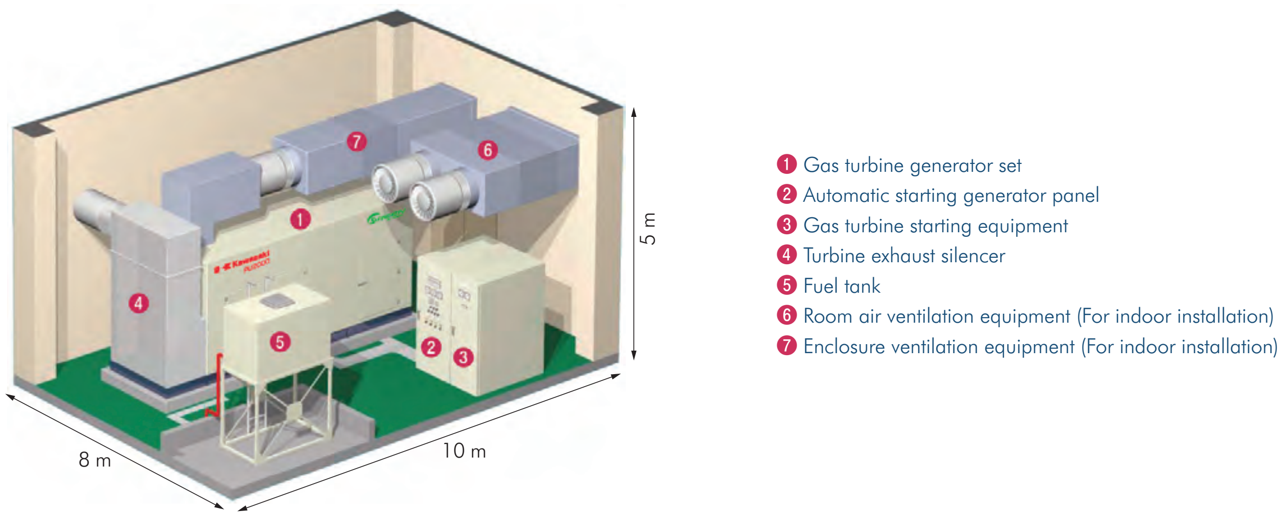

Fig. 3 Example configuration of gas turbine plant (2,000 kVA)

Table 1 Main specifications of Kawasaki PU series

Item \ Model		PU 200	PU 250	PU 250S	PU 300	PU 375	PU 500	PU 500S	PU 625	PU 750	PU 1000	PU 1250	PU 1500	PU 1750	PU 2000	PU 2500	PU 3000	PU 3500	PU 4000	PU 4500	PU 5000	PU 6000
Rated output (kVA)	Standby use (40°C)	187.5	225	250	300	375	437.5	500	625	750	1,000	1,250	1,500	1,750	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000
Alternator	Voltage (V)	200 ～ 6,600							400 ～ 6,600						3,300 ～ 6,600							
	Frequency (Hz)	50/60																				
	Number of poles(P)	4																				
Gas turbine		S1A -01	S1A -02	S1A -03	S1A -06	S1T -02A	S1T -02	S1T -03	S2A -01A	S2A -01	M1A -01A	M1A -01	M1A -03	M1A -06	M1A -23	M1T -01S	M1T -03	M1T -06	M1T -23	M1T -23S	M1T -33A	M1T -33

1 Features of Kawasaki's standby gas turbine

(1) Quick startup

After the occurrence of a service interruption, Kawasaki's gas turbine set is capable of feeding power within 40 seconds of starting up automatically.

Usually, the problem of a longer startup time occurs as a gas turbine becomes larger and increases output. With Kawasaki's gas turbines, however, the starting unit has been optimized through startup torque simulation. As a result, even a 6,000 kVA gas turbine is capable of starting up within 40 seconds.

(2) Stable frequency characteristic

A single-shaft type gas turbine has a large equivalent moment of inertia because the compressor is driven and the rotational output is transmitted via the same turbine (main shaft) and because the speed of the main shaft rotating at a high speed (18,000 to 53,000 rpm) is reduced to that of the output shaft at 1,500/1,800 rpm. This leads to minimal change in speed under instantaneous load fluctuation, yielding good rotational speed (frequency) characteristics. This provides a substantial advantage for a standby generator set susceptible to instantaneous overload.

(3) Self-air-cooled type

A gas turbine employs a self-cooling system that uses air from the outlet of the compressor to cool the high temperature sections. This feature eliminates the need for cooling water and its accompanying equipment, hence the need to prepare against water supply interruptions and freezing in cold seasons. This is a useful feature for a standby generator unit that must be operated in a variety of environments.

(4) Small size and lightweight

A gas turbine, as a rotary machine, is characterized by continuous fuel combustion and the capability of handling a large quantity of working fluid. Accordingly, a gas turbine unit can be made compact and lightweight.

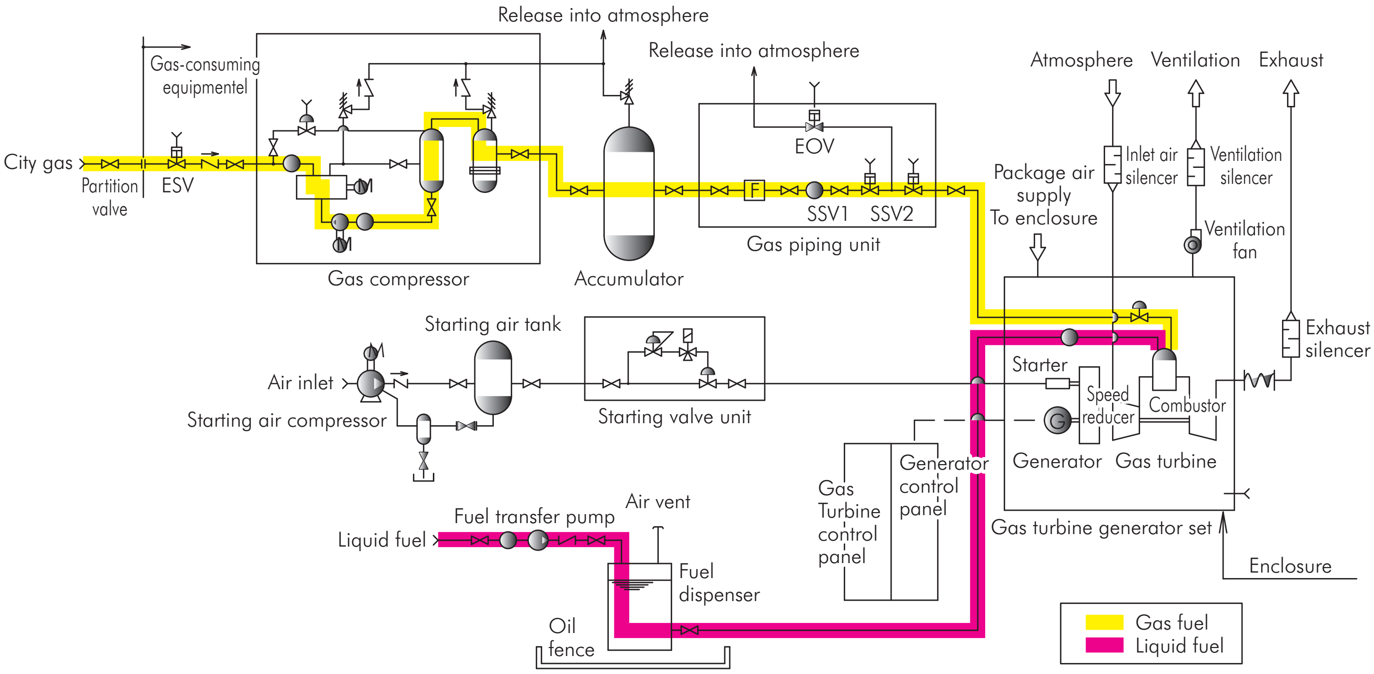

Fig. 4 Example system flow of dual fuel type gas turbine

(5) Diverse fuel options

Standby generator sets are fueled mainly by liquid fuels such as fuel oil A, light oil or kerosene. The allowable temperature ranges of the fuels in the environment of installation are as follows.

① Fuel oil A : –10～40°C
② Light oil Nos. 1 and 2: –10～40°C
③ Light oil No. 3 : –15～40°C
④ Kerosene : –25～40°C

The startup reliability associated with the use of fuel oil A and light oil is improved by taking measures against filter clogging due to an increase in low temperature dynamic viscosity and other causes, that is, by heating the fuel dispensing tank, fuel piping, and the like.

Recently, We started supplying dual fuel systems that change over to gas fuel after the completion of startup with the aim of making turbine generator sets operate for a longer time.

2 Dual fuel system

Standby generator sets have been installed for supplying power for a relatively short period of time. For this reason, when they are required to operate for a long time as in planned service interruptions required as a result of the earthquake this time, how to supply fuel in a stable way becomes an important problem in operating these standby generator sets.

Most standby generator sets use liquid fuels such as fuel oil A, light oil, or kerosene, and fuel is stored in underground tanks and the like, which limits the quantity that can be stored. A dual fuel system is intended to allow both liquid and gas fuels to be used should the fuel supply be interrupted in an emergency.

For a gas turbine, changeover between liquid and gas fuel is easier. In a dual fuel specification system, a gas turbine standby generator set starts up on liquid fuel after the occurrence of a service interruption, uses electricity it generates to drive a gas compressor, and changes over from liquid fuel to gas fuel during operation. This allows the system to keep running on different fuels. These systems have established track records in routine-use generator sets, and modifications to the fuel system components, such as the fuel injection nozzles, have made the systems operational on standby generator sets Fig. 4 shows an example system flow of a dual fuel type gas turbine.

3 Mobile power unit

The “compactness, lightweight, and no need for cooling water” are ideal features for a mobile power unit in times of a disaster. The following report presents the gas-turbine-equipped mobile power unit of the Kawasaki MPU series, which adds mobility to the Kawasaki PU series gas turbine generator set that has been enjoying a high reputation and an almost overwhelming delivery track record in the fixed gas turbine market (Fig. 5).

Fig. 5 Mobile power unit

(i) Low vibration and low noise
Similar to a stationary system, a gas turbine is a rotary motion engine without a reciprocal motion section, thus nearly free of vibration. The major part of the noise generated is in the high frequency region that is easy to isolate and is isolated very effectively by means of a simple-structured sound isolation panel and a silencer. This allows a gas turbine standby generator set to be operated in an urban area or at night.
(ii) No need for cooling water
Being self-air-cooled, a gas turbine does not need cooling water. This is a very favorable attribute of a mobile power unit that is required to perform under a variety of operating conditions.
(iii) Resistance to coldness and high startup reliability
A gas turbine that does not need cooling water and is free of sliding parts is structurally resistant to coldness. Even cold climate versions do not need a large-scale heating system as is required by a diesel power vehicle. It can work on fuel oil A, light oil, or kerosene, and can be started up at temperatures as low as −25°C without heating means. In addition, being capable of engaging full load operation without warming-up is an attraction peculiar to a gas turbine.

4 Track records of operation of standby gas turbine generator sets

(1) Actual state of operation in the wake of the Great East Japan Earthquake

The Great East Japan Earthquake that hit Japan with a magnitude of 9.0 was the greatest earthquake in the history of seismic observation since 1990 and of a scale that was counted as one of the world's five greatest earthquakes. The disaster area covers one metropolis and 15 prefectures including the Tohoku and Kanto areas. Table 2 shows how the Kawasaki PU series standby gas turbine generator sets worked in the disaster area.

In the disaster area, 3,092 of Kawasaki's standby gas turbine generator sets, Kawasaki PU series products, were deployed, while 1,035 were deployed in areas where service interruptions due to the earthquake occurred. Except one unit that had not undergone maintenance, all of the units mentioned above operated normally, proving that the units had high startup reliability.

In the implementation of planned power service interruptions in and around the Kanto area after the earthquake, all generator sets in the areas in question worked normally.

Table 2 Operation of Kawasaki PU series in disaster area

Prefecture.	Number of deployed sets		State of operation	
	Disaster areas	Service interruption areas	In operation	Not in operation
Aomori	57	50	50	
Iwate	50	50	50	
Miyagi	134	119	119	
Akita	32	28	28	
Yamagata	73	67	66	1 (Insufficient maintenance)
Fukushima	64	41	41	
Niigata	89	0	0	
Tokyo	1, 277	49	49	
Kanagawa	363	175	175	
Saitama	216	125	125	
Chiba	233	91	91	
Ibaraki	125	76	76	
Tochigi	65	43	43	
Gunma	106	90	90	
Yamanashi	28	13	13	
Shizuoka	180	18	18	
Total	3, 092	1, 035	1, 034	1

(2) Actual state of operation of generator sets in the wake of past disasters

In the Great Hanshin-Awaji Earthquake of January 1995, diesel-engine-based generator sets could not operate because of water supply interruption. On the other hand, many of self-air-cooled gas turbine generator sets did, with Kawasaki's standby gas turbine generator sets exhibiting a working rate of 95.9%. Many of the sets that did not work had not been serviced regularly since their installation, and this was the reason why they did not operate in an emergency. Under these circumstances, the occurrence of the earthquake provided an opportunity for recognizing the importance of regular inspections and servicing. As a result of this lesson, a working rate of 100% was attained with standby gas turbine generator sets in the great blackout of the metropolitan area in August 2006, the 2007 Noto Peninsular Earthquake, the 2007 Chuetsu Offshore Earthquake, and the 2008 Iwate-Miyagi Inland Earthquake.

Concluding remarks

Recently, a move toward strengthening power supply security has been visible as a result of the implementation of planned service interruptions by power utilities and power shortages. From the viewpoint of business continuity planning (BCP) as well, awareness has been growing of the importance of standby gas turbine generator sets with a dual fuel system that are capable of feeding electricity to disaster-preparedness loads and security loads in an emergency. It is expected that cases where these systems are adopted will increase in the future.

The mobile power unit with a small gas turbine excels in mobility and is useful as a backup system for supporting social infrastructure. The gas turbine to be mounted in the unit is selected from a variety of viewpoints, but high efficiency, high reliability, and low environmental loading are required of it invariably. In response to these requirements, we will continue its efforts to improve the quality of gas turbines, spread their use, and build up a periodic maintenance service system essential to the assured operation of gas turbines in an emergency.

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