2020 - Consequences of using Low Sulphur Fuel from an engine operation point of view

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Abstract

Changing the fuel, from heavy fuel oil to greener low-sulphur alternatives, is a necessary approach to fulfil the emission regulations in 2020. However, the changeover has shown to cause bore polishing and scuffing problems[6].

As the industry have focused mainly on *how* to cope with the regulation, too little focus have been on the consequences of the decision (whether that is to install a scrubber or use a compliant fuel with <0,5% sulphur) seen from an engine operation point of view. Experiences have shown, that it is not trouble free to make such fundamental shifts in the operation of an engine without repercussions. Bore polishing, increased liner wear, reduced life time of liners and rings and increased cylinder oil consumption are expected if ship owners and operators do not prepare their engine operation for this new regime.

1. A fundamental shift in engine operation

By 2020, the majority of the World's fleet will substitute the traditional sulphur-rich fuel with a low-sulphur fuel type with maximum 0.5% sulphur content in order to comply with new environmental legislation.

Low sulphur fuels have less lubricity, due to the desulphurization process, which removes the natural lubricating properties of the fuel. Experimental studies have shown that fuel with lower sulphur content has a lower lubricity and hence a lower scuffing resistance. In some studies, it has been shown that sulphur rich fuels have about 20% higher scuffing resistance than fuels with a low content of sulphur [1, 2].

This fundamentally changes the lubrication requirements and requires that owners ensure their engines are equipped with a flexible cylinder lubrication system that can adjust to this new scenario.

1.1 Why is this a challenge?

Sulphur has lubricating properties, which contributes significantly to the so-called "fuel lubricity". In other words, the traditional fuel have contributed to the lubrication of the cylinder liners and piston rings hence protected the engines from excessive wear.

The lubricating effect of sulphur in traditional fuels is crucial in areas exposed to boundary lubrication, since it creates a protective layer between the surfaces of the liner and the piston rings. This is predominantly on the upper part of the liner (the combustion area), which is also the most exposed area of a two-stroke marine engine and where the highest wear is observed.

Using fuels with <0.5% sulphur, the lubricity will almost have dissapeared entirely. This significantly intensifies the need for improved distribution of the injected cylinder oil to protect both the cylinder liners as well as the piston rings.

The challenges that can arise from this new situation, are poorly understood in the maritime industry, with many misconceptions existing in the aftermath of new regulations.

1.2 Field Experience

An ideal distribution (hence an ideal engine condition) is best obtained with a high-pressure spray technology like the patented SIP system from Danish manufacturer Hans Jensen Lubricators. Hans Jensen Lubricators A/S invented the method of spraying cylinder oil onto the cylinder liner of a two stroke marine engine more than 20 years ago. Numerous tests including field tests [3, 4] have proven this technology to possess technical advantages to ensure optimal engine condition. Simultaniously it is possible to reduce the cylinder oil consumption because the cylinder oil is utilized more efficient.

2. Bore Polishing

By 2020, many engines will be challenged by "bore polishing" when the main engine is continuously operating on fuel with <0.5% sulphur.

When the sulphur is no longer present (or only present to a limited extent), the liner and rings will wear out faster. This is due to the fact that the liners were previously partially lubricated from the sulphur contained in the fuel.

Furthermore, when the sulphur in the fuel is removed, the continuous mild corrosion of the liner wall ceases. Continuous and controlled corrosion provided by the high sulphur fuel, has the advantage of keeping the cylinder wall open with small pockets (graphite pockets) which serves two purposes:

1. Wear particles can be absorbed to get away from the surface
2. The injected oil can enter the pockets and settle as an oil reservoir.

Together, these two factors create "bore polishing"; when the liner surface structure is no longer open and lubrication is lacking, bore polishing occurs.

Bore polishing in a marine engine cannot be avoided as it occurs naturally, but a flexible lubrication system can significantly postpone the development of bore polishing and thereby extend the service life of liners and rings. A better distribution (with HJ SIP) ensures better lubrication on the entire wall - especially in the upper part of the liner which is particularly exposed and thus will also reduce the appearance of "bore polishing".

3. Use of Low BN Cylinder Oil – Lack of Cleaning

The need for cleaning the cylinders and rings is the same, no matter if low sulphur oil or conventional sulphur rich fuel is in use.

Using a low BN oil (eg. BN25), is currently the most widespread countermeasure on engines adopting low Sulphur oils. However, this creates new and other challenges.

The base contained in the cylinder oil creates a layer ("membrane") that surrounds particles contained in the oil; this includes non-combusted fuel components or contaminants (asphaltenes, cat fines), neutralization products ($CaSO_4$, $FeSO_4$) and metal debris from the abrasive wear. Together these particles are referred to the "insoluble particles".

The layer ("membrane") created by the BN prevents the particles to "coagulate"[1]

A low BN is less efficient to prevent the coagulation as the level of over based detergents (calcium sulphonate or phenate) is reduced with the BN number.

As a result, particles build up and turn into bigger particles that are difficult to flush out with the conventional lubrication system. Excessive deposit formation on the piston crown may cause bore polishing, whereas deposits building up in the piston ring area may result in ring sticking. These deposits cause improper sealing of the combustion chamber and result in loss of compression, blowby, loss of oil control, increased wear and subsequent problems.

In order to prevent deposit formation, particles formed must be kept very small and be dispersed in order to be flushed out effectively. This cannot be ensured by the low BN cylinder oil, but can be compensated by a more frequent injection of fresh lubrication oil.

With a conventional lubrication system this is achieved either by increasing the feed rate or alternating between high and low BN cylinder oil.

With a HJ Lubtronic SIP cylinder lubrication system the cleaning is adequate due to injection of cylinder oil more often and a better distribution on the cylinder liner surface . This will ensure a continues refresment of lubrication oil that prevents deposit build-up.

4. Conclusion

The lost lubricity of the low sulphur fuel must be replaced by conventional cylinder lubrication oil, which primary function is to provide a continuous stable hydrodynamic oil film between surfaces in relative motion to reduce friction and prevent wear and thereby prevent seizure of the mating parts. Ensuring a stable hydrodynamic oil film between the surfaces will prevent the wear down of the surface plateaus and thereby increase the period of steady state wear (as illustrated in Figure 2).

To overcome the challenges of operating with fuel with lower sulphur, the required amount of cylinder lubrication oil must be distributed correctly on the cylinder liner. This has been highly prioritized by Hans Jensen Lubricators. For this purpose, HJ SIP spray injection valves, placed at the liner circumference, direct the lubricating oil spray upwards and into the engines scavenging air swirl. Thus, the lubrication oil is evenly distributed at the upper part of the cylinder liner, where the oil film is exposed to a hazardous environment e.g. high pressure and temperature.

It is proven that a combination of HJ SIP valves and HJ Lubtronic lubricator ensures good cylinder liner condition, minimises wear and reduce the risk of bore polishing and scuffing [5].

[1] when similar particles connects to each other and change to solid or semi-solid state

The HJ Lubtronic lubricator operates with automated stepless stroke adjustment and timed lubrication. Cylinder lubrication oil injection at each piston stroke will refresh the oil film at each piston stroke, which ensures a stable oil film as well as minimises the stress level of the oil film on the cylinder liner.

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