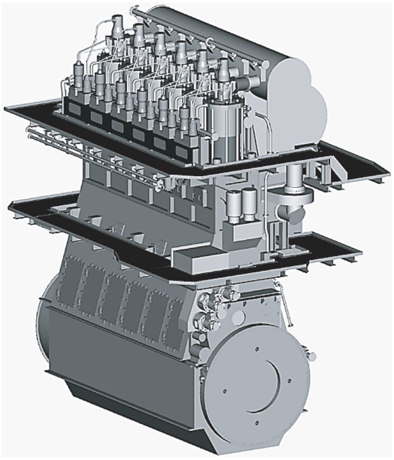

Environmental Friendly Diesel Engine "UEC Eco-Engine"

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1. Introduction

Recently, environmental protection has become a major important issue of concern for marine diesel engines. ANNEX VI to the International Convention of the Prevention of Pollution from the Ships (MARPOL 73/78) was adopted by the International Maritime Organization (IMO) in 1997. In part, the ANNEX VI sets the limits for NOx emissions, which will be applicable to ship's propulsion and auxiliary engines. This regulation is expected to come into effect in the near future, whereupon it will be retroactively applied to all new vessels and engines constructed after January 1, 2000. Therefore, the most of all marine diesel engines currently being delivered by engine manufacturers are being set to comply with the IMO's NOx requirements.

In addition, the IMO's regulation will be gradually strict even further once the regulation comes into effect. Moreover, the EPA (Environmental Protection Agency) in the United States is studying regulations that exceed the requirements of the IMO for specific local areas, as well as other domestic regulations.

In order to cope with the trend towards the enhancement of low emission in the marine industry, Mitsubishi Heavy Industries, Ltd. (MHI) has developed an environmental friendly diesel engine, "UEC Eco-Engine".

2. Development Concept

The environmental friendly diesel engine, "UEC Eco-Engine" is named for the letters of "Eco" which are found in its design goals of ECOology, Excellent engine COndition, Easy COntrol, and ECOnomy, all by Electronic COntrol,.

The UEC Eco-Engine is an engine that has been developed by modifying a conventional engine, of which fuel injection system, exhaust valve driving system, engine starting system, and cylinder lubricating system are controlled electronically. As a result, the engine structure is much simplified by eliminating the conventional large mechanical parts, such as cams, camshaft, and driving gears, as shown in **Fig. 1**.

The modification and conversion to an electronic control system makes it possible to adjust optimal timing of the fuel injection and exhaust valve actuating and fuel injection rate according to the engine operating condition, ambient conditions, and fuel properties. As a result, engine performance can be optimized across the entire load range. Therefore, the consumption of fuel oil and cylinder lubricating oil are both reduced as a result, the emission characteristic with regards to NOx and smoke can be improved. Higher reliability of the combustion chamber can be ensured by the optimization of the op-

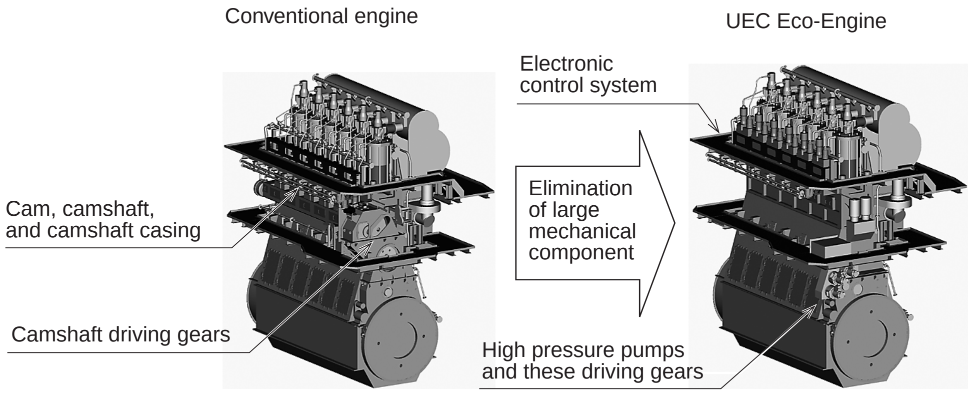

Fig. 1 Fundamental structure of engine

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eration condition, and the higher economical operation can be achieved. Furthermore, since the starting performance is improved and an extremely lower revolution operating can be achieved by the realization of better maneuvering capability.

The UEC Eco-Engine will be a leading engine in the next generation, which has the above-mentioned various advantages in addition to the highly economy and highly reliability that has been proven on the conventional UEC engines.

3. Overview of electronic control system

3.1 Fuel injection system

Fig. 2 shows the configuration of the fuel injection system. The fuel injection system consists of pilot solenoid valve, main valves, fuel injection pump, and fuel injection valves.

The pilot solenoid valve consists of a main solenoid valve and sub solenoid valve. The fuel injection rate can be controlled by actuating the main and sub solenoid valves at different times, as shown in **Fig. 3**. As a result, the initial combustion temperature is reduced making it possible to reduce NOx emission, compared with the conventional engines.

Usually there is trade-off relationship between fuel oil consumption and NOx emission, as shown in **Fig. 4**. The UEC Eco-Engine is able to reduce NOx emissions by about 10 to 15% compared with conventional engines, at same fuel oil consumption levels, when priority is given to the NOx mode. On the other hand, fuel oil consumption can be reduced by 1 to 2%, at the same NOx emission levels, when priority is given to fuel oil consumption. In addition, in the UEC Eco-Engine, the operation mode can easily be switched at the control panel, so that it becomes possible to choose the optimal operation at any condition.

In the conventional engines, fuel injection pressure gets lower at low load operation since it depends on the rotational speed of the engine. On the other hand, in the UEC Eco-Engine, since the fuel injection is performed using high-pressure hydraulic oil throughout the entire load range, fuel injection pressure is maintained at nearly maximum levels, even under low loads. Therefore, appropriate injection pressure improves combustion condition at lower load and reduces smoke emission significantly (**Fig. 5**).

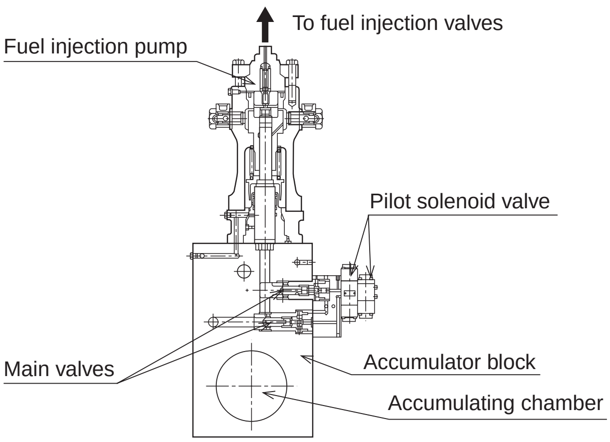

Fig. 2 Configuration of fuel injection system

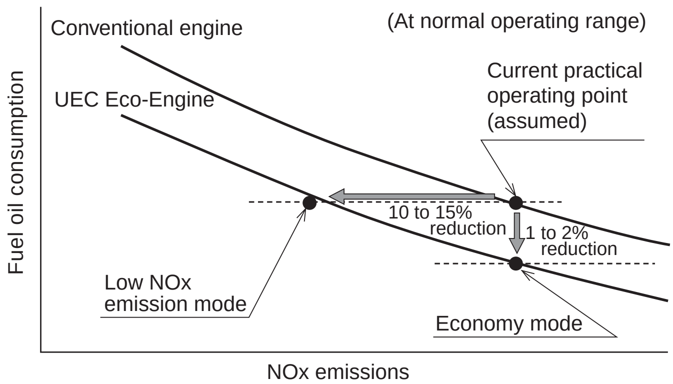

Fig. 4 Relation between fuel oil consumption and NOx emission

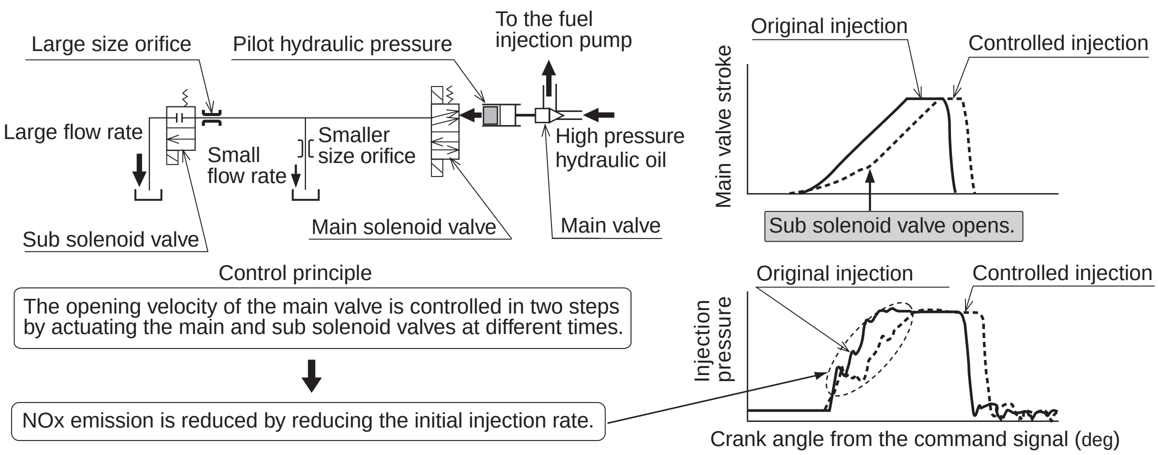

Fig. 3 Mechanism of fuel injection rate control

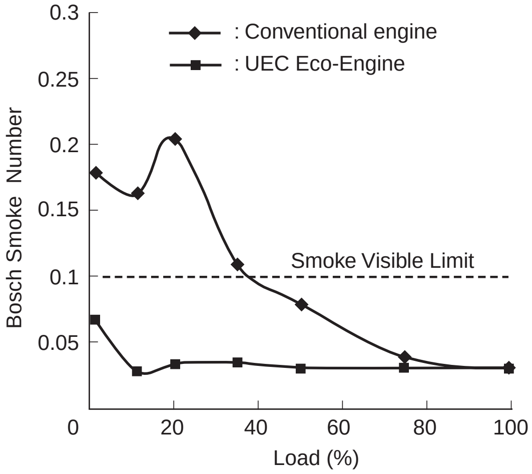

Fig. 5 Smokeless operation

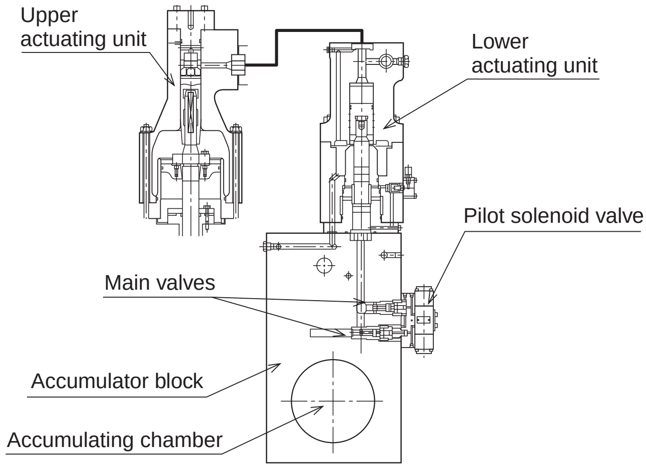

Fig. 6 Configuration of exhaust valve driving system

3.2 Exhaust valve driving system

The configuration of the exhaust valve driving system is shown in **Fig. 6**.

The exhaust valve driving system consists of a pilot solenoid valve, main valves, lower actuating unit, upper actuating unit, and exhaust valve. The timing of the opening of the exhaust valve can be optimized by adopting an electronic control system throughout the entire load range. Accordingly, the timing for opening the exhaust valve can be delayed by increasing the velocity of the opening, so that the effective work of the piston can be increased.

These optimizations result in an improvement in fuel oil consumption of approximately 1 to 2%, compared with the conventional engines.

4. Conclusion

A 7UEC33LSII type diesel engine, the stationary set of the diesel generating power plant in MHI Kobe Shipyard & Machinery Works, were converted to be electronic control type in October 2001. From December 2001 to the present, the commercial operation combined with endurance tests have continued, with excellent results.

At the present, the development of the UEC33LSII-Eco and UEC50LSII-Eco engines has been completed and development of the UEC60LSII-Eco will be completed any moment. In order to cope with stricter emission regulations, MHI intends to line up the larger bore-sized UEC Eco-Engines quickly, extending the same concept to the latest LSE series.


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