



Market Update Note

3 July 2013

Cylinder Liner Cold Corrosion Control

Introduction

Cylinder liner cold corrosion has surfaced lately in relation to operation of our two-stroke engines. Various reasons exist for this phenomenon:

- General low load operation
- Optimisation at low load – Turbocharger cut-out
- New engines with higher pressures at low and part load

Optimising an engine for better SFOC at lower load essentially means increasing the firing pressure. This is obtained by increasing the scavenge air pressure, and thereby the compression pressure while also advancing the fuel injection timing. The pressures, of course, have to be within the permitted window with a view to mechanical load of the engine.

At lower loads, also cylinder liner wall temperatures get somewhat lower. The higher pressure regime, together with the lower liner temperature, enhances condensation. The atmosphere in the cylinder contains SO_x from the sulphur in the fuel. The SO_x dissolves in the condensating water on the cylinder liner wall, making it into sulphuric acid, which results in corrosion, referred to as cylinder liner cold corrosion.

Cold corrosion is counteracted by raising the temperature of the exposed parts of the cylinder liner within permissible limits by making modifications to the cylinder liner design or by making changes of the cooling water system. Various solutions exist for different engine types and these are now being implemented.

Another necessary countermeasure is to ensure an adequate neutralising capacity in the cylinder lubricating oil, by a balanced combination of feed rate and base number, BN, in the oil. For modern engines, MDT recommends a minimum BN of 70, so as to be able to stay with its trademark low cylinder oil consumption values.

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Cylinder Liner Design

For some of the new engine designs, cold corrosion in the upper part of the cylinder liner was discovered already after sea trial, see Fig. 1.



Fig. 1: Cold corrosion in upper part of cylinder liner

Such an early sign of cold corrosion has called for immediate action of design changes to counteract any further development towards high corrosive liner wear values.

The jacket cooling water outlet temperature has been increased to 90°C. Insulated cooling pipes in all cooling bores and applied on cylinder liners already machined, and new cylinder liners have been designed with decreased cooling intensity. This is obtained by decreasing the number of cooling bores and increasing the distance between the liner running surface and cooling bores. Fig. 2 shows the cooling bore design and the use of insulated cooling pipes.

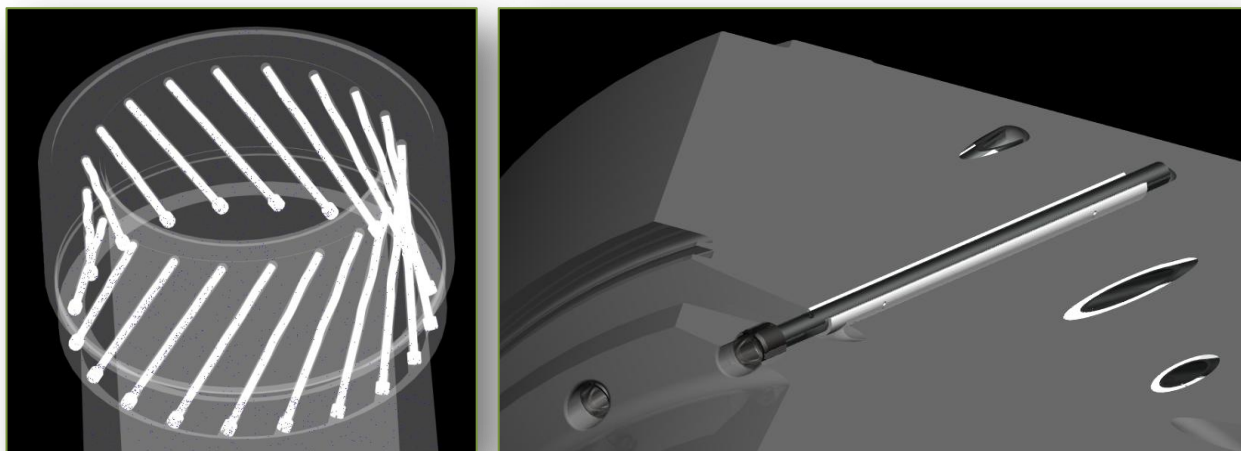


Fig. 2: Cylinder liner cooling bore design and insulated cooling pipes

Modified Jacket Cooling Water Systems

A jacket cooling water bypass system has been developed. The purpose is to bypass the cooling water space of the cylinder liner a large amount of the cooling water leading the bypassed water directly to the cylinder cover and exhaust valve. Fig. 3 shows a version of this bypass system for an S70 engine. Tests indicate that such a system can raise the cylinder liner wall temperature by approx. 12°C.

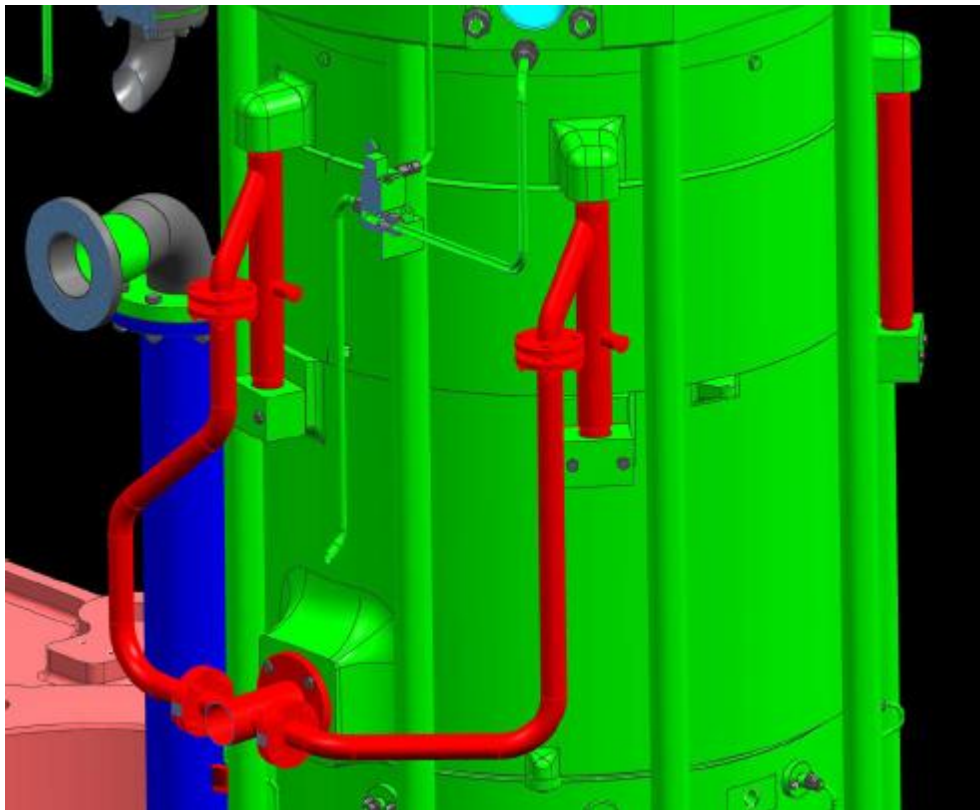


Fig. 3: Jacket cooling water bypass



A more active bypass system is now being prepared on our new generation of G-type engines and future other Mark 9 engines. The system shown in Fig. 4 consists of two extra cooling water pipes along the engine. An extra pump and an extra control valve ensure up to 120°C on the cooling water for the cylinder liners while maintaining 80-90°C on the cover and exhaust valve. A high temperature on the cylinder liner is only maintained in the low and part load range.

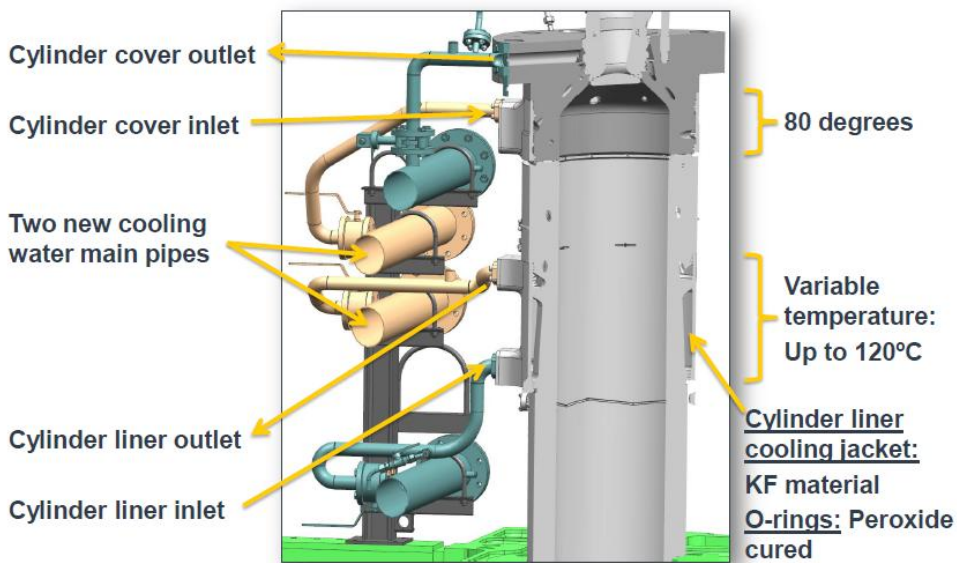


Fig. 4: Active cooling water bypass system

Optimisation of Cylinder Oil Feed Rate

Lately, MAN Diesel & Turbo has concentrated on further enhancing the fuel efficiency while, at the same time, fulfilling Tier I and Tier II. In order to improve the specific fuel oil consumption, the pressure in the combustion chamber has been increased on the newest engine designs, especially at low load. This pressure increase, together with the increased operating time at low load, has led to increased water and acid condensation on the cylinder walls, which leads to cold corrosion in the combustion chamber.

Also the most recently developed part-load and low-load tuning options utilise increased combustion chamber pressure as the main tool to ensure a low SFOC (Specific Fuel Oil Consumption) at part load, and the same result may be experienced for the ME/ME-C/ME-B engine ranges.



Appropriate cylinder oil feed rates and ACC (Adaptable Cylinder oil Control) values must be obtained on the basis of service inspections, measurements and wear data from combustion chamber parts (piston rings, liner and crown), and can be supplemented with scavenge drain oil analyses with benefit.

Cylinder oil is essential for the two-stroke engine. Today's cylinder oils are made with a complex chemistry, and the individual feed rate must, therefore, be assessed for each oil brand, viscosity class and BN level.

Cylinder oil is mixed to achieve the necessary level of detergency and dispersancy to keep the piston rings and piston crown clean, and to achieve the necessary base number (BN) to neutralise the acids formed during combustion.

The cylinder oil not only serves to lubricate the moving parts, but is also designed to control the degree of corrosion on the liner surface.

This is illustrated by our feed rate guide, which sets the minimum feed rate to the level needed to keep the parts moving within a safe margin. However, so as to ensure the necessary lubrication effect, an increased formation of acid would call for a higher BN level than specified at the minimum feed rate. This is compensated for by calculating a feed rate on the basis of an ACC factor within the guide shown in Fig. 5.

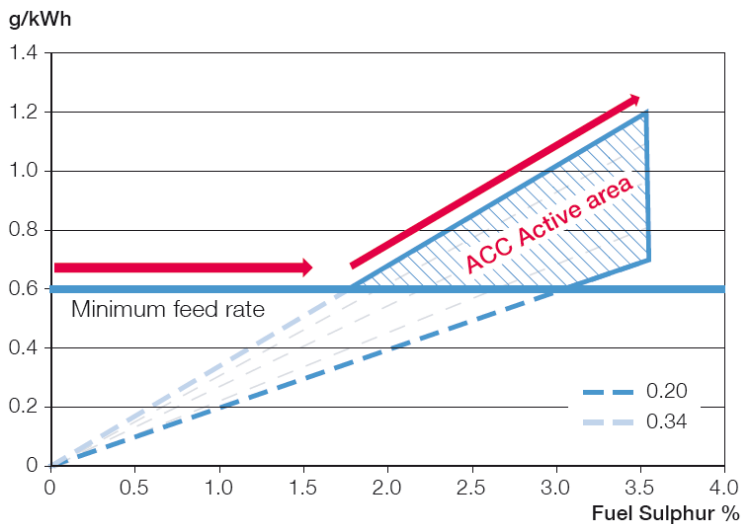


Fig. 5: ACC range for BN 70 cylinder oils

The most efficient way to establish the optimum ACC factor is to use so-called drain oil analyses. It is a strong tool for judging the engine wear condition. Drain oil samples will show if the oil feed rate can be optimised while keeping the BN between 10-25 mgKOH/kg and the iron (Fe) content below 200-300 mg/kg in the drain oil, see Fig. 5. Used oil taken from the engine through the scavenge bottom drain can be used for cylinder condition evaluation.

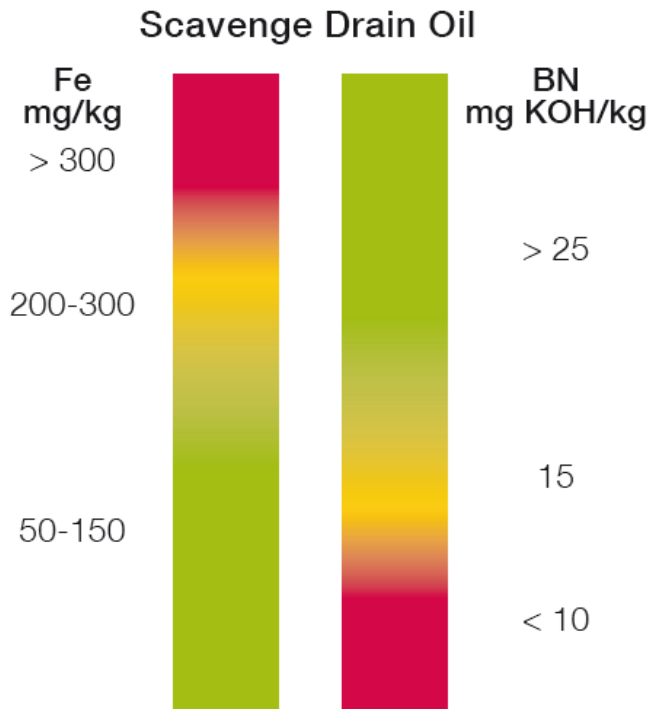


Fig. 5: Scavenge drain oil results

Cylinder Oil Feed Rate Sweep Tests

A possibility is to perform a stress test called “feed rate sweep”. The sweep test is based on a fast six-day test at steady load and, preferably, running on fuel in the high-sulphur range of a 2.8-3.5% sulphur content. The feed rate is adjusted to set values, i.e. 1.4, 1.2, 1.0, 0.8 and 0.6 g/kWh. Each feed rate must be applied for 24 running hours before taking a sample and switching to the next feed rate. A detailed feed rate sweep protocol is enclosed in our Service Letter SL2013-571.

Fig. 6 shows the result of a cylinder oil feed rate sweep test for a 9S90ME-C8.2 performed at 25% load using BN 70 cylinder oil operating on 2.7% HFO.

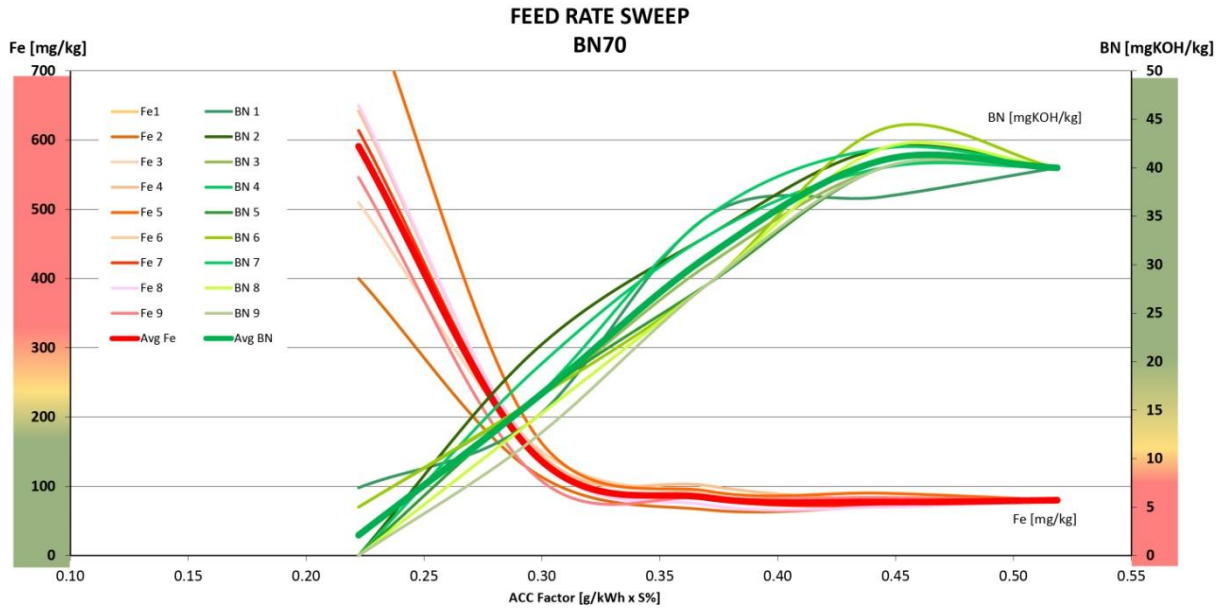


Fig. 6: 9S90ME-C8.2 cylinder oil feed rate sweep test, 2.7% HFO, BN 70 cylinder oil (Source: ExxonMobil)

The influence of the use of higher BN cylinder oil has also been validated in a number of test cases. In general, it can be said, based on these test cases, that neutralising the efficiency is proportional to the BN number. Fig. 7 shows the result of a cylinder oil feed rate sweep test for a 9S90ME-C8.2 performed at 25% load using BN 85 test cylinder oil operating on 2.7% HFO.

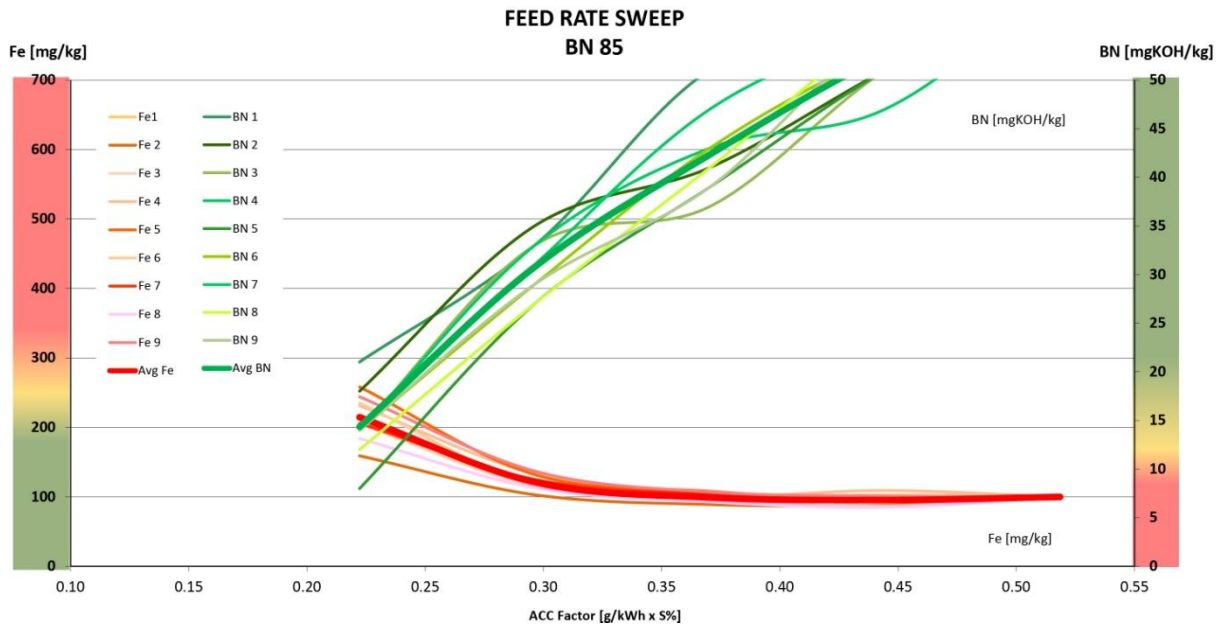


Fig. 7: 9S90ME-C8.2 cylinder oil feed rate sweep test, 2.7% HFO, BN 85 test cylinder oil (Source: ExxonMobil)

Conclusion

We hope that this presentation has assisted in explaining the challenges and solutions available in order to control cylinder liner cold corrosion on MAN B&W two-stroke engines.

If you require more information, do not hesitate to contact department LSP, at LSP@mandieselturbo.com

Yours faithfully
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