Kawasaki Green Gas Engine Cogeneration System

Cogeneration systems that integrate our Kawasaki Green Gas Engine, which is fired solely by city gas/ natural gas, are often installed to reduce energy consumption throughout facilities, including that of heat recovery. The latest model of the Kawasaki Green Gas Engine achieves a power generation efficiency of 51.0%, a global best-in-class level, and it is increasingly being installed as a BCP measure as a hedge against disaster. It supports quick start-up, low-load operation, and frequency fluctuation, and we have also established a 30 vol% hydrogen mixed-fuel combustion technology. In addition, gas engines hold great promise as a product to help promote the use of renewable energy to achieve a carbon neutral society by 2050.

Introduction

At the 26th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26), Japan pledged to reduce its CO_2 emissions by 46% by FY2030 compared to the FY2013 level. While promoting the use of renewable energy has widely been highlighted as a means of achieving carbon neutrality, expectations are increasing for gas engine power generation, not only as a BCP measure in the event of a disaster, but also as a way to flexibly handle the variance in power supply from renewable energy sources.

1 Background

Cogeneration systems using gas engines, which enable high economic efficiency and energy savings as combined heat and power systems that generate electricity and effectively utilize waste heat on the demand side, have become popular. As of December 2022, orders for our Green Gas Engine have reached 224 units, providing a total power generation capacity of 1,684 MW.

2 Product overview

For our top-selling KG-18-V, the recovery rate at 100% energy input is 49.5% for electricity, 15.2% for steam, 13.4% for high-temperature water, and 4.0% for low-temperature hot water, achieving an overall efficiency of 82.1% (conditions: city gas; 0.784 MPaG saturated steam; high-temperature water recovery [75°C (inlet) / 90°C (outlet)]; and low-temperature hot water [25°C (inlet) / 60°C (outlet)]). The steam is used as a heat source for heating in the production process; the high-temperature water is used as a heat source for a hot water absorption chiller; and the low-temperature hot water is used for heating utilities and other purposes.

3 Product features

(1) Global best-in-class level of power generation efficiency and environmental performance

The Kawasaki Green Gas Engine lineup consists of the five types shown in **Table 1**, and the latest model KG-18-T, which adopts two-stage turbocharging, has achieved a power generation efficiency of 51.0%, a global best-in-class level. The KG-18-T adopts our technology for low NOx emissions of 200 ppm or less (O_2 = 0%), a quantity that in many regions does not require a selective catalytic reduction device.

As shown in **Fig. 1**, the KG-18-T is the first gas engine in its class in Japan to introduce a two-stage turbocharging system that features two turbochargers and two air coolers as a module to improve turbocharger efficiency, thereby enabling a substantial increase in power generation efficiency.

Table 1 Lineup of Kawasaki Green Gas Engines

		「KG-12」	「KG-18」	「KG-12-V」	「KG-18-V」	「KG-18-T」 (Two-stage turbocharging)
Number of cylinders		12	18	12	18	
Electric output〔kW〕	50Hz	5, 200	7, 800	5, 200	7, 800	
	60Hz	5, 000	7, 500	5, 000	7, 500	
Power generation efficiency〔%〕		49. 0		49. 5		51. 0
NOx〔ppm〕		200 or less（O_2 = 0%）				

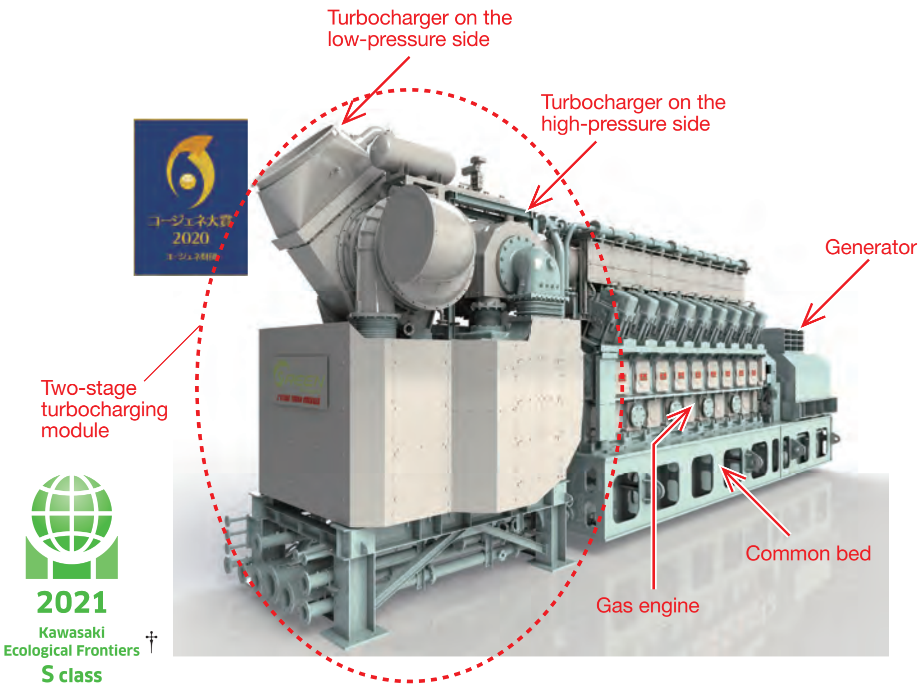

Fig. 1 Two-stage turbocharging gas engine (KG-18-T)

In recognition of these features, it has received numerous awards, including the Chairman's Award in the Technological Development Category at the 2020 Cogeneration Awards hosted by the Advanced Cogeneration and Energy Utilization Center Japan, and the Agency for Natural Resources and Energy Commissioner's Award at the FY2022 Energy-Saving and Decarbonization Machinery and Systems Award hosted by the Japan Machinery Federation.

† New high-performance Green Gas Engine equipped with an 8-MW-class two-stage turbocharging system, which achieves the world's highest level power generation efficiency among engines of the same capacity and significantly reduces fuel gas consumption

(2) Quick start-up

While the normal start-up time is ten minutes or less from issuance of the start-up command to reaching the rated load, the time is reduced to five minutes or less by using the quick start-up system, which employs compressed air to assist turbocharger rotation to maintain stable turbocharger pressure and to prevent abnormal combustion due to load increase.

(3) Wider range available in low-load operation

In response to market demand, we have expanded the available range in the low-load combustion operation from the conventional 30% load to 20% load. As a result, the ability to adjust the supply-demand balance has been improved, in addition to improved start-up performance.

(4) Support for frequency fluctuation events

The blackout caused by the Hokkaido Eastern Iburi Earthquake has increased the need to improve the tolerance to possible frequency fluctuations. To meet this challenge, we introduced a new evaluation of dynamic characteristics when the frequency drops, thus enabling all models to operate even when the frequency drops to 94% of normal, thereby contributing to stabilizing the frequency of the power grid.

(5) Establishment of 30% hydrogen mixed-fuel combustion technology

We have established a system that can appropriately control the combustion state according to the power generation output and the hydrogen mixture ratio, and we conducted hydrogen mixed-fuel combustion tests and other tests using a single-cylinder demonstration unit. As a result, we became the first Japanese gas engine manufacturer to develop a combustion technology that enables stable operation of large gas engines with a power generation capacity of 5 MW or more by mixing up to 30% by volume of hydrogen with natural gas. In hydrogen mixed-fuel combustion, safety measures against hydrogen leakage are important, so we equipped the demonstration unit with a system for safely venting any leaked hydrogen around the combustion chamber to the outside, as shown in **Fig. 2**.

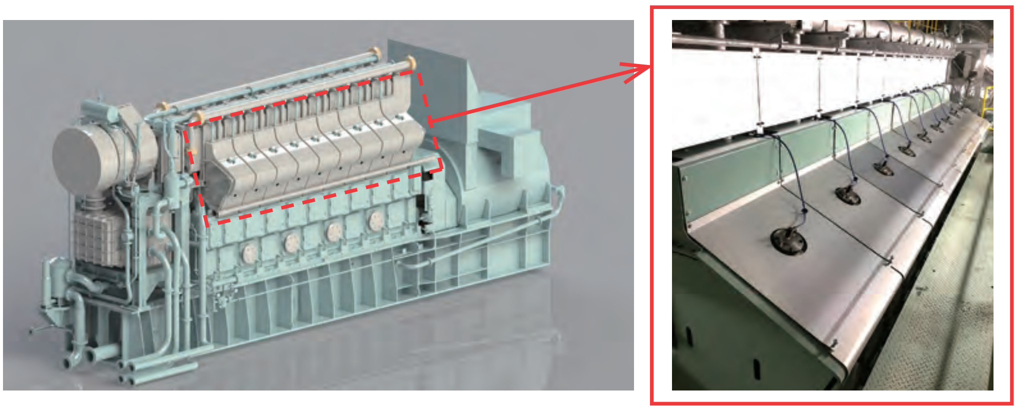

Fig. 2 Hydrogen mixed-fuel combustion gas engine for demonstration and leak detection covers

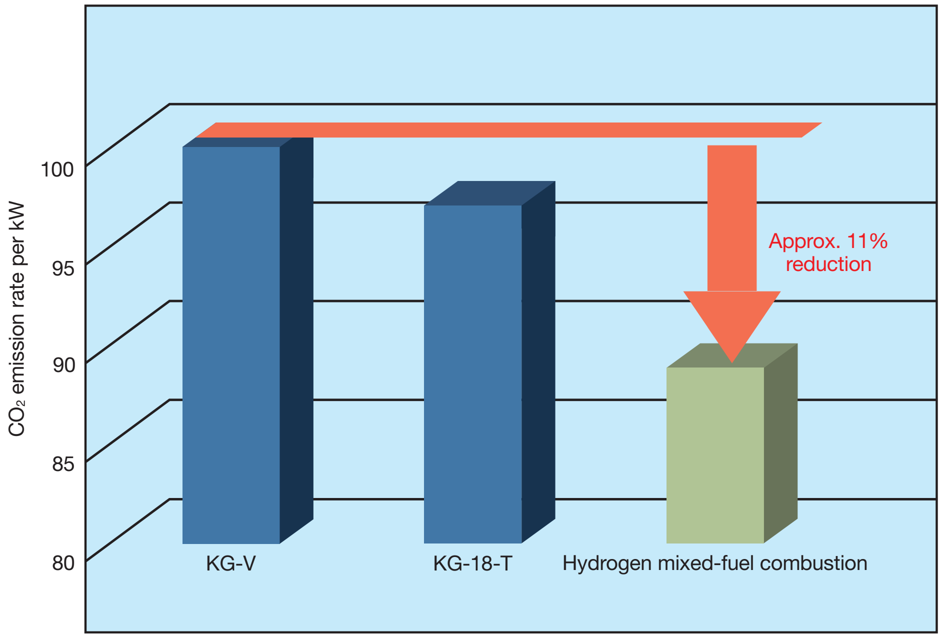

Fig. 3 Comparison of CO_2 emission rates among Kawasaki's gas engines

After conducting various tests on the demonstration unit, we plan to commercialize a model for hydrogen mixed-fuel combustion in 2025 and a model capable of 100% hydrogen combustion in addition to hydrogen mixed-fuel combustion in 2030. As shown in **Fig. 3**, 30% hydrogen mixed-fuel combustion reduces the CO_2 emission rate by about 11% compared to that of the conventional models, and 100% hydrogen combustion results in a 0% CO_2 emission rate.

Conclusion

Gas engines have been further developed to reduce CO_2 emission rates, and they will respond flexibly to the period of transition from a low-carbon society to a decarbonized society.

There are high expectations for this product, which incorporates technologies that contribute to the decarbonization of society, as we work toward the realization of a carbon neutral society in 2050.

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