<SDGs> High-efficiency Gas Turbine Combined Cycle Power Plant Using Existing Steam Turbine and Natural Gas
~ Case Project: Kohjin Life Sciences Co., Ltd. Saiki Factory ~ *1

Abstract

Kohjin Life Sciences Co., Ltd., Saiki Factory is an important manufacturing site of Mitsubishi Corporation Life Sciences Group. The company uses fermentation-related technologies to develop a broad range of food ingredients, including yeast extracts and related health food ingredients, which are sold globally.

The Saiki Factory seeks to contribute to the sustainable development goals (SDGs) promoted by the Group. However, recent increases in production volumes have resulted in an increase in the environmental load, making it imperative for widespread changes to be made urgently.

In response to these issues, the Group has sought to reduce its carbon footprint by introducing natural gas using a liquefied natural gas (LNG) satellite facility. Simultaneously, the Group began the use of gas turbine combined cycle technology as a revolutionary method of power generation. This technology combines the new gas turbine cogeneration system with existing steam turbines to achieve a substantial reduction in CO_2, with contributions from existing heat generation systems. The result is a system offering increased power generation efficiency (> 90%), and is rated as the best in its class.

In addition, the new system is equipped with measures aimed at preventing voltage fluctuations and backup gas boilers. Factory production activities are therefore able to continue uninterrupted, even in the event of a disaster or loss of grid power, thus improving system resilience.

1. Introduction

In Kohjin Life Sciences Co., Ltd. Saiki Factory, the energy used in manufacturing processes has traditionally been provided by heavy oil-fired boiler turbine generators (BTGs) and purchases from the grid. However, increases in the production volume have led to an increase in environmental load, which is an issue that needs to be addressed. Furthermore, increased efforts are necessary for the company to make any meaningful contribution to the SDGs promoted by the Group.

Table 1 System overview

Types of motors	Gas turbine + existing steam turbine
Rated power generation output/number	10570 kW × 1 unit (GT: 7550 kW, existing ST: 3020 kW)
Use of waste heat	Manufacturing process
Fuel source	LNG vaporized gas
Reverse power flow	YES
Start of operation	February 2019

Fig. 1 Building exterior

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In response, we have recently introduced a gas turbine cogeneration system (8 MW class) with an LNG satellite facility. This system is an upgrade of the existing boiler-based system, and converts the fuel used from heavy fuel oil (also known as bunker oil) to LNG. Furthermore, we designed a gas turbine combined cycle (GTCC) system that provides an increase of approximately 3 MW in the power generated by making effective use of the existing steam turbines.

An innovative heat recovery steam generator system was built for the cogeneration system to enable it to deliver a constant supply of high-temperature/high-pressure steam. This ensures that the fluctuating power / steam needs of the production line can always be met and that a high-efficiency GTCC is achieved.

The power supply requirements of the plant are covered by power generation from the new gas turbine and the existing steam turbine, and surplus power is sold to the grid. The heat supply demands are met by using the steam extracted from the existing steam turbines as process steam, and the back pressure steam is used to process hot water. Any shortages in the process steam are covered by newly built once-through boilers.

Large fluctuations in the demand for power and steam in the plant lead to technical issues in managing the gas fuel fluctuation range of gas turbines with strictly controlled fuel rates. However, we used simulations to determine the optimum buffer tank capacity and parameters for control valves.

Two types of vaporizers (chilled water and steam) have been installed. At high temperatures, the chilled water vaporizer is used to provide the air intake cooler of the turbine with chilled water, and at low temperatures, the steam vaporizer is used to reduce the power needs of the chilled-water pump.

2. Features

2.1 Upgrading from BTG to GTCC

When upgrading systems from BTG to GTCC, the existing steam turbines are often disposed owing to problems with steam quality and heat recovery efficiency. However, through the innovative development of an exhaust heat recovery boiler system, we have retained the existing steam turbine, which generates another 3 MW in addition to the 8 MW power generated by the gas turbine. We have achieved further carbon reductions in energy by shifting the thermoelectric balance to the high-value electric side, while maintaining a high overall efficiency.

The key aspects of the new boiler development are:

- Installation of a duct burner with a wide operating range to increase the temperature of exhaust gases for high-pressure and high-temperature superheated steam.
- Construction of a variable-boiler heat transfer area system.

We pioneered a new type of product and successfully combined a high-efficiency 8-MW-class industrial gas turbine with the efficient use of existing steam turbines. We also believe that this development represents a new method of upgrading aging BTG systems.

2.2 High efficiency (ultimate use of cascade heat)

The steam turbine is an extraction back-pressure turbine. Furthermore, the input high-pressure/high-temperature superheated steam is used for power generation, while the extracted steam is used as process steam. The back pressure steam is then used to produce hot water, thereby achieving the ultimate heat cascade use. We achieved a total efficiency rating of 91% and an annual total efficiency record of 89% (highest efficiency in an 8-MWclass industrial GTCC).

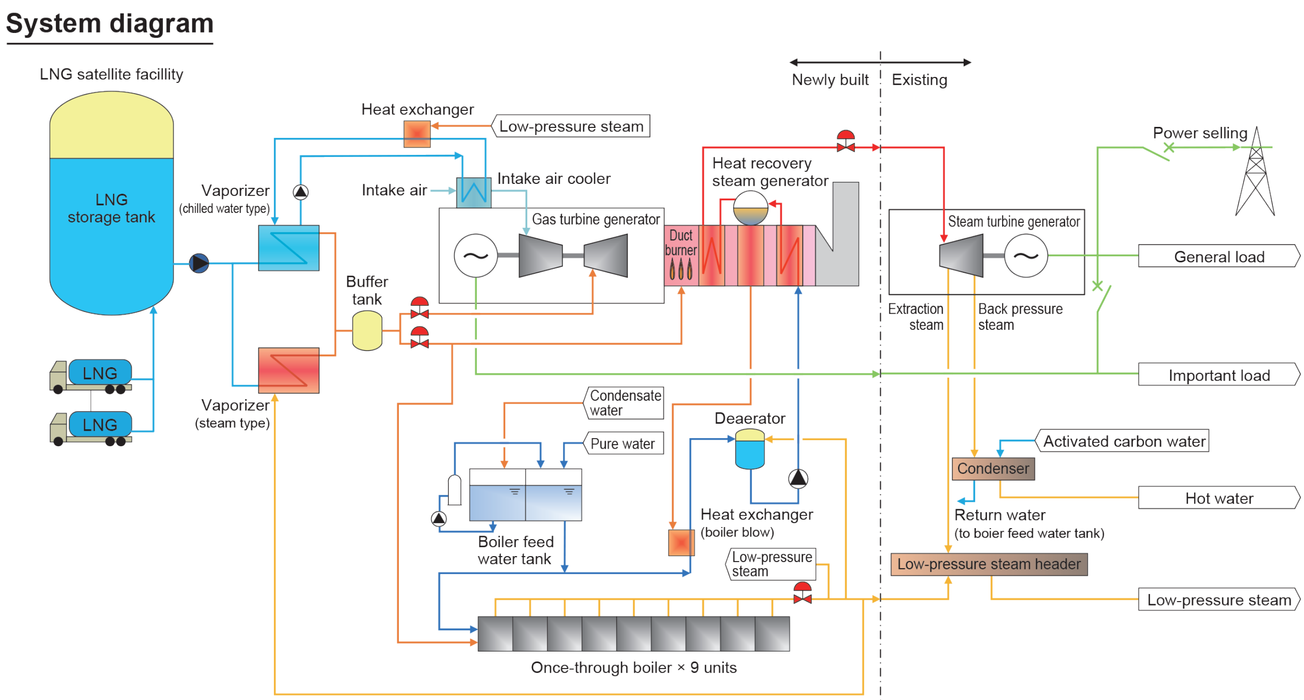

Fig. 2 System flow

2.3 Area energy network of LNG vaporization heat

We constructed a chilled-water circulation system that cools the gas turbine intake and uses the warm water to vaporize the LNG. In this way, full use is made of the heat, which contributes to increased power generation and CO_2 reduction.

2.4 System resilience

LNG satellites have sufficient LNG storage capacity to last for several days. The gas fuel needed for power generation and control power are supplied through the important load system so the GTCC system can continue to operate even in the event of a disaster or failure of grid power. Combined with secure utility water, the steam supply can also be maintained even in the event of an emergency.

We achieved a total efficiency rating of 91% and an annual actual total efficiency record of 89% by using gas turbine 8 MW power generation, exhaust heat, reheating of superheated steam turbine 3 MW power generation, and the extraction of steam/back pressure steam. We achieved approximately 40% CO_2 reduction compared to the existing system by including the use of the heat that is obtained from the turbine intake air cooling to provide heat for LNG vaporization.

2.5 Contribution to SDGs

The introduction of this system contributes to the achievement of several different SDGs such as “7. Affordable and clean energy,” “9. Industry, innovation, and infrastructure,” and “13. Climate action.”

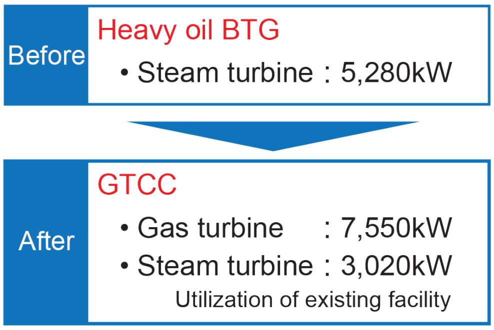

Fig. 3 System efficiency and CO_2 reduction

3. Issues and Solutions for Existing Steam Turbine Utilization

3.1 Issues affecting GTCC usage of existing steam turbines

It is challenging to supply high-pressure/high-temperature superheated steam of consistent quality within the time frameworks required of a steam turbine using the heat recovery steam generator (owing to fluctuations in the power generation output of the gas turbine). Setting the steam condition of the heat recovery steam generator to high-pressure/high-temperature superheated steam simultaneously increases the temperature of the exhaust gas from the chimney, which reduces the efficiency of the heat recovery.

3.2 Solution based on development of original heat recovery steam generator system

For the system to consistently and reliably supply the required amount of high-pressure/high-temperature superheated steam to satisfy varying plant steam loads, even if the gas turbine output fluctuates owing to the power load, which depends on the plant production conditions, the following is needed:

- Duct burner with a wide operating range.
- Variable boiler heat transfer area system.

These developments will enable automatic control of the amount of steam that is supplied to the existing steam turbines while tracking the fluctuating power/steam load.

4. Conclusion

This project won the Excellence Award in the industrial category of the Cogeneration Award 2020 sponsored by the Cogeneration Foundation. This is the third consecutive year that we have won the Cogeneration Award, following the 2018 (Chairman’s Award) for “Introduction of cogeneration by on-site energy supply in Thailand and realization of stable high-efficiency operation,” and the 2019 (Chairman’s Award) for “Overhaul of existing cogeneration system and high-efficiency re-development in order to improve power generation by 3% pts (update of aged machines).”

Nippon Steel Engineering Co., Ltd. will continue to contribute to the SDGs by consistently constructing and operating equipment based on our numerous achievements, reducing the environmental load, and achieving both stable operation and high efficiency.

Contact information
Nippon Steel Engineering Co., Ltd.
Industrial Service Business Division
On-Site Energy Service & Power Plant Marketing Department
TEL (main number) 03-6665-2000