FOBAS Bulletin

21st September 2020

Issue of Excessive Cylinder Component Wear on Large Two-Stroke Engines During the Use of 0.50% Sulphur Fuels

Fuel combustion in an engine is a complex chemical/physical reaction and has been an area of intense research over the years. Inconsistency in composition of residual marine fuels makes it even more difficult to predict. Larger engines, especially two-stroke designs, has enabled ships to burn a wide variety of residual fuels. Since the implementation of MARPOL Annex VI regulation 14.1.3 from 1st January 2020, FOBAS have seen an upsurge in combustion related incidents resulting in cylinder liner damages of large two-stroke engines. These particular incidents started to appear around November 2019 when majority of the world fleet started transitioning from high sulphur fuel oil (HSFO - max 3.5%) to very low sulphur fuels (VLSFO – max 0.50%).

Figure 1 compares the FOBAS data for eight months (November to June) for last two consecutive periods. The reported failure modes have been divided into four main categories i.e. sludging, fuel injection equipment failure, cylinder component damage and others.

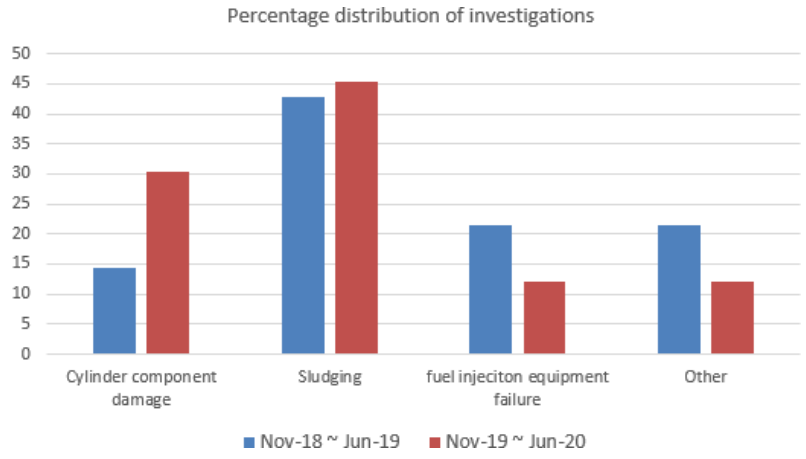

Figure 1: percentage distribution of FOBAS investigations

The data indicates that overall incidents related to cylinder component damage almost doubled for the studied period (Nov-19~Jun-20) whilst sludging incidents remain on similar levels though reduction in fuel injection equipment failure incidents have been observed. Moreover, recent cylinder component damage cases seem to have only been reported on large two-stroke main engines during VLSFO consumption. Though since March 2020, FOBAS has observed a downward trend in ships reporting cylinder component damage problems.

The Failure Mode

There could be several ways the failure could occur on two-stroke engine cylinder components, but it usually starts off with the excessive wear and then manifest itself into conditions such as blow by, scavenge fire, high liner and exhaust temperatures, low power output, excessive vibration, surging of turbocharger and so forth. The following diagram provides the basic wear types and corresponding key description.

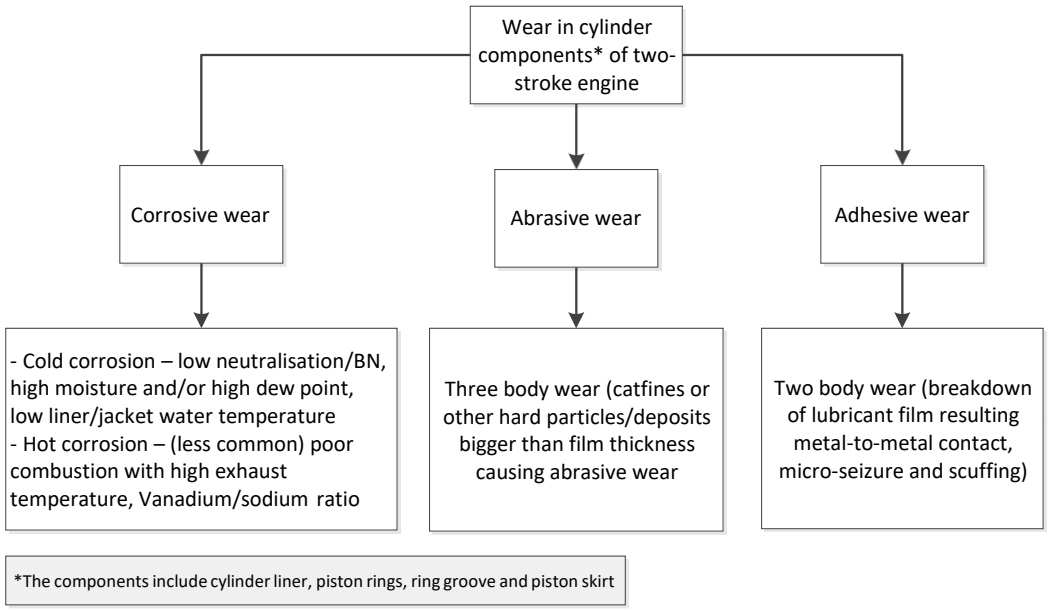

Figure 2: Wear in cylinder component of two-stroke engine

During the high sulphur fuels oil (HSFO) consumption, the two-stroke engines were frequently subjected to corrosive wear also known as ‘cold’ corrosion. Abrasive wear was also not uncommon due to HSFO containing higher concentration of catfines (Aluminium + Silicon) and other sediments making its way to engine inlet due to unsatisfactory fuel management. Ships switching to lower (0.50%) sulphur fuels which were less likely to cause cold corrosion (low acid-neutralisation requirement) and contain relatively lower concentrations of catfines. Though ships still reported excessive wear which is most likely to be associated with the third type i.e. adhesive wear where metal to metal contact takes place resulting in micro-seizure and scuffing.

The investigation

FOBAS was asked to investigate those incidents and whether VLSFO quality is a contributory factor. The suspected fuels were tested for standard ISO 8217 (table 2) parameters and results were satisfactory. Further testing options in cases where a ship only reported damages to cylinder components are limited. If standard parameters results are satisfactory then FIA (Fuel Ignition Analyser) test is recommended to evaluate the fuels ignition characteristics. Some of these suspected VLSFO fuels were tested and key parameters are compared against the standard HSFO in figure 3.

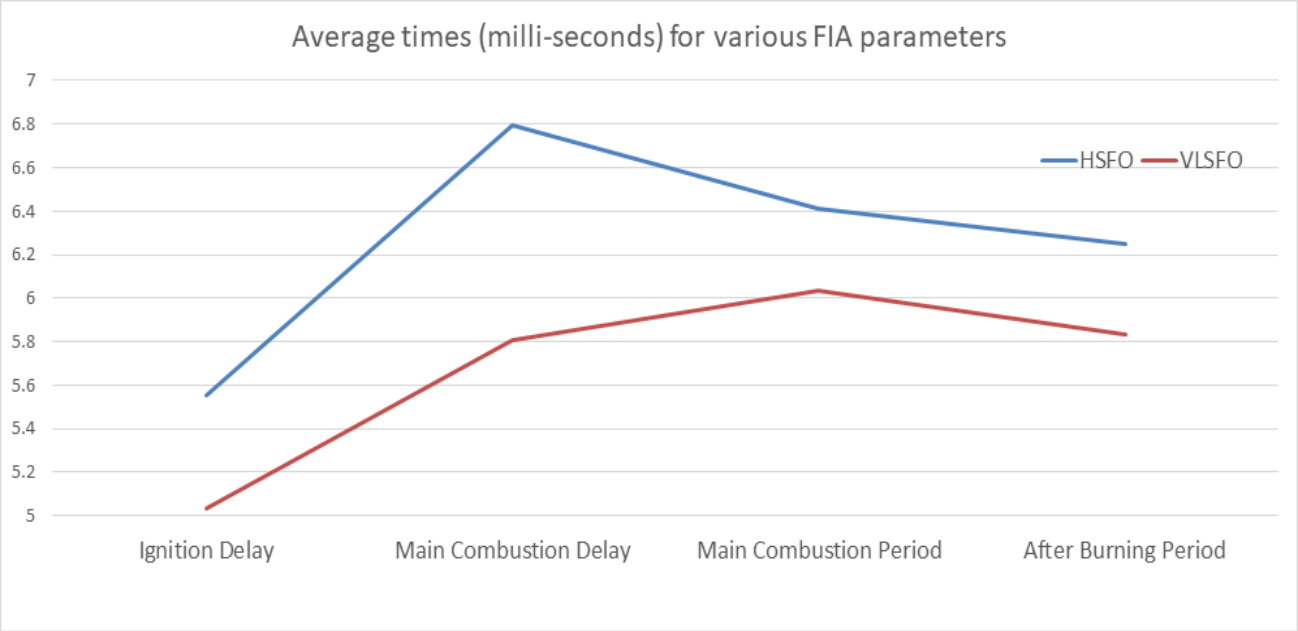

Figure 3: Comparison of key Fuel Ignition Analyser (FIA) results between VLSFO and HSFO samples

Above results from FOBAS data indicate that VLSFO has seen on average around 10% improvement on various ignition parameters compared to the HSFO. Although FOBAS tested a couple samples which showed relatively poor ignition quality one from Santos, Brazil and another one from Houston, USA with estimated cetane number (ECN) of just below 10. The FIA results from Houston seems to be an exception rather than the rule however Santos fuels are known for low ECN in the past. Nevertheless, considering the robustness of large two-stroke engines in burning fuels with varying ignition qualities and in view of CIMAC guidelines, it is not straight forward to link the fuel quality with the reported issues. Further information received from the ships reporting these problems were studied and following observations were made;

- Signs of liner scuffing with some piston ring broken or wore out excessively
- Ships did not experience operational problems on other parts of the fuel system neither on four-stroke engine operation
- Other operational parameters such as scavenge air temperature, pressures, appear to be satisfactory for corresponding operating conditions
- Some of the vessels were not fitted with hard coated piston rings as per OEM's guidelines
- Mild deposits on piston top-land
- Most ships were using 40BN cylinder lube oil
- Ships not making any timing adjustments (fuel injection or exhaust valve) to suit various quality fuels

Probable reasons

The information received from the ships in most cases were insufficient to draw conclusions considering (ISO 8217) analysis performed on the suspect fuel samples were mostly satisfactory. However, based on our extensive experience of dealing such investigations, following are few observations;

1. Hard coated piston rings: One of the most common factors observed was the lack of hard coated rings on engines as per engine makers recommendation. It has been observed since 0.10% sulphur fuel usage in ECA-SOx that operation without hard coated rings are particularly vulnerable. It seems that hard coating provides better protection against the micro seizure/scuffing due to improved high temperature performance and hardness of the material over the liner material minimising the risk of micro-seizures and eventual scuffing incidents.
2. Cylinder lube oil (CLO) feed rate: There could be cases where CLO feed rate was insufficient and in certain cases excessive. If optimum feed rate for the operational conditions are not maintained, then it would result in loss of lubrication or deposit formation. There is some evidence to suggest that at the start of transition, few ships were not fully tuned in to timely adjust the feed rates for the VLSFO usage and lower BN oils which may have contributed to the cases which were reported.
3. CLO quality: With the majority of the world fleet using 40BN oils, there have been suggestions that

higher BN (70+) shows better dispersancy characteristics compared to 40BN oils, though regular use of higher 70+BN oils may develop excessive neutralisation buffer and could result in formation of calcium deposits.

4. Engine maintenance: Lack of engine maintenance is an important factor and it has been observed that engine components operated close to their useful remaining lives are considered vulnerable and more likely to report such issues. Running hours of engine liner, piston rings, fuel injector, fuel pump and dropping efficiency of lubricator pump over time are important factors to consider.

Conclusion

As mentioned in above paragraphs that frequency of such incidents are on the decline with ships making necessary operational adjustments and getting more experience of burning VLSFO in their engines. At FOBAS, we welcome our customers to report any fuel related incident to help the onboard engineers overcome the problem.

In cases such as damage to cylinder liner and piston rings, it is important to seek guidance from the engine manufacturers. Moreover, ship operators should refer to their engine operations manual, consult latest service letters and also apply a best practice approach to mitigate and avoid future occurrences.

In light of varying fuel quality VLSFOs, the use of appropriate condition monitoring tools could further reduce the risk of breakdown scenario through diagnostic capability of picking up any incipient failure. FOBAS also provides lube oil analysis and for more comprehensive engine condition monitoring our FOBAS Engine Assessment Programme (FEAP) can be used to monitor two-stroke engine performance.

If you require clarification and support on these issues or like to hear more about our FEAP condition monitoring programme, please feel free to contact us via email fobas@lr.org or speak to one of our consultants on +44 (0)330 414 1000 (Southampton UK), +44 (0)1642 440991 Redcar (UK), +65 3163 0888 (Singapore), +30 210 4580 932 (Greece).

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