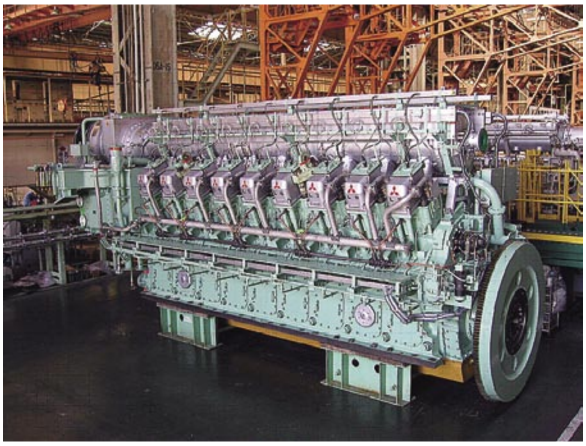

Reducing CO_2 with a High-efficiency Large Gas Engine Cogeneration System

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Amid mounting concern over global warming, power producers are turning their attention to electric power generation systems fueled by natural gas, an energy resource with low CO_2 emissions. For this purpose, Mitsubishi Heavy Industries, Ltd. (MHI) has developed and practically supplied a large 6-MW-class gas engine, the MACH-30G. This report describes the design strategy for achieving total thermal efficiency with the MACH-30G, including the strategy to recover heat from exhaust gas and other sources. Various approaches for improving thermal efficiency, quality control for site work using modular design, and other features of the new engine are also described.

1. Introduction

In light of the heightened need to reduce global warming in accordance with the implementation of the Kyoto Protocol (2008 to 2012) and discussions at the COP 13 Bali Conference to develop a roadmap for reducing greenhouse-effect gases after 2012, attention is turning to an engine powered by natural gas, a fuel with low carbon dioxide (CO_2) emissions. When used in power generation systems, gas engines have the additional merit of emitting very low levels of sulfur oxide (SOx), the source of acid rain, and low levels of nitrogen oxide (NOx), which is harmful to the human body. These engines are excellent for preserving the global environment as a whole, as well as the climate itself.

This paper introduces the efficiency-improvement technologies adopted for the MACH-30G,[1] a large gas engine of 3000 kW or more. It also summarizes various advantages of the gas engine cogeneration system, for example, in terms of quality control at the site, a reduced construction period involving modular design (the realization of MD), and reduced CO_2 emissions through improvements in the total thermal efficiency.

2. Approaches to improve the efficiency of power generation

In 2000, MHI developed the MACH-30G, a gas engine ignited by pilot fuel oil, which was modeled after a conventional spark ignition gas engine and diesel engine. As of the end of 2007, customers have placed 138 orders for MACH-30G gas engines in Japan in addition to 19 orders for engines overseas. The key selling points for customers have been environment-friendly performance and reduced energy consumption in factories.

Fig. 1 Power plant in the Yokohama Dockyard & Machinery Works of MHI
MHI started operating the plant in October 2002, and since then has achieved an availability factor of 99% or higher.

To recognize the needs of the customers who have installed gas engine cogeneration systems and to verify the reliability and improve the performance of gas engine cogeneration plants, in 2002, MHI started operating a power-generation plant with its first and second MACH-30G gas engines in its Kanazawa factory at the Yokohama Dockyard & Machinery Works (**Fig. 1**). MHI has enhanced the efficiency of actual engines using the test plant (see the results shown in **Fig. 2**),[2] and through the various improvement measures shown in **Fig. 2**, MHI improved the efficiency from an initial level of 42.5% to 44.5%. The company has now targeted further improvement to a 48% level of efficiency though various strategies.

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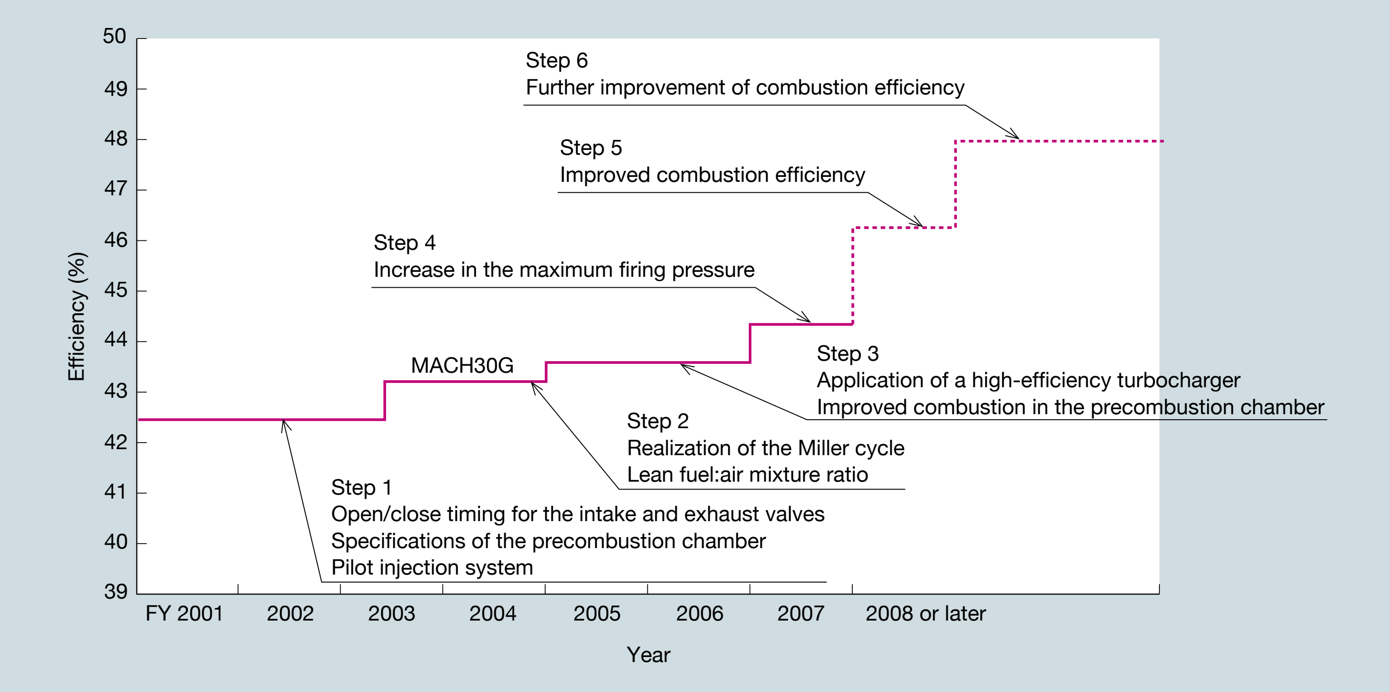

Fig. 2 Steps for improving efficiency
MHI has been taking steady measures to improve efficiency since the market release in 2002.

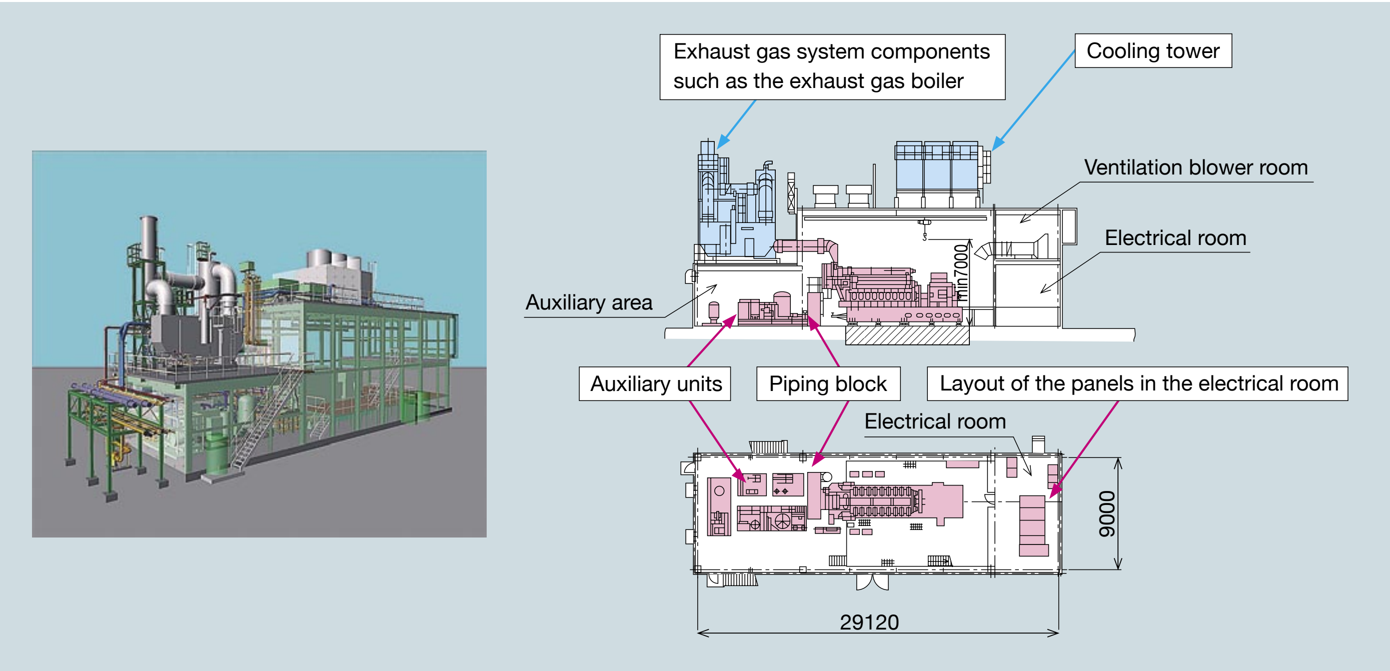

Fig. 3 Example of a 6 MW plant design
The plant design seeks to reduce the construction period and assure quality by modularizing the respective units of the gas engine plant.

3. Configuration of the gas engine plant and realization of MD

A gas engine plant has several components, such as several auxiliaries for fuel gas, pilot fuel oil, lubricating oil, cooling water, compressed air, intake air, exhaust gas, various electrical equipment, and an engine and generator. Heat-recovery equipment and antipollution facilities such as NOx-removal equipment are added in some cases, in accordance with various needs of customers, and regulations at installation sites.

By adopting a MD to modularize the basic auxiliaries and combining modules in several cases, MHI has responded to the various needs of customers and realized compatibility

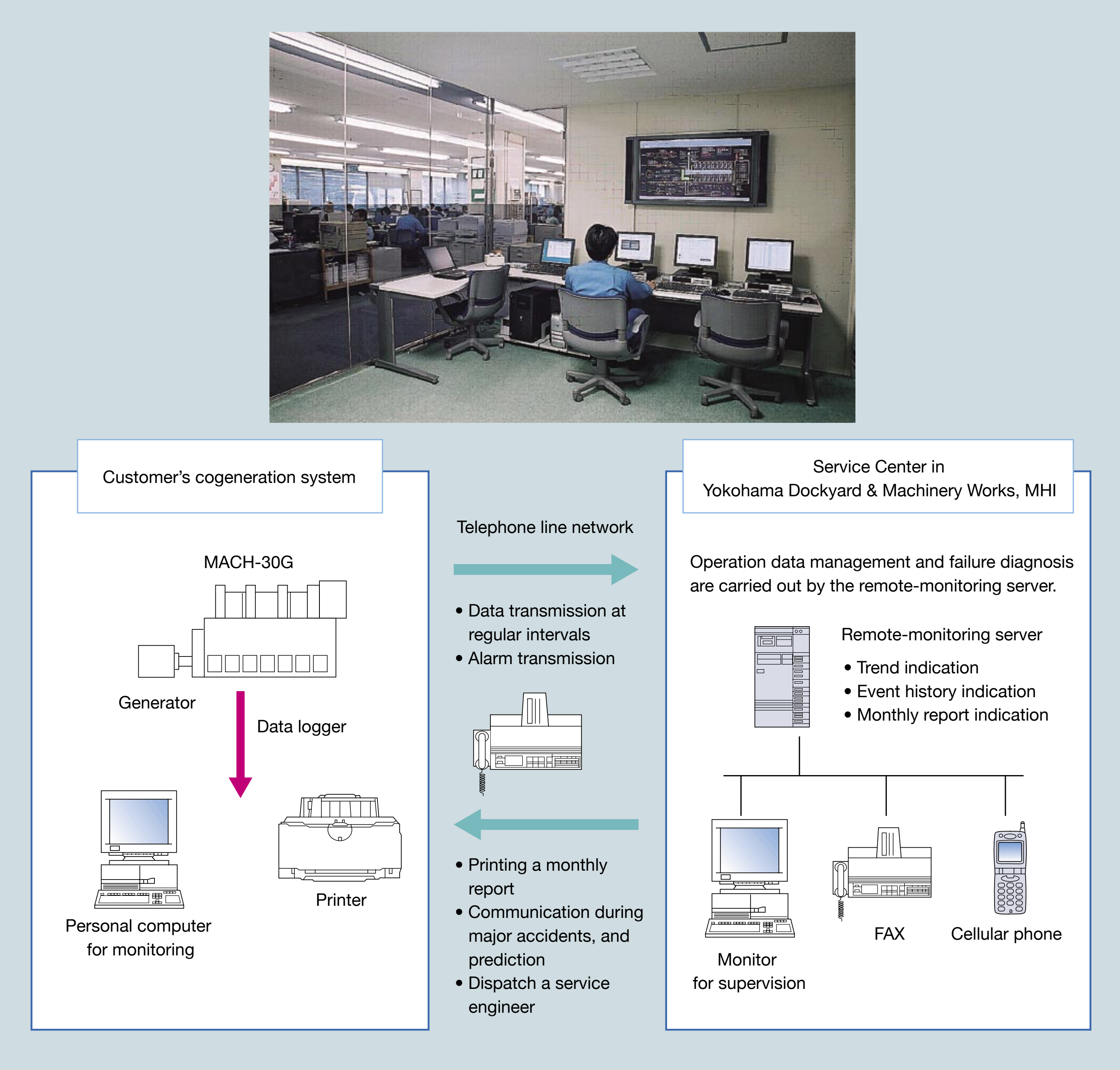

Fig. 4 Remote monitoring system
This system connects the customer's plant and MHI's service center for service requiring extreme care.

between quality control for site work. Moreover, MHI has reduced construction periods using several combinations of specific modules consisting of engine and auxiliary units, and variable modules such as auxiliaries for exhaust equipment (**Fig. 3**). MHI enhances services for customers by monitoring the operating conditions of engines remotely and exploiting superior engine properties, such as quick-start capability, rapid loading for sudden load changes, and minimal efficiency reduction with variation in air temperature. In addition, the condition of the engines can be measured and analyzed during operation by collecting data on the combustion pressure of each cylinder and various kinds of temperature data for combustion control using a remote monitoring system (**Fig. 4**).

4. Total thermal efficiency

To reduce CO_2, the total thermal efficiency is important in terms of not only the power generation efficiency but also, heat recovery from the exhaust gas, cooling water, and lubricating oil. In one plant, a total thermal efficiency of 77% was achieved by raising this heat recovery efficiency to 33% (a total thermal efficiency of 80% or higher is achieved if low-temperature water recovery is included). This high efficiency reduces energy consumption and brings about a total expected CO_2 reduction of about 15,000 ton/year in comparison with a conventional plant, when calculated at two levels:

- A CO_2 reduction of about 9,000 ton/year through power generation with natural gas.
- A CO_2 reduction of about 6,000 ton/year through heat (steam and hot water) recovery by cogeneration

5. Conclusion

The solid record of the high-efficiency performance of the MACH-30G since its commercial release in 2002, together with its enhanced reliability through the use of a remote-monitoring system and other measures, has convinced customers to place more than 150 orders for this engine, both inside and outside Japan.

MHI will continue to support the efforts of its customers to prevent global warming and improve economy through enhanced efficiency and reliability.

References

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