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Dual Fuel Engine Gas Fuel Conversion Technology†

1. Introduction

Since the Great East Japan Earthquake of 2011, the possibility of using multiple fuels in prime movers for power generation has been strongly demanded as a measure for improving power supply security, and there have been increasing requests for installation of dual fuel engines (hereinafter, "DF engine"), which are multi-fuel engines.

In other countries, a trend toward fuel conversion to natural gas for private power plants can be seen in Southeast Asia, India, and elsewhere. The aim of these trends is to reduce the unit cost of power generation, as natural gas is more economical than fuel oil. In this case, demand for gas fuel conversion of power generation plant is increasing.

Under this situation, JFE Engineering developed a gas fuel conversion technology for existing large-scale diesel engines to DF engines, and has commercialized this technology. To date, the company has received orders for a total of 9 units in 5 projects in Japan and other countries. The longest-operating unit now has an operational record of approximately 20 000 hours. Satisfactory reliability results have been obtained. **Photo 1** shows a unit in Indonesia. Responding to customer needs, JFE Engineering has also commercialized 5–6 MW class newly-manufactured DF engines utilizing this technology.

This report presents an outline of the developed DF engine.

Photo 1 16PC2-5DF (Indonesia)

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2. Features of DF Engine

2.1 System of DF Engine

The main features of the DF engine are shown in **Fig. 1**. The principle of operation in the diesel mode is diffuse combustion by fuel oil injection, which is the same as conventional diesel engines. In the gas mode, the main fuel is fuel gas. A small amount of pilot fuel oil is also injected using the diesel fuel oil injection mechanism, and premix combustion is realized with the pilot fuel oil as the ignition source (**Fig. 2**).

2.2 Gas Fuel Conversion of DF Engines

In DF gas fuel conversion, existing diesel generation equipment is modified to a DF engine. The main work is modification of the engine itself and addition of the gas fuel equipment. As a precondition of conversion, it is assumed that the generator, auxiliary equipment, etc. are mostly reused without modification. This means that the initial investment can be reduced to approximately 1/3 of that required for new construction. Moreover, because the construction period is short, the customer can enjoy the higher profit margin resulting from conversion to fuel gas more quickly. The main content of engine modification is outlined below (**Fig. 3**) [1].

2.2.1 Fuel oil injection system

In many cases, DF engines must provide approximately the same output in both the diesel mode and the gas mode. To achieve this, the most suitable parts for realizing stable injection of a small amount of oil in the gas mode, while maintaining a high injection rate in the diesel mode, are applied to fuel oil injection system.

2.2.2 Fuel gas system

As in gas engines, gas piping, a fuel gas shut off valve, a fuel gas pressure regulator, a gas filter, and related devices are installed as additional equipment. In the engine itself, the modification items are installation of a fuel gas manifold and installation of gas valves for each cylinder.

2.2.3 Air and exhaust system

Turbocharger matching is changed in order to secure the optimum air excess ratio. The existing equipment is used without changing the type. Air fuel ratio control

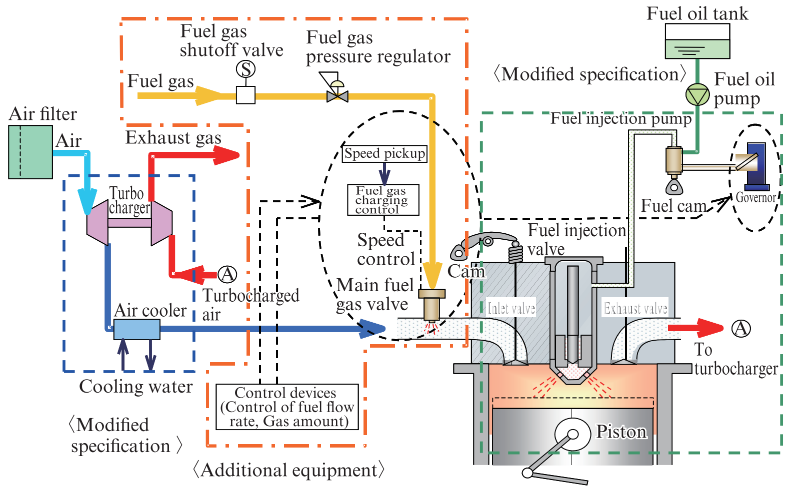

Fig.1 DF System diagram

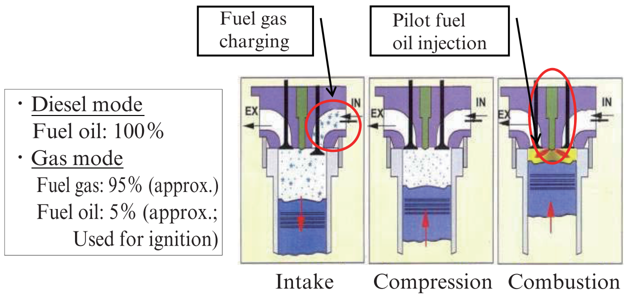

Fig. 2 Gas mode cycle

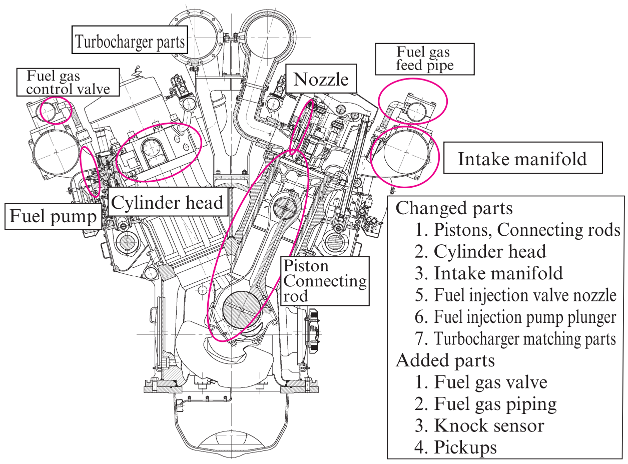

Fig. 3 DF Conversion

system is installed to air supply line to control the air excess ratio.

2.2.4 Combustion chamber

As the compression ratio of conventional diesel engines is 12–13, the knocking limit is lower side in the gas mode, and high output can not be secured. Therefore, the engine is modified by changing the pistons and connecting rods so as to reduce the compression ratio to the same level as in gas engines.

2.2.5 Control system

A gas valve control function is added to the gas system, and an operating sequence that enables governor control of the fuel injection system in both the diesel mode and the gas fuel mode is made. A system that controls both modes using the same controller is developed.

3. Performance

As performance requirements in Japan, regulations related to NO_x and soot and dust are applied under the Air Pollution Control Law. In other countries, they are the requirement to reduce pilot fuel consumption to the minimum level in areas where there is a large difference between the prices of liquid fuel and fuel gas. By applying a special fuel injection system, the optimum compression ratio, and air fuel ratio control, JFE Engineering achieved a liquid fuel ratio of 2% or less by calorific value ratio under an optional specification, in comparison with a standard 5%. As a result, NO_x = 600 ppm (O_2 = 0%) and a soot and dust level of 0.1 g/m^3-norm. or less have been achieved. This system also satisfies generating efficiency of 40% or more.

4. Conclusion

Unlike conventional gas engines, a DF engine can also operate only with liquid fuel, which is a major advantage when considering cases in which supply of fuel gas is interrupted.

In Japan, multifarious electric power supply sources and fuels is under study for equipment in which it is not permissible to interrupt the power supply due to power supply problems following earthquake disasters. To meet this need, attention has begun to focus on DF engines.

In addition to modification of existing facilities, as

Table 1 JFE-DF Product Engine line up

Engine type	12PC2-6V	16PC2-6V	Remarks
Output (Gas mode) (kW)	4 800	6 400	
Output (Diesel mode) (kW)	4 800	6 400	
Generating efficiency (%)	40	40	Generator end
Fuel consumption (Gas) (Nm^3/h)	1 011	1 348	Gas mode operation (at 100% load)
Fuel oil consumption (Diesel oil) (kg/h)	51	67	Gas mode operation (at 100% load)
Fuel oil consumption (Diesel oil) (kg/h)	964	1 285	Diesel mode operation

Fuel type and low calorific value: City gas 13A (9 700 kcal/m^3-norm.), Diesel oil (10 200 kcal/kg)

described here, JFE Engineering has made further improvements in this dual fuel conversion technology of engines, and also supplies brand-new DF engines (**Table 1**) based on this technology.

References

1) Shimizu, Akira; Matsuura, Wagenji. Dual fuel engine technology of JFE Engineering. Clean Energy 2012. vol. 21, no. 4, p. 6–9.

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