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The UEC engine program and its latest development

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Abstract: The UEC engine was born in 1955. Since then, many customers all over the world have remained faithful to the UEC engine, with its low fuel consumption and high reliability, for half a century. At present, the UEC is one of the few engines that continue to use low speed marine propulsion. In addition, the most important aspect is that the UEC is the only engine with which the licensor itself performs development, manufacture and after-sale service, and feeds back the results to design.

The UEC-LSII is the first full lineup series with a bore of 33 to 85 cm, and more than 300 sets have been in satisfactory service.

A new series, the UEC-LSE, was released in 1998 based on service results fed back on the UEC-LSII, and can be applied to recent larger and/or higher speed ships. Development of the UEC52LSE, UEC60LSE and UEC68LSE has been completed thus far. Eleven sets of the UEC52LSE have been ordered for small class container ships and RoRo ships, and the first UEC52LSE has been in service since Sep. 2001. Orders for the UEC68LSE reached 10 sets for Capesize BCs, Suezemax tankers and Feeder container ships, and the first UEC68LSE with six cylinders commenced service in May 2003. We have now started development of a 50-cm bore engine, which is a joint work with Wartsila Switzerland aiming predominantly at the Handymax BC and Panamax BC.

To comply environmentally new technologies are continuously developed. One is the SIP system, developed together with a Danish lubricator manufacturer. The SIP system injects a cylinder LO with high pressure to spray onto the cylinder liner surface. Since it makes a thin uniform cylinder LO film on the wide area of the cylinder liner surface, cylinder LO consumption is reduced far below that of conventional systems. This new cylinder lubricating system has been already applied and ordered for more than 100 sets of engines.

In addition, the development of an electrically controlled engine, named the UEC Eco-Engine, is ready to be applied to a commercial engine. Compared to a conventional engine driven by a camshaft, the UEC Eco-Engine can reduce fuel oil consumption, NOx emission and smoke, and engine performance is improved, especially with low loads.

This paper sets forth the latest UEC engine program and the latest technologies.

ABSTRACT

The UEC engine was born in 1955. Since then, many customers all over the world have remained faithful to the UEC engine, with its low fuel consumption and high reliability, for half a century. At present, the UEC is one of the few engines that continue to use low speed marine propulsion. In addition, the most important aspect is that the UEC is the only engine with which the licensor itself performs development, manufacture and after-sale service, and feeds back the results to design.

The UEC-LSⅡ is the first full lineup series with a bore of 33 to 85 cm, and more than 300 sets have been in satisfactory service.

A new series, the UEC-LSE, was released in 1998 based on service results fed back on the UEC-LSⅡ, and can be applied to recent larger ships and/or higher speed ships. Development of the UEC52LSE, UEC60LSE and UEC68LSE has been completed thus far. Eleven sets of the UEC52LSE have been ordered for small class container ships and RoRo ships, and the first UEC52LSE has been in service since Sep. 2001. Orders for the UEC68LSE reached 10 sets for Capesize BCs, Suezemax tankers and Feeder container ships, and the first UEC68LSE with six cylinders commenced service in May 2003. We have now started development of a 50-cm bore engine, which is a joint work with Wartsila Switzerland aiming predominantly at the Handymax BC and Panamax BC.

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In addition, the development of an electrically controlled engine, named the UEC Eco-Engine, has been progressing steadily and is ready to be applied to a commercial engine. Compared to a conventional engine driven by a camshaft, the UEC Eco-Engine can reduce fuel oil consumption, NOx emission and smoke, and engine performance is improved, especially with low loads.

This paper sets forth the latest UEC engine program and the latest technology, such as the SIP system and the electrically controlled "UEC Eco-Engine".

INTRODUCTION

The total amount of worldwide ship construction has been gradually increasing in recent years, and annual gross tonnage doubled for the last decade, particularly due to South Korea's growth. On the other hand, the number of ships built has remained almost the same or decreased, compared with 10 years ago. This means that ship size is increasing. For example, for the Handymax bulk carrier, 56,000 DWT class vessels have actually entered the market. In addition, it was announced that the development of a 60,000 DWT class vessel has been started. Ship speed also continues to increase year after year. This trend toward larger and faster ships requires higher main engine power. As for the environmental issues, regulation tends to become more and more severe. In addition to the current regulation, NOx and SOx, CO_2 and/or PM will be regulated in the near future.

As stated above, requirements for the main engine are increasing in every field of power, performance and environmental issues. The various new technologies have been developed to solve these issues, and these latest technologies are applied to the UEC engine while maintaining reliability. Furthermore, it is clear that the most important thing for the main engine manufacturer is to supply engines that can be operated by the users with peace of mind.

ENGINE PROGRAM

Since 1955, as shown in Fig.1, the UEC engine was developed in step with our original technology. The current main series is the LSⅡ, which has a good service record on more than 330 engines. In 1998, we began development on the new series "LSE", feeding back the good service results of the LSⅡ. The design of the UEC52LSE, UEC68LSE and UEC60LSE has already been completed, and we are now developing the UEC50LSE in collaboration with Wartsila Switzerland.

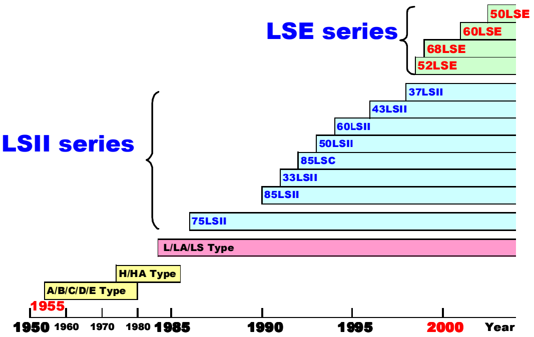

Figure 1 History of UEC development

Tab.1 compares the latest line-up of the LSⅡ and LSE series. The LSⅡ has a bore size of 33 to 85 cm with a stroke bore ratio of less than 4.0. BMEP is 1.7 to 1.8 MPa and the mean piston speed is 8 m/s. As for the LSE, the stroke bore ratio is 4.0, BMEP is 1.9 MPa, and the mean piston speed is 8.5 m/s. The LSE series can be applied as the main engine of the recent larger and faster ships.

Table 1 Line-up of UEC-LSⅡ/LSE

Series		LSⅡ								LSE			
Bore		33	37	43	50	60	75	85	85C	50	52	60	68
Stroke/ Bore		3.2～3.5			3.7～3.9				2.8	4.1	4.0		
BMEP	MPa	1.7～1.8								1.95	1.9		
Piston Speed	m/s	≦8.0								8.5			

DEVELOPMENT OF UEC68LSE

The UEC68LSE was developed as the main engine of the Capesize BC, Suezmax Tanker and Feeder container ship. Fig.2 shows the construction features of the UEC68LSE. The non-cooled gas passage and hydraulic rotator of the exhaust valve, CSS (Controlled Swirl Scavenging) port of the cylinder liner, and the MET turbocharger are incorporated the same as in the LSⅡ. These constructions reduce fuel oil consumption. To maintain reliability for a high power engine, the Nimonic exhaust valve is applied, and higher-grade material is applied to the 3rd and 4th piston rings. The bedplate and column are welded monoblock with a double wall type. These enhance strength and rigidity. The crankpin bearing, crosshead pin bearing and main bearing are made of white metal.

The main bearing is designed with high reliability, applying a highly accurate main bearing simulation method. The emergency maneuvering stand is located at the fore end of the engine to keep vibration from the camshaft gear. The UEC68LSE was designed to reduce vibration sufficiently.

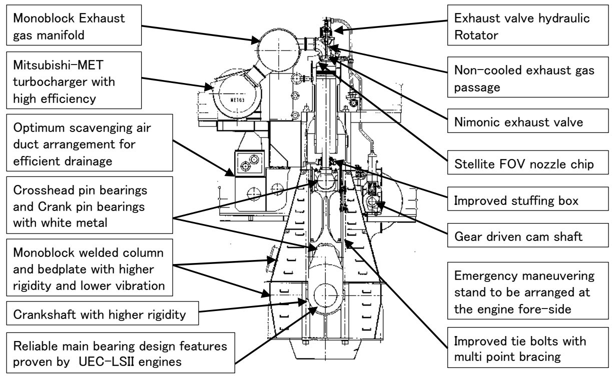

Figure 2 Construction features of UEC68LSE

Regarding engine performance, low fuel oil consumption is achieved in spite of high BMEP based on the various analyses. Actually, the fuel oil consumption of the UEC engine is the lowest among the low speed marine diesel engines. To analyze airflow in the scavenging air chamber and cylinder, a CFD (Computational Fluid Dynamics) calculation was carried out and a CSS liner port arrangement was optimized. To calculate the thermal load of the combustion chamber parts, combustion simulation was carried out and the fuel oil valve atomizer was optimized. Of course, all UEC engines including the UEC68LSE fully comply with the IMO-NOx regulation. (See Fig. 3 and Fig.4)

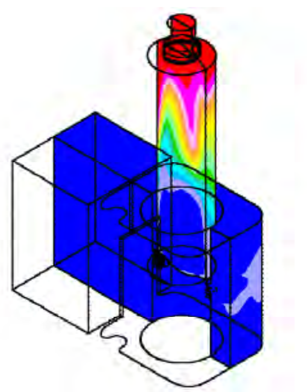

Figure 3 CFD analysis in scavenging air chamber and cylinder

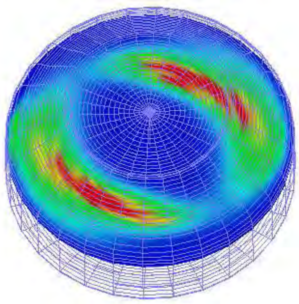

Figure 4 Thermal load simulation
in combustion chamber

The UEC engine has demonstrated high reliability with CAE (Computer Aided Engineering) analysis, test engine experiments, actual engine measurements and service results feed-back. These latest methods of calculation and measurement technology were developed at our in-house research and development (R&D) centers. Fig.5 is a sample of the mainframe FEM (Finite Element Method) calculation result of the CAE analysis. Commercial calculation code software is used for analysis of the FEM or CFD such as the mainframe, crankshaft and combustion chamber parts. On the other hand, original simulators developed in our R&D center are used for calculation of the main bearing analysis, combustion chamber simulation, fuel oil injection simulator, exhaust valve driving simulator and gear behavior simulation. The above calculations are always verified by measurement on an actual engine or test engine.

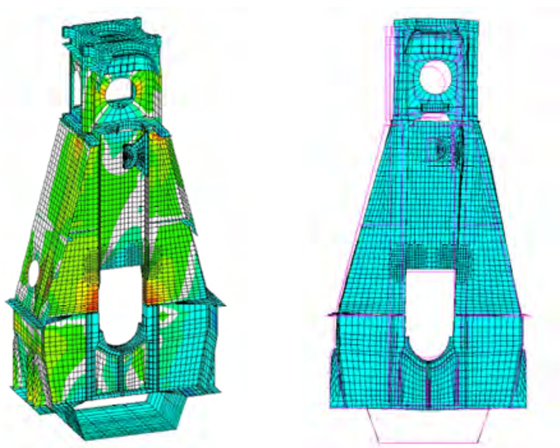

Figure 5 FEM analysis of mainframe

Fig.6 and Fig.7 show the measurement results, respectively, of the first UEC68LSE. Fig.6 shows the stress measurement results of the mainframe. It was confirmed that the stress of all points is under the planed value and the welding seams have enough fatigue strength.

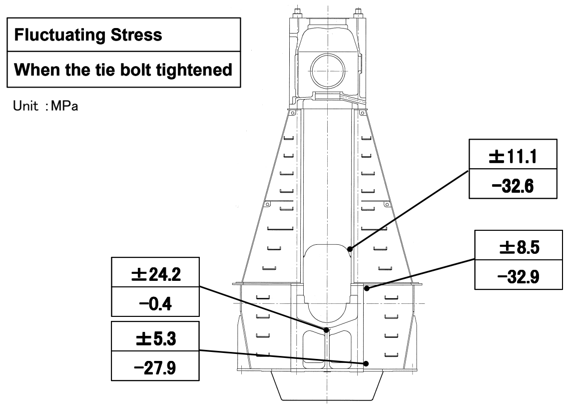

Figure 6 Stress measurement result of UEC68LSE

Fig.7 shows the temperature measurement results of the combustion chamber. The temperature of all points satisfies the design criteria. Fig.8 shows photos of the ring and liner after the shop test. Fig.9 is a photo after a sea trial. These photos indicate good condition, and the reliability of the combustion chamber parts was confirmed.

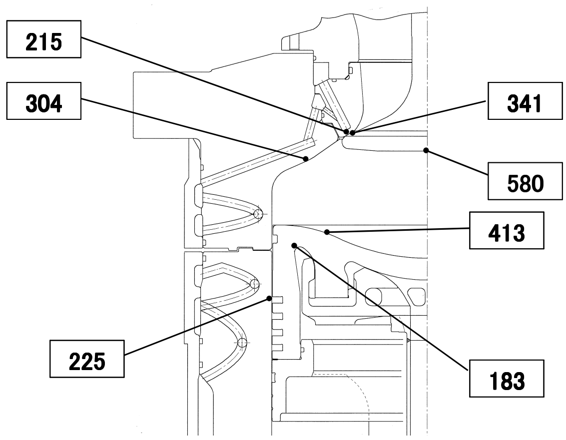

Figure 7 Temperature measurement result of UEC68LSE

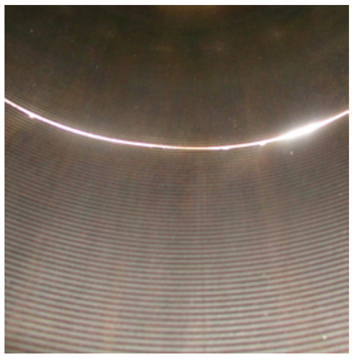

Figure 8 Ring & liner condition after shop test

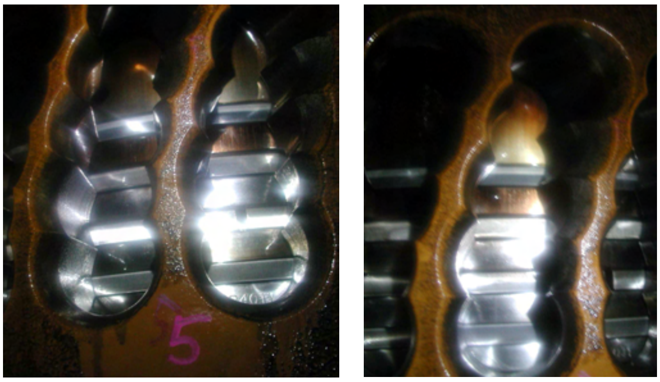

Figure 9 Ring condition after sea trial

SIP SYSTEM

The SIP system is a new cylinder lubrication system that was developed by a Danish shipowner and lubricator manufacturer, and was brushed up with our technology. We joined up with the manufacturer and its orders reached more than 100 unit engines.

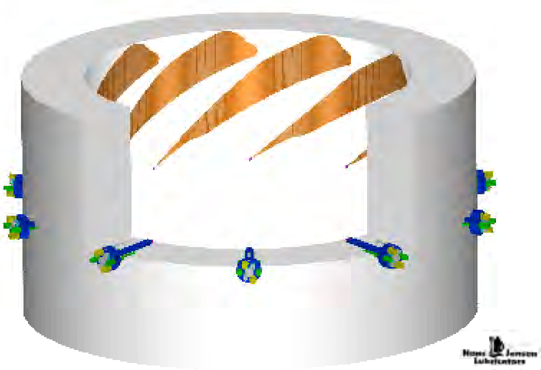

Figure 10 SIP system

The feature of the SIP system is to spray cylinder oil by high-pressure injection. Fig.11 shows the photos taken of the cylinder oil injection of the SIP system by test equipment. With a conventional system, cylinder oil, which is fed into the cylinder, is spread by ring movement. However, in the upward process of the piston, some cylinder oil is splashed up into the cylinder. In the downward process of the piston, some cylinder oil is splashed down to the under side the piston. Therefore, when cylinder oil is fed in, 30% to 50% of it is wasted. However the SIP system can save such wasted oil, since thin and uniform oil distribution is made by spray injection of the cylinder oil. That is why the SIP system can achieve a low cylinder oil feed rate.

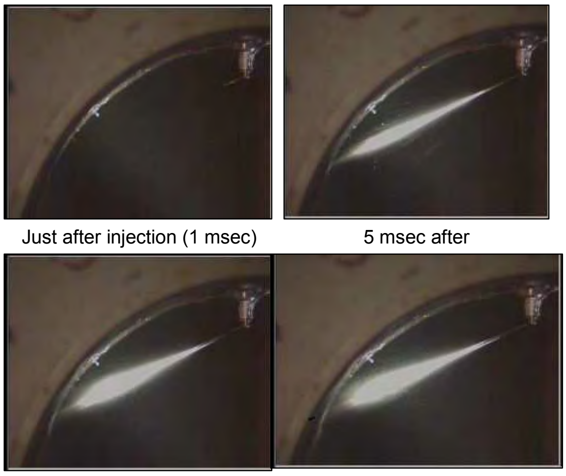

Figure 11 Lub oil spray observation of SIP system

Fig.12 shows the trend of the cylinder oil feed rate of the 7UEC85LSC-installed SIP system. Since the ring and/or liner were renewed with retrofitting work for installation of the SIP system, the cylinder oil feed rate was increased temporarily at the initial stage. However, it was reduced down to 0.58 (g/PSh) at present. The reduction speed of the cylinder oil feed rate is much faster than the conventional system. Fig.12 shows that the cylinder oil feed rate is reduced from 1.3 to 0.58 (g/PSh) in approx. 5700 H.

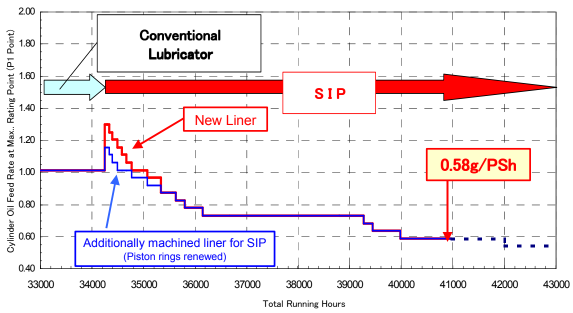

Figure 12 Trend of cylinder lub oil feed rate on 7UEC85LSC

Fig.13 is the liner wear rate trend of this vessel. The wear rate is also very low after installation of the SIP system as well as before installation. One of the SIP system's features is that the wear rate of the ring and liner is small in spite of a very low cylinder oil feed rate.

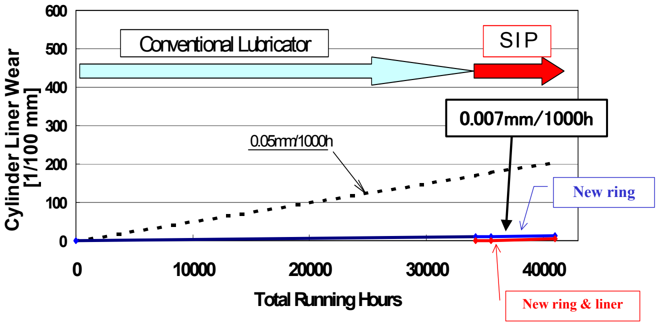

Figure 13 cylinder liner wear trend on 7UEC85LSC

Fig.14 shows the ring and liner condition after approx. 1 year of SIP system installation on the vessel. Furthermore, Fig.15 shows photos of the 8UEC60LSII after the shop test. Both are in good condition, and the ring and liner wear rate was excellent as stated above.

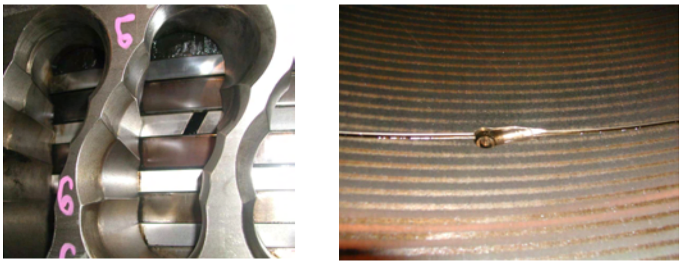

Figure 14 Ring & liner condition on 7UEC85LSC after 6720H of SIP system installation

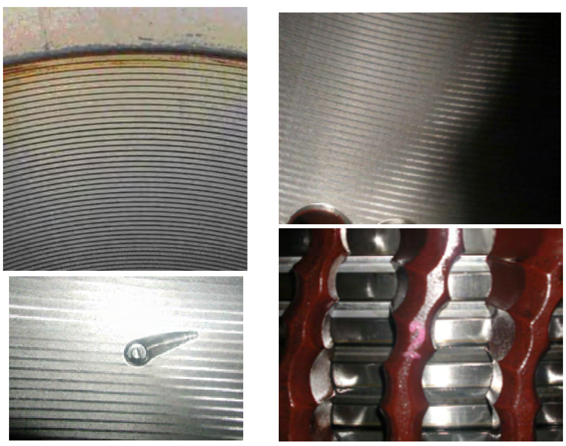

Figure 15 Ring & liner condition on 8UEC60LS II after shop test

ENGINE DIAGNOSIS SYSTEM

Next, we introduce the engine diagnosis system, which makes use of IT (Information Technology) techniques, to enhance the reliable operation of the main engine. Fig.16 outlines this system. This system has two functions of automatic performance diagnosis and parts management. On ships with data logger systems, the data for performance diagnosis is taken into a PC automatically except for some data, such as weather conditions and fuel oil specification. In addition, the maintenance information of parts is input manually. These data are sent to the data base server through INMARSAT and the Internet. The host computer carries out performance diagnosis, parts lifetime estimation, etc., and the results are sent back to the ship immediately. At the same time, the results are also sent to the ship management company. This system not only diagnoses the engine performance, but also estimates the cause of the failure and recommends appropriate action if it is judged that the results indicate some problems. This function can be realized only by know-how accumulated as an engine manufacturer, and this is the feature of this system. The parts management system takes care of the combustion chamber parts, such as the cylinder liner, piston and exhaust valve. By manual input of wear amount, etc., the maintenance history can be managed. Additionally, the expected lifetime can be calculated according to estimation time to reach a use limit from the wear rate.

As mentioned above, this system is quite effective for enhancing the reliable operation of the main engine on the following points. The main engine condition can be monitored for 24 hours automatically. Abnormal engine performance can be detected immediately. Quick action to countermeasure can be taken on board in case of trouble. The exchange time of consumable parts can be determined exactly.

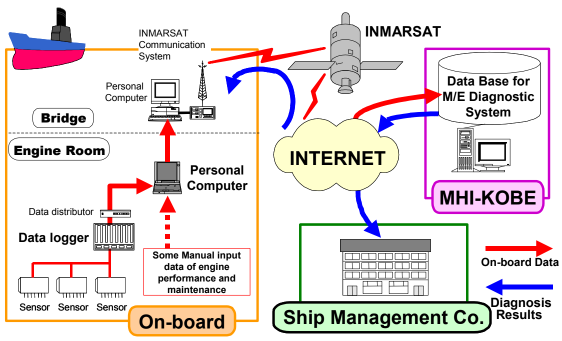

Figure 16 Outline of engine diagnosis system

EMMISION CONTROL

The current IMO NOx limit is 17 g/kWh for low speed marine engines of less than 130 rpm. However, we will see progressively stricter regulation in the future, as with other regulations such as EPA. Fig.17 shows the estimated movement of regulation and compliance policy for the UEC engine. The water injection system or electronically controlled engine can achieve up to a 30% reduction from the present 17 g/kWh. An 80% reduction can be achieved with an electronically controlled engine combined with a water injection system.

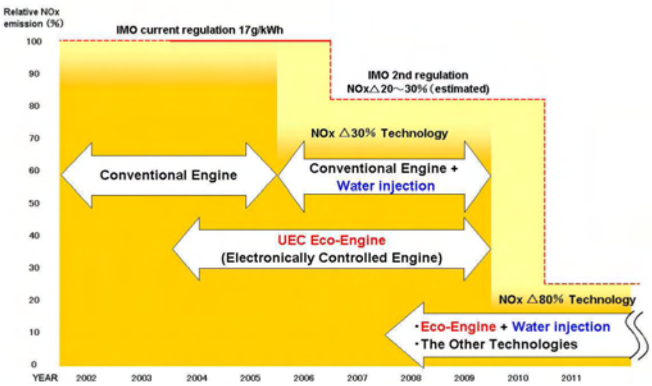

Figure 17 IMO NOx regulation

Fig.18 shows the outline of the electronically controlled engine, named the UEC Eco-Engine. The camshaft has been removed. The fuel oil injection unit, exhaust valve driving unit and starting unit are controlled by a solenoid valve. Since flexibility of the fuel injection and exhaust valve driving increases, fuel oil consumption and/or NOx emission can be improved. In addition, since fuel oil can be injected with high pressure from a low load, lengthy continuous operation at low load, improvement of smoke level, reduction of lowest revolution and long MTBO can be achieved. The system design for a bore size of 50 and 60 cm has already been completed, and engines that can apply the Eco system will continue to expand.

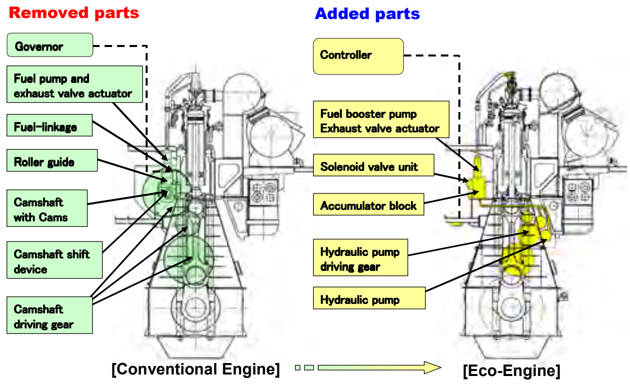

Figure 18 UEC Eco-Engine

Fig.19 shows the stratified fuel water injection system. “Stratified” means to inject fuel oil and water like a sandwich simultaneously with one stroke from one valve. The feature of this system is a good tradeoff relationship between fuel oil consumption and NOx, and the reduction of much NOx with few penalties of fuel oil consumption can be possible. (See Fig.20)

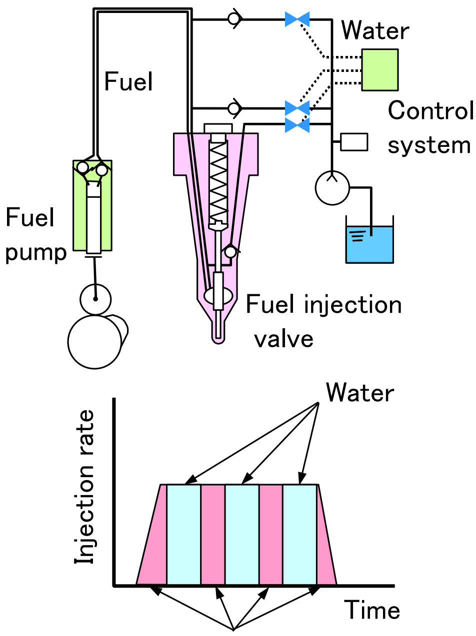

Figure 19 Stratified fuel water injection system

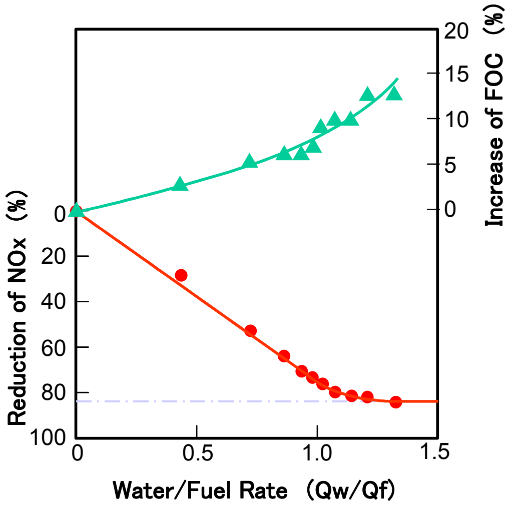

Figure 20 Test result of stratified fuel water injection system

CONCLUSIONS

The LSE was created with high BMEP and mean piston speed in order to satisfy market requests for larger and/or faster ships, and we are now developing LSE engines one after another to expand the series.

A CAE technique is used to design the LSE engine in order to achieve high performance, high reliability and low emission. These abilities are confirmed by comprehensive tests of the UEC68LSE, and the first UEC68LSE is in service and in good condition.

The SIP system achieved a low cylinder oil feed rate of 0.58 g/PSh with a low wear rate of the ring and liner on the 7UEC85LSC.

An engine diagnosis system is effective to enhance the reliable operation of the main engine, since the main engine condition can be monitored for 24 hours automatically and the exchange time of consumable parts can be determined exactly.

The electronically controlled "UEC Eco-Engine" and/or water injection system are ready to comply with the next step in emission regulation.

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