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The latest technological development of the J-ENG UE engine for zero emission and digital transformation

New Engine Developments - Diesel

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ABSTRACT

Under the global emission challenges, Japan Engine Corporation (J-ENG) is trying to achieve Zero Emission as a licensor of two stroke diesel engine. UE engine has been featuring high economic efficiency, high reliability, and environmental-friendliness for more than half a century. Now J-ENG is specially focusing on the development of NOx, SOx and GHG emission reduction technology including CO2 reduction as EEDI/EEXI.

The latest UEC-LSH series engines are lined up with bore diameter from 33 to 50cm, which can achieve higher output and lower fuel consumption, and thus can contribute to CO2 emission reduction. UEC-LSH series engines can be also equipped with NOx reduction technology to comply with IMO-NOx Tier3 regulation. Low pressure EGR (LP-EGR) system and low pressure SCR (LP-SCR) system have been developed and can be equipped with these engines. Both systems have been already tested and verified in service vessels.

As the IMO-SOx regulation came into the force globally in 2020, limiting sulphur content of fuel to 0.5% m/m, the ship owners, shipyards, engine maker, etc. have to adopt a solution either SOx scrubbers or use of low sulphur FO or LNG with consideration of the cost impact. In order to accommodate this circumstance, the new concept UEC-LSJ series engine was developed. As UEC-LSJ engine uses MGO (Marine Gas Oil) as mono-fuel, the engine can comply with three environmental regulations, not only SOx regulation, but also NOx and EEDI regulations simultaneously. The advantages of using MGO are no necessity of SOx scrubber, no necessity of (or smaller) exhaust gas economizer and prolong maintenance intervals. Although MGO cost is relatively higher than the other marine fuel in current market situation, the excessively high efficiency (low fuel oil consumption) and low initial cost makes the impact smaller. The first developed UEC-LSJ series engine was UEC50LSJ, and now 35LSJ, 42LSJ and 60LSJ are lined up.

In addition to the compliance with above regulations, J-ENG is also developing the technology for GHG emission reduction. Using carbon free (Hydrogen, Ammonia) / low carbon (Bio fuel, etc) fuels as the alternatives of existing fuels are now under development.

J-ENG is also promoting activities for Digital Transformation (DX) especially in the field of engine monitoring and effective data processing. For the advanced support technology, J-ENG is focusing on CBM (Condition Based Maintenance) and Digital Twin by using IoT and AI.

1 INTRODUCTION

Japan Engine Corporation (J-ENG) was established in April 2017 by merging the marine diesel engine business division of Mitsubishi Heavy Industries Marine Machineries & Engine Co., Ltd. (MHI-MME) and Kobe Diesel Co., Ltd.

Both MHI-MME and Kobe Diesel have a long term partnership by complementing each other as licensor and licensee relationship. J-ENG enhances this relationship by integrating the respective business from the upstream as the licensor to the down-stream as a licensee.

Figure 1 shows the development history of UE engine. First UE engine was manufactured in 1955, and after that, various engine models have been launched until now. LSH series is the latest generation and LSJ series which is equipped with stratified water injection system has been added to the lineup, and now Ammonia fueled engine LSJA and Hydrogen fueled engine LSGH are now being developed.

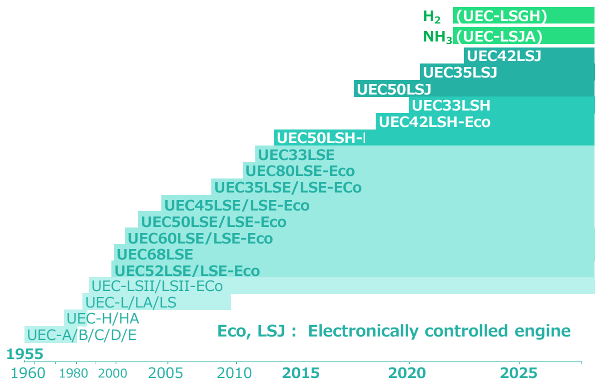

Figure 1. Development history of UE engine

The strength of the UE engine is that it achieves the industry's highest level of fuel efficiency that far surpasses competitors with its cutting-edge technology. For approx. 70 years since the first engine was manufactured in 1955, we have been striving to further improve the fuel efficiency through various efforts such as reducing mechanical loss, reducing heat loss, and optimizing the fuel injection system.

The UE Engine meets the regulations set by the International Maritime Organization (IMO), such as those for nitrogen oxide (NOx), sulfur oxide (SOx), and carbon dioxide (CO_2) by applying J-ENG's own unique technologies as shown in Figure 2.

Furthermore, aiming for carbon neutrality in 2050, J-ENG has started developing ammonia fueled and hydrogen fueled engines in parallel since 2021. And as a bridge solution to the use of these carbon-free fuels, J-ENG has also started studying for application of alternative fuels such as LPG, methanol, biofuels etc. which are expected to contribute to GHG reduction.

In addition, J-ENG is also promoting activities for Digital Transformation (DX) especially in the field of engine monitoring and effective data processing. For the advanced support technology, J-ENG is focusing on Condition Based Maintenance (CBM) and Digital Twin by using IoT and AI.

In this paper, initiatives for CO_2, NOx, SOx, GHG reduction (future alternative fuels) and Digital Transformation on UE engine are summarized and introduced. Here, CO_2 emissions are calculated using EEDI (Energy Efficiency Design Index). It is CO_2 emissions per ton and mile, which varies according to ship type and size. EEDI is legislated by IMO to reduce greenhouse gases emitted from ships.

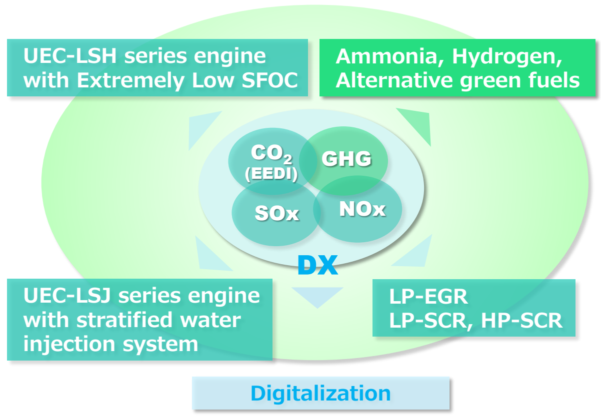

Figure 2. Technical strategy of UE engine

2 INITIATIVE FOR EEDI IMPROVEMENT

2.1 History of EEDI Improvement on UE engines

SFOC of UE engines has been gradually improved by each series engines of LSE, LSH and LSJ, starting since 2000, 2013 and 2018, respectively. According to the reduction of SFOC, the EEDI of UEC-LSJ series engines have been improved by 3 - 7% comparing with LSE series through lower fuel consumption.

2.2 UEC-LSH series engines

The UEC-LSH series is engines that uses conventional fuels or compliant fuel oils, has complied with the environmental regulations for SOx and NOx, and has achieved further reduction in fuel consumption compared to the conventional models. The first UEC50LSH engine was completed in March 2015. Having been received favorably, the number of orders has been steadily increasing. Additionally, the first UEC42LSH engine was completed in March 2021 and the latest model, UEC33LSH, was completed in September 2022 respectively.

The world's first 6UEC33LSH-C2 type engine was completed by Zhejiang Yungpu Diesel Engine Co., Ltd. (YDE) located in Ningbo, China as shown in Figure 3.

Figure 3. The first UEC33LSH engine in YDE

Figure 4 shows the main particular and rating map of UEC33LSH-C2 type engine.

Main specifications		
Cylinder bore	[mm]	330
Piston stroke	[mm]	1 050
BMEP at P1	[bar]	22.5
Piston speed at P1	[m/s]	8.1
Stroke / bore	[-]	3.18

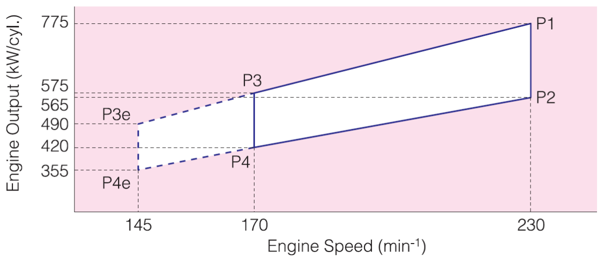

Figure 4. Main particular and rating map of UEC33LSH-C2 type engine

UEC33LSH-C2 type engine was developed as a strategic core engine for UE licensing business to strengthen the lineup of the LSH series which have received abundant records of orders. It is characterized by an ultra-wide rating (approximately 34% larger than the original rating) that covers a wide range from low to high engine speed so that it can be perfectly fitted for various type of vessels such as small bulk carriers, chemical tankers, cement carrier, and LPG carrier, and so on.

UEC42LSH type engine shown in Figure 5 was completed in April 2021 and went into service in March 2022. This engine was developed for middle/small size chemical tankers and handy-size bulk carriers, and is strongly expanding its production thanks to strong market demand of handy-size bulk carrieirs' booming. This engine is also increasing its market share in Chinese costal vessels. By its rapid expansion of orders for the engines in domestic and world market, its further expansion is expected for the shipyards applying the engines as their standard selection.

Figure 5. 6UEC42LSH engine

2.3 New SFOC version of LSH series engines

For LSH series engines, new version, named version 4, which has lower specific fuel oil consumption is under development by upgrading the fuel injection system. By individually changing the fuel injection pattern from multiple fuel injection valves, the shape of heat release rate in the cylinder is improved and the trade-off between NOx and SFOC can be improved.

The UEC50LSH-Eco-C4 and UEC42LSH-Eco-D4 engines equipped with the above fuel injection system have been added to the UE engine lineup.

2.4 UEC-LSJ series engines

The LSJ series is a model that integrates the LSH series with the UE engine's independently-developed technologies of complete combustion and stratified water injection in order to meet the SOx global cap for using Marine Gas Oil (MGO) or Maine Diesel Oil (MDO) only in or after 2020. It achieves a significantly lower fuel consumption (improving fuel efficiency by approx. 5%

compared to the previous models) while complying with NOx regulations. Integrated with J-ENG's own technology, which is low-pressure EGR or low-pressure SCR system, it is possible to meet the Tier III regulations [1].

The first UEC50LSJ-EGR engine shown in Figure 6 was completed in December 2018. Subsequently the UEC35LSJ have been developed and completed in July 2022

Figure 6. The first UEC35LSJ engine

Using MGO as the mono-fuel, fuel oil supply system can be simpler than heavy fuel usage by omitting the fuel heating system. Fuel oil change-over procedure from heavy fuel to MGO when entering port is not required. MGO is said to have stable properties and it is expected that maintenance interval of combustion chamber components can be extended through increase of reliability and reduction of crew's burden.

The stratified injection system is a technology to inject two different liquids from a single injector as shown in Figure 7. On the LSJ series engines, MGO and water are injected to realize lower fuel consumption and NOx reduction simultaneously.

In addition, in the shop test running of the first UEC35LSJ engine, 100% bio fuel with stratified water injection operation, namely carbon neutral operation, was demonstrated and verified for the first time on a commercial engine.

MGO-mono-fueled/water stratified injection engine is appreciated as the main middle/small size vessel by ship owners and shipyards, because effective solution to reduce initial investment and to save installation space for fuel tank(s).

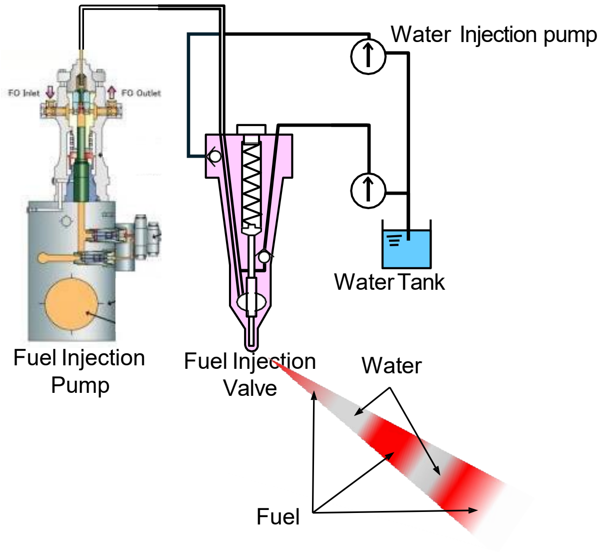

Figure 7. Schematic of the stratified fuel injection system

3 INITIATIVES FOR NOX (IMO TIER III) REGULATIONS

For IMO NOx Tier III regulation, low pressure EGR, low pressure and high pressure SCR systems are lined up. These are all uniquely-developed systems that have a simple configuration, simple operational control, excellent fuel economy and NOx trade-off, high reliability, and reduced CAPEX and OPEX. And these systems are applied to all UE engine types.

3.1 Low Pressure EGR system

The LP-EGR system is available for medium or large bore size engines (over 40cm bore).

LP-EGR system handles low pressure exhaust gas discharged from the turbocharger. Therefore, this method is generally called LP (Low-Pressure). Figure 8 shows the outline of the LP-EGR system. A part of the exhaust gas is branched from the main flow downstream of a turbocharger turbine. After branched, those gases are washed and cleaned by a scrubber, then led to the intake of the turbocharger, mixing evenly with fresh air.

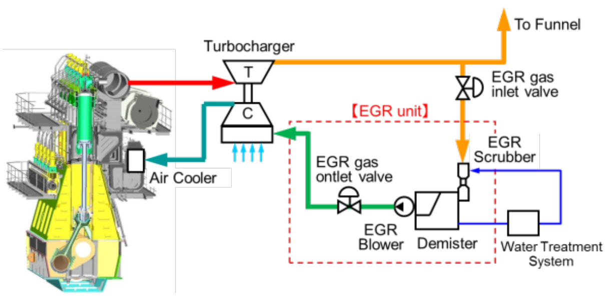

Figure 8. Outline of LP-EGR

Figure 9 shows the overview of the integrated LP-EGR unit on 6UEC50LSH-Eco-C2-EGR. The Low Pressure EGR components are located off the turbocharger. The first vessel which applied the system went into service in March 2021. The low-pressure EGR system has already applied to several engine types and has been building up stable service results.

3.2 Low Pressure SCR system

The LP-SCR system is recommended for small bore size engines and mechanically controlled engines (camshaft driven). The components of the LP-SCR system are installed after turbocharger(s) on low pressure exhaust side. The LP-SCR system is separated from engine configuration and control. Therefore, the arrangement and control of the LP-SCR system can be simple.

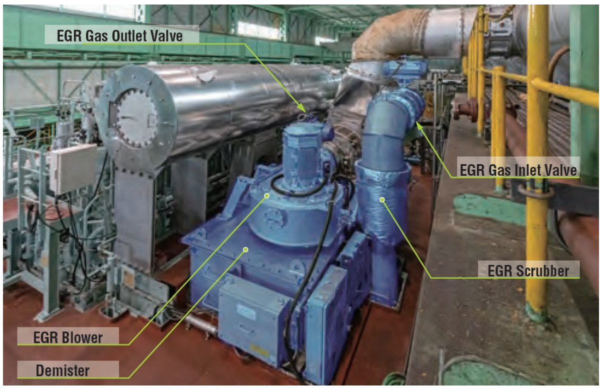

Figure 9. Overview of the integrated EGR unit on UE engine.

3.3 High Pressure SCR system

The HP-SCR are available for specified engines in medium or large bore-size engines. As the components of the HP-SCR system are installed before turbocharger(s) on high pressure exhaust side, the system is integrated in engine configuration and it works with engine control. The reactor for HP-SCR is designed to be smaller than that of LP-SCR, due to its higher density of the exhaust gas.

4 INITIATIVES FOR GHG REDUCTION AND ALTERNATIVE FUELS IN THE FUTURE

4.1 Development of Ammonia fueled engines

4.1.1 Framework of the project

J-ENG is developing an ammonia fueled engine named UEC-LSJA, as a member of the exclusively organized domestic consortium. The consortium consist of Nippon Yusen Kabushiki Kaisha (NYK Line), J-ENG, IHI Power Systems Co., Ltd., and Nihon Shipyard Co., Ltd.

And this project is financially supported by Japanese Government, Namely, Green Innovation Fund of New Energy and Industrial Technology Development Organization (NEDO).

The engine under development is 50 cm bore size named UEC50LSJA.

In this project, J-ENG is planning to complete the engine in 2025. And this engine will be installed in the Ammonia Fueled Ammonia Gas carrier (AFAGC) which will be built by Nihon Shipyard and will be owned by NYK Line.

The vessel is planned to go into service in 2026.

Along this project, J-ENG is starting from the study of the Ammonia combustion technology, and will carry out single cylinder engine test. After that, Full-scale commercial engines will be designed, manufactured and tested in J-ENG's factory.

4.1.2 Technical issues and countermeasures of ammonia fueled engines

Main physical characteristics of ammonia are shown in Figure 10 and the main technical issues caused by them are described below;

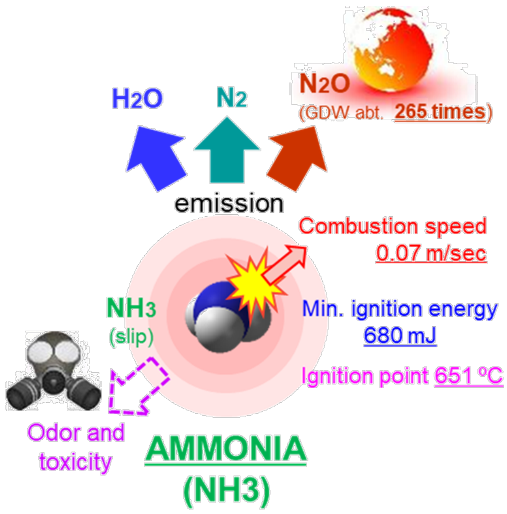

Figure 10. Physical characteristics of ammonia fuel

- Flame retardant: Ammonia has a slow burning rate (1/5 that of methane) and a high spontaneous ignition temperature of 651° C. During incomplete combustion, there are concerns that nitrous oxide (N_2O), which has a global warming potential approximately 300 times that of CO_2, are generated. Therefore, a certain amount of pilot fuel will be needed and it is important that ammonia is effectively burned with smaller amount of pilot fuel oil.

- Toxicity: Ammonia is highly irritating to mucous membranes and can cause severe damage to the respiratory tract and lungs in a short period of time. It is necessary to apply safety measures such as double piping, purge equipment, and separation and recovery equipment. Purge equipment is the device which sends an inert gas into the space to remove the ammonia gas that has been accumulated in the space.

- Corrosive: Ammonia is corrosive to copper /nickel alloys and plastics. Since it has the property of causing stress corrosion cracking, which is a phenomenon in which corrosion occurs on a metal surface and cracks occur when tensile stress is applied, it is necessary to select a material and take measures to prevent the cracking.

- Storability: The lower calorific value of ammonia is as low as 18.8MJ/kg, and the amount of fuel supplied to the engine increases to 2.3 times (=1/0.44) that of heavy fuel oil, so it is necessary to develop an appropriate control system and safety mechanism.

In order to achieve zero emissions, countermeasures for effective combustion are required to control and minimize N_2O emissions contained in engine exhaust gas while increasing the usage ratio of flame-retardant ammonia fuel.

At the same time, a design to prevent leakage of toxic ammonia and adequate safety measures in the event of leakage are needed. Safety measures based on risk assessments are necessary to ensure the same level of safety as conventional vessels.

The Consortium conducted a HAZID risk assessment for the safety of using ammonia as marine fuel in anticipation of obtaining approval of an alternative design, which is indispensable for realizing a demonstration operation in FY 2026. Here, the approval of an alternative design refers to the process of obtaining approval from the competent authorities for the design of a vessel for which no international regulations have yet been established by proving that the design is equivalent to the safety requirements of the existing international regulations. The use of ammonia as marine fuel in ammonia carriers currently deviates from the provisions of the SOLAS (International Convention for the Safety of Life at Sea). On the other hand, if the design is equivalent to the safety requirements of the relevant chapters of the IGC Code (International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk) based on the SOLAS, it is possible to design a vessel to use ammonia as a marine fuel. Now that the four companies have obtained the AiP for the AFAGC, the parties will work on a more detailed design and aim to obtain approval of an alternative design before the vessel's construction begins.

On September 2022, the Consortium received an AiP from Japanese class society ClassNK after concluding that safety can be ensured. This is the first time that a risk assessment has been conducted and an AiP obtained not only for a concept but also an alternative design.

4.1.3 Combustion method of ammonia fuel

In J-ENG's ammonia fueled engines, the diffusion combustion method is adopted because it is possible to secure time for the liquid ammonia to be injected and evaporated in the cylinder due to its lower rotating speed. The diffusion combustion method is that in which high-pressure fuel is injected into compressed air that has been compressed to a high temperature, and the evaporated fuel is ignited by itself. The advantage of the diffusion combustion method is that it is possible to aim for ammonia calorific ratio in spite of its flame-retardant characteristic and to reduce the slip of unburned ammonia. On the other hand, the disadvantage is that it is necessary to install equipment according to the supply pressure for liquid ammonia state.

In order to overcome technical issues of ammonia fueled engines described above, "Stratified injection system" which is J-ENG's unique technology will be applied to ammonia fueled engines.

Figure 11 shows the outline of stratified injection system. In this system, flammable pilot fuel, flame retardant ammonia and flammable post fuel are injected in turn from one injector.

Figure 12 shows the example of the CFD (Computational Fluid Dynamics) analysis result. First sprayed red colored pilot fuel envelops yellow colored Ammonia spray, during spray formation process. This process ensure good Ammonia ignition and maintain a stable flame. And last sprayed blue colored post fuel pushes out Ammonia spray toward the outside Ammonia flame, then activates Ammonia combustion to the last. With this stratified fuel spraying and combustion process, it is certain that good ammonia combustion and less N_2O emission with moderate amount of pilot / post fuel can be effectively realized.

This technology had originally been developed by J-ENG for the stratified water injection system to reduce Nitrogen Oxide (NOx) emission of the conventional diesel engine for complying with IMO-NOx regulation and applied to UEC-LSJ type engines [1].

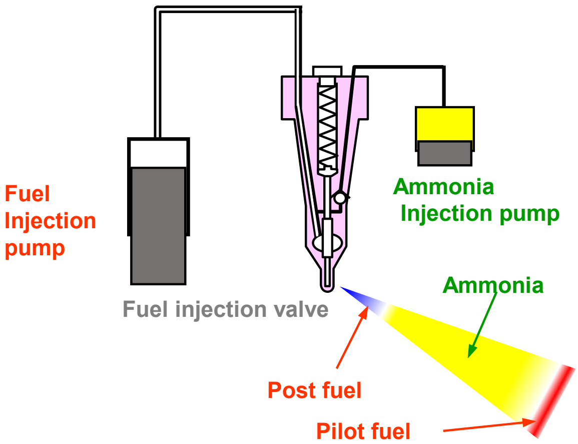

Figure 11. Outline of stratified injection system

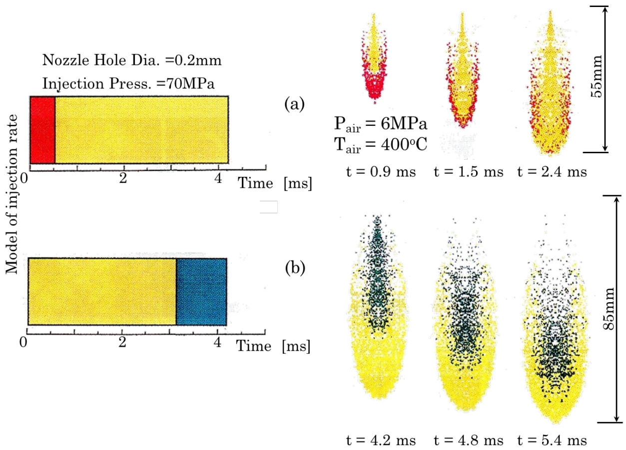

Figure 12. CFD analysis result of stratified injection

4.2 Development of Hydrogen fueled Engines

4.2.1 Framework of the project

J-ENG is developing hydrogen fueled engines which will be the world's first main engine for large ocean-going or coastal vessels, by forming a consortium with Kawasaki Heavy Industries, Ltd. and Yanmar Power Technology Co., Ltd. and established a joint development company HyENG Corporation with them in 2021.

The engine development was selected for a government-subsidized project by NEDO, part of Green Innovation Funding Program.

The first hydrogen-fueled engine, UEC35LSGH with a bore of 35cm, is expected to complete in 2026.

A demonstration operation is planned with an in-service vessel equipped with hydrogen-fueled engine which will be operated by TOKYO—Mitsui O.S.K. Lines, Ltd. (MOL) and MOL Drybulk, Ltd., aiming to commercialize net zero hydrogen-powered vessels and promote their wide adoption in the ocean shipping industry.

4.2.2 Technical issues and countermeasures of hydrogen fueled engines

Main physical characteristics of hydrogen are shown in Figure 13 and the main technical issues caused by them are described below;

- Flammability: Hydrogen has a low self-ignition temperature and a very high combustion speed, so even a very small amount of ignition source can ignite it, preventing abnormal combustion and stably controlling fuel is a key factor in the technological development.
- Hydrogen embrittlement: Engine parts have the risk of not being able to secure the expected reliability due to hydrogen embrittlement, so it is necessary to use appropriate materials that are not affected by hydrogen embrittlement.
- Easy to leak: Since hydrogen has the smallest molecular weight among all substances, it has the characteristic of leaking easily. Therefore, it is necessary to construct appropriate sealing technology and take measures to prevent leakage.

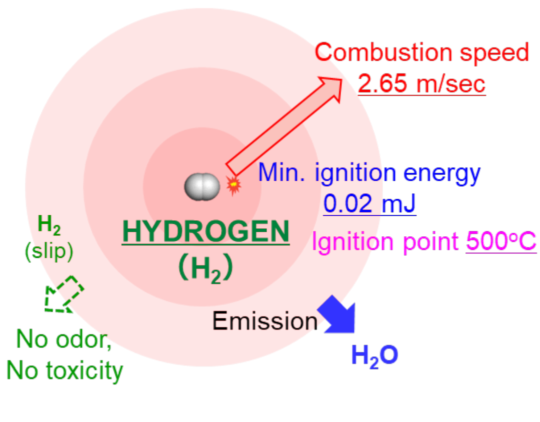

Figure 13. Physical characteristics of hydrogen fuel

4.2.3 Combustion method of hydrogen fuel

Figure 14 shows representative gas injection methods applied on 2 stroke engines, which are “High pressure gas injection” and ”Premixing”

In case of the premixing method, unburned hydrogen is exposed to high temperature and high pressure in the combustion chamber in one cycle since the low-speed 2-stroke diesel engines have a rotation speed of approximately 1/10 of that of the medium- and high-speed 4-stroke engines. As the duration exposed to such environment is approximately 10 times longer, the risk of abnormal combustion such as ignition of hydrogen at an unexpectedly early timing is extremely high.

One of the solutions to this problem is to limit the engine output in order to alleviate the high temperature and high pressure conditions in the combustion chamber. On the other hand, the engine size must be increased to obtain the same power output. That solution is not preferable.

In order to avoid the disadvantage of premixing method, high pressure injection method is applied to J-ENG’s hydrogen fueled engines. By this method, stable combustion can be achieved since hydrogen is directly injected into the combustion chamber at the timing, when the combustion chamber reaches high temperature and high pressure.

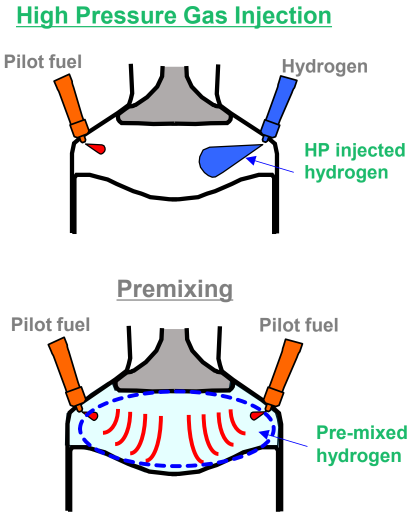

Figure 14. Hydrogen gas injection methods

4.3 Transition to carbon neutrality

Figure 15 shows GHG reduction strategy with low-carbon and carbon-free fuel.

In order to promote substitution from conventional fossil fuels to low-carbon/carbon free fuels, several low-carbon fuels such as LNG, LPG and methanol have already been used as an alternative to the conventional fuels in international shipping industry.

As GHG reduction rates by these alternative fuels are expected around 20% or less, it is assumed that synthetic fuels such as ammonia and hydrogen from renewable energies are needed to reach the carbon neutrality. However, these low-carbon fuels are promising as a bridge solution to the goal.

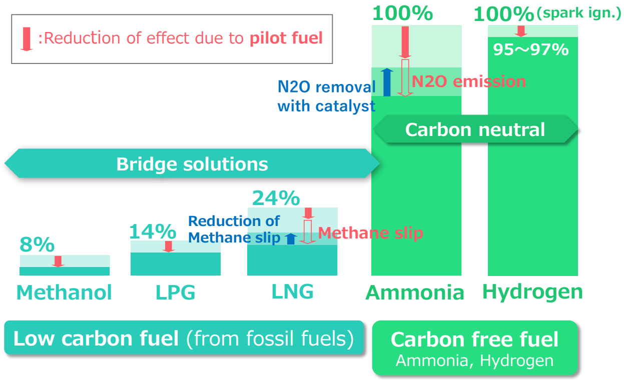

Figure 15 GHG reduction strategy with low-carbon and carbon-free fuel

J-ENG has a technical strategy and a studying of the engines that can use these alternative fuels has been started as shown in Figure 16.

For gas fueled engines, dual-fuel combustion technology had already been developed for LNG fueled engines and the validation with test engine had been completed. This technology is applied to the hydrogen fueled engines and will be also applied to synthetic methane fueled engines in the future.

For liquid fueled engines, J-ENG’s unique stratified injection system can be applied. As described in Section 2, this technology had originally been developed for the stratified water injection system for complying with IMO-NOx regulation and applied to UEC-LSJ type engines. Ammonia fueled engines are being developed by applying this technology, which water is replaced to ammonia. Although ammonia is difficult to burn, the stratified injection with pilot fuel and post fuel (ammonia) in multiple layers can realize an utmost combustion control and optimize a high suppression of N_2O emission. In the same way, this technology is also being studied for application to liquid fuels such as LPG, methanol, biofuels etc. which are expected to contribute as a bridge solution.

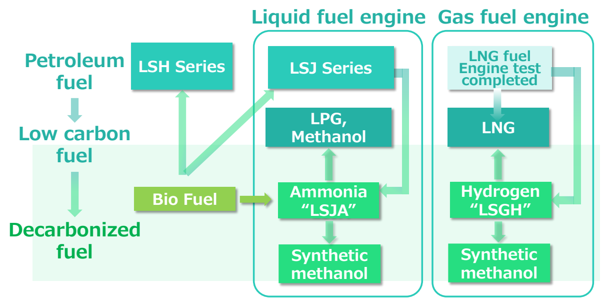

Figure 16. J-ENG's technical strategy for using alternative fuels

5 INITIATIVES FOR DIGITAL TRANSFORMATION ON UE ENGINES

J-ENG is also engaged in research and development of advanced support technology utilizing IoT and AI technology in order to provide optimal after-sales service for the customers. And the areas that particularly focused on are CBM and the digital twin.

Figure 17 shows the development history of digital technology on UE engines.

In 2017, the first vessel which applied 4th generation (4G) Eco control system went into service. In 2019, joint research agreement for CBM based on the monitoring was contracted. And the development started. In 2020, a joint research on next generation engine control system which will be 5th generation Eco control system (5G) was started. In April 2022, a coastal vessel which applying Advanced Ship Safety Management System (ASMS) for MLIT using a remote monitoring and condition diagnosis system went into service.

In this section, these initiatives and technologies are introduced as follows.

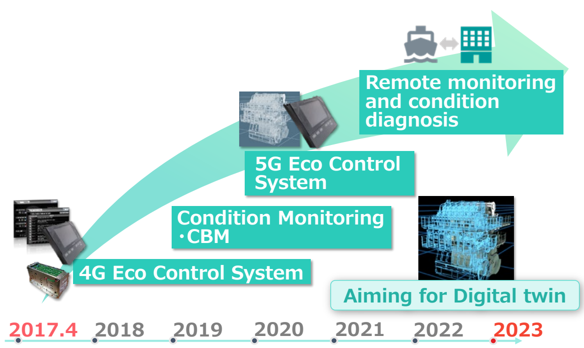

Figure 17. Development history of digital technology on UE engines

5.1 Next generation "Fifth generation (5G)" Eco Control System

Next generation electronically-control system (5th generation (5G) Eco system) based on the current 4G Eco system has been developed so that CBM and digital twin can be implemented in the near future.

The engine control system, which will be the core technology for the next generation engines, will be upgraded numerously based on the current system. Specifically, wireless signal transfer from engine sensors to engine monitoring system, engine performance analysis function for users by displaying on on-engine monitor, multiple engine control and data utilization with enhanced engineering and/or statistical processing on-board sensing data are planned. This system can provide a virtual testing area for developers to advance open innovation. The newly developed product will also be applicable for the current engine control system as an extended module.

5.2 Main Engine Monitoring System

As a part of IoT and AI technology applications, main engine monitoring technologies such as in-cylinder pressure control, electronic control engine waveform monitoring, bearing wear monitoring, and bearing temperature monitoring systems have been developed. Figure 18 shows the representative technologies. Details of each technology are introduced below.

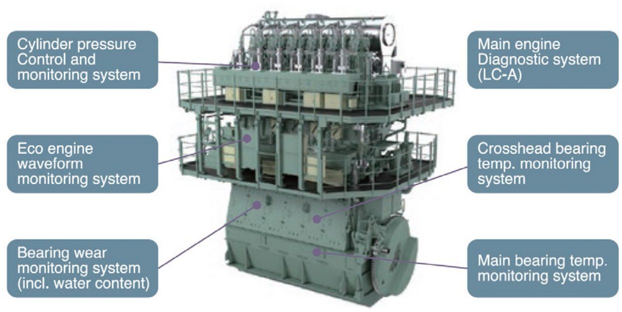

Figure 18. Main Engine Monitoring System

5.3 Initiatives for Condition Based Maintenance (CBM)

Initiatives for CBM are taken by using the main engine diagnostic and monitoring system. The advantages of CBM compared conventional Time Based Maintenance (TBN) are described below;

- With various sensors, the condition of the equipment can be grasped more accurately without opening it.

- Serious accidents or long-term non-operation can be prevented by performing appropriate operation and management according to the condition.

- Depending on the condition of the equipment, it is expected that the conventional maintenance interval can be extended, leading to a reduction in operating costs.

- The risk of assembly defects and foreign matter contamination caused by performing overhaul maintenance can be reduced.

J-ENG is also working on joint development of CBM with NYK Line, MTI Co., Ltd. and ClassNK. Data analysis of engine condition and element test has continuously been carried out by using actual vessels to establish and maintain condition evaluation methods.

5.4 Challenge to Digital Twin

J-ENG is also focusing on the development of advanced technologies such as digital twins which utilizes simulation technologies to reproduce main engine's running condition virtually based on the actual running data. Figure 19 shows the future vision of digital twin.

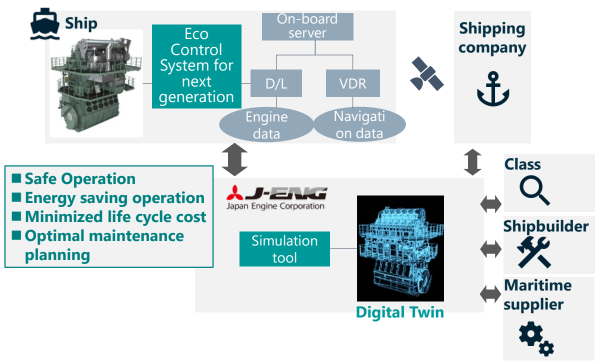

Figure 19. Future vision of digital twin

6 CONCLUSION

This paper introduces J-ENG's strategies aiming for Zero Emission, which are CO_2 (EEDI), SOx, NOx and GHG reductions.

Regarding EEDI reduction, J-ENG has continued the development of low SFOC UE engines and improving EEDI gradually from LSE to LSH and LSJ series.

For IMO NOx Tier III regulation, EGR and SCR systems are lined up. These system have features of simple configuration, simple operational control, excellent fuel economy and NOx trade-off, high reliability, and reduced CAPEX and OPEX.

For SOx regulation from 2020, applying LSJ series engines which are designed for using MGO or MDO only is one of the solution.

Aiming for carbon neutrality in 2050, J-ENG has started developing ammonia fueled and hydrogen fueled engines. The ammonia fueled engines are developed based on UEC-LSJ engines which applies the stratified injection system. And the hydrogen fueled engines are developed based on LNG dual-fueled engines.

J-ENG has also started studying for application of alternative fuels such as LPG, methanol, biofuels etc., which are expected to contribute as a bridge solution to carbon neutrality. The technologies for ammonia and hydrogen fueled engines will be applicable for the alternative liquid and gas fueled engines respectively.

J-ENG is also engaged in research and development of advanced support technology utilizing IoT and AI technology in order to provide optimal after-sales service for the customers. The areas of CBM and the digital twin are particularly focused and the related technologies are being developed.

7 DEFINITIONS, ACRONYMS, ABBREVIATIONS

GHG Greenhouse Gas

SFOC Specific Fuel Oil Consumption

EGR Exhaust Gas Recirculation

SCR Selective Catalytic Reduction

HAZID Hazard Identification Study

MLIT Ministry of Land, Infrastructure and Transport of Japan.

CAPEX Capital Expenditure

OPEX Operating Expense

AiP Approval in Principle

LNG Liquefied Natural Gas

LPG Liquefied Petroleum Gas

IoT Internet of Things

AI Artificial Intelligence

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