GREATER FLEXIBILITY IN CYLINDER LUBRICATION DELIVERY REQUIRED FOR TWO-STROKE ENGINES

The shipping industry's ambitions for reducing CO2 emission are likely to follow several technological pathways, so a more flexible and modular lubrication system is now available, says Dr Rathesan Ravendran, Technology and Innovation Specialist at Hans Jensen Lubricators.

There is a paradigm shift underway that aims to make the maritime industry more environmentally friendly. As part of this, the drive towards higher efficiency has led to design changes in slow speed two-stroke marine diesel engines, the most significant being the application of the electronical-controlled, supercharged and long-stroke engine, which allows more flexible usage and higher combustion pressure.

These changes in engine design as well as the way engines are being run have led to challenges when it comes to cylinder condition and lubrication, because the lubrication systems and methods delivering cylinder oil to lubricate piston rings and cylinder liner have remained largely unchanged.

Lubrication challenges with low sulphur fuels

A large majority of the vessels made the transition to low-sulphur fuel well. However, as anticipated, a number of issues was observed on several vessels. High cylinder liner and piston ring wear, severe scuffing, heavy deposits and piston rings sticking leading to heavy blow-by/ring breakage, were some of the issues occurring just a few days after changing over.

The lower lubricity of low sulphur fuels has been made up for by cylinder lubrication oil, distributed correctly on the cylinder liner. Using a low 15-40 BN cylinder oil is currently the most widespread countermeasure adopted. However, using low BN oils creates new and other challenges, since the cleaning ability of the cylinder oil is not sufficient to keep the cylinder and piston clear of deposits, which potentially can lead to increased wear, bore polishing and scuffing.

A common procedure when observing high wear rates is to increase the cylinder lubrication oil feed rate, but this is not always the right solution. Increasing the dosage of lubrication oil does not mean less frictional losses and wear. It can be as damaging as low oil dosage, as calcium deposit formation (unused BN additives), is naturally increased with the lubrication oil consumption.

Operators are also advised that higher BN cylinder oils are needed to keep the cylinder clean from deposits, but attention must be paid to secure against cylinder liner bore polish. When using a high-BN cylinder oil, the risk of top land calcium deposits increases. The calcium deposits may polish on the cylinder liner surface and cause polished areas which can initiate a cylinder liner scuffing.

To improve the cylinder condition in terms of cleanliness and deposit control, a number of tools have been recommended by OEMs and lubricant suppliers. Coated piston rings have become standard for every engine types. The coatings have higher melting temperature and hardness compared to standard aluminium coated piston rings, which ensures an increased safety margin against scuffing as well as low wear of the coating. Engine designers also recommend changing the piston configuration to three piston rings in order to minimize the deposit build-up between the rings.

New cylinder oils have been introduced by lubricant supplies, which have improved their formulations with ashless additives increasing the dispersancy for better cleaning ability. A less practical approach for improving the cleanliness with traditional cylinder oils is manual alternation between low and high BN oils. This method is proposed to create a balance between the limited neutralization of sulphuric acids and having a sufficient deposit control. As an alternative to the manual BN alternation, an automatic cleaning sequence has been incorporated in lubrication systems which periodically

increases the cylinder oil feed rate to facilitate better cleaning of the cylinder. For short periods, the additional oil is injected into the piston rings in order to react with and flush out deposited particles.

The growing importance of servicing

Lubricating two-stroke marine diesel engines has become more complex over the years, as the engines are operating under more demanding conditions and must be capable of using different fuel types. About 54% of vessels in operation today are not optimally lubricated, which could have a long-term impact on the engine's lifespan, components and drydocking intervals. Selecting the optimal cylinder oil type and the feed rate is not easy, as it depends on multiple factors e.g. fuel quality, engine type, size and operating conditions. Furthermore, a large variety of different lubrication oil formulations have been introduced, which may be difficult to navigate through. This places a great challenge and burden on engine operators, as they must ensure good main engine condition as well as reduce operational expenses.

Lubrication systems have become more flexible over the years, but this also creates more complexity for the end-users. Firstly, there is added complexity with the possibilities of the system. Experienced and trained crew are required to operate the system, which is today a challenge on the majority of the vessels.

Secondly, there is also added complexity in terms of more advanced parts and critical components. This sets a great challenge of proper operation and service. A survey conducted by The Swedish Club has shown that most main engine claims are as a direct and indirect result of incorrect maintenance. Numerous cases have been noted where damage occurs shortly after the engines have been overhauled by ship or shore staff. This emphasizes the importance of correct training and maintenance. The lack of training and planned equipment maintenance is often the issue, when vessels are not achieving the full potential of the lubrication system with regards of optimal lubrication performance and minimum lubrication oil consumption.

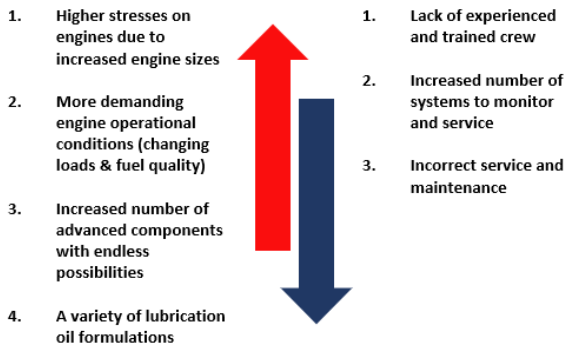

Fig 1. An overview of the challenges, which the vessels are struggling with today.

Today, the recommended minimum lubrication oil consumption is 0.60 g/kWh. However, practical studies by Jensen et al. (2016) have shown that the minimum oil dosage can be reduced to a new minimum using the HJ SIP lubrication system. Such low lubrication oil dosage has not previously been recommended and used in practice. The studies showed that the recommended minimum could be reduced to a feed rate of 0.30 g/kWh, and at the same time even lower wear rates could be maintained. It is therefore believed that there is room of optimization of lubrication oil consumption, and that the limits will be pushed with newer lubrication technologies and injection methodologies.

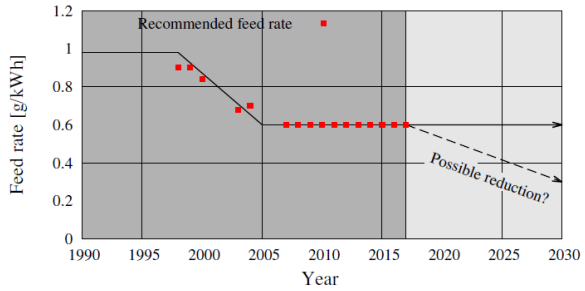

Fig 2. History of the minimum recommended feed rate for two-stroke marine diesel engines and the possibility for optimization.

A new paradigm in lubricant flexibility

Today's changes in engine design and operation due to the environmental legislation are just the tip of the iceberg, and further optimization will be seen in the maritime industry. New technologies and methods for achieving optimal cylinder condition will be introduced. Digitalization and condition monitoring will be an important information source for early machine failure detection just like the role of the human blood sample testing in order to perform disease detection. The condition of lubrication oil and its circulation system reflect the health status of the machinery and its components. Furthermore, more flexibility and modularity in the lubrication system will be added to deal with the constantly changing engine operation and the availability in a variety of carbon-free fuels.

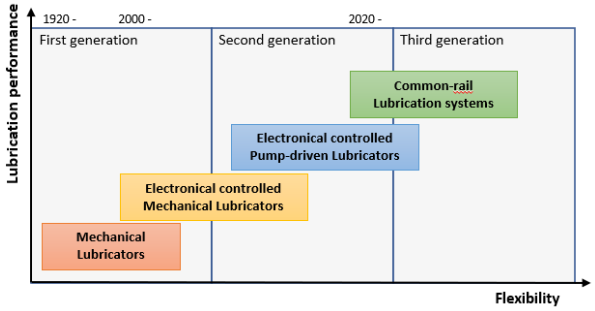

Fig 3. The development in lubrication technology

Beyond the 2020 requirements, the future direction of new fuels for the shipping industry is largely insecure. There is an ambition to reduce CO2 emissions, but there are several technological pathways to achieve this. It is therefore necessary to have a flexible and modular lubrication system, that is able to handle different situations. This has led to the introduction of a new approach for delivering the cylinder oil, which is currently the most flexible system available compared to all other current systems and making it compatible to all engine configurations and operations (scrubbers, LSFO, LNG, other).

The system is HJ Smartlube 4.0, which is invented by Hans Jensen Lubricators. The system consists of a solenoid valve controlling the opening and closing of the valve. The hydraulic system comprises a frequency-controlled motor pump unit to build the common rail pressure and a pressure sensor to maintain correct pressure level of the cylinder oil. The electrical control system uses an Ethernet protocol for all signal communication, ensuring a thoroughly standardized and robust network with high bandwidth and low latency.

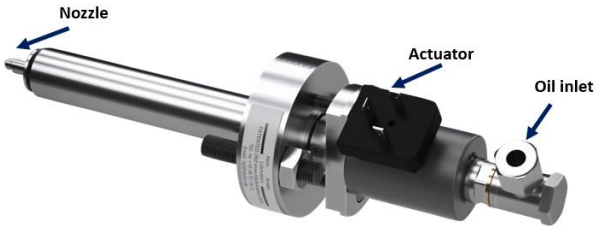

Fig 4. The injection valves for the HJ Smartlube 4.0 system introduced by Hans Jensen Lubricators A/S, which is the most flexible lubrication system on the market.

With the possibilities of advanced control such as multi-timing on individual valves, optimal utilization of the cylinder oil is achievable, which will lead to less cylinder oil consumption and better cylinder condition. Direct control of the valves means more accurately timed injections as there is minimal hydraulic delay from signal to injection. This gets the cylinder oil to the intended target and will lead to a higher utilization of the cylinder oil.

Very small amounts can be injected while maintaining good spray quality. This makes the system able to deliver oil every revolution, or even multiple times per revolution (multi-timing). Multi-timing allows cylinder oil to be placed both on the liner surface above the piston and between the piston rings in the same revolution. The quantity can be adjusted between injections, enabling advanced multi-timing control.

Concluding remarks

In recent years, changes in engine design as well as the way an engine is being run have led to challenges when it comes to cylinder condition and lubrication. Today, it is necessary to pay more attention to the cylinder lubrication system's operation and service to achieve optimal cylinder condition, and the introduction of a new approach for delivering the cylinder oil has now been developed by Hans Jensen Lubricators.