Alpha Adaptive Cylinder-oil Control
Alpha ACC

Introduction

The Alpha Lubricator System, Fig. 1, available for all MAN B&W MC/MC-C two-stroke engines, has an algorithm controlling cylinder oil dosage proportional to the sulphur content in the fuel. This algorithm is referred to as Alpha Adaptive Cylinder-oil Control (Alpha ACC).

To explore the potential savings with Alpha ACC, a large scale testing programme is in progress on MAN B&W MC/MC-C type engines in service for a number of owners.

The aim of the testing programme is to determine the level of savings in cylinder oil consumption when taking advantage of the electronically controlled Alpha Lubricator System. An added benefit is that such savings in cylinder oil consumption will reduce the environmental impact from operating vessels with the Alpha Lubricator System. Also more uniform and optimal cylinder liner wear rates can be expected.

The testing programme involves large bore engines for both container vessels (K-MC/MC-C) and for VLCC propulsion (S-MC/MC-C), as well as small and medium bore MC/MC-C engines.

In the following, the very promising preliminary results from the testing programme will be described and evaluated.

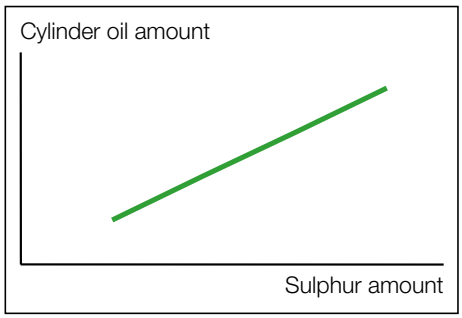


Fig. 2: Cylinder oil amount proportional to sulphur amount entering the cylinders (the basic principle of Alpha ACC)

Fig. 1: Alpha Lubricator fitted on a 12K98MC-C main diesel engine

Working Principle

The principle of the Alpha ACC appears from Fig. 2. The cylinder oil amount is controlled such that it is proportional to the amount of sulphur entering the cylinder with the fuel.

The following two criteria determine the control:

- The cylinder oil dosage shall be proportional to the sulphur percentage in the fuel
- The cylinder oil dosage shall be proportional to the engine load (i.e. the amount of fuel entering the cylinders).

The implementation of the above two criteria will lead to an optimal cylinder oil dosage, proportional to the amount of sulphur entering the cylinders.

The above principle is founded on the observation that the main part of the cylinder liner wear is of a corrosive nature, and the amount of neutralizing alkalinic components needed in the cylinder should therefore be proportional to the amount of sulphur (generating sulphurous acids) entering the cylinders. A minimum cylinder oil dosage is set in order to account for other duties of the cylinder oil (securing sufficient oil film, detergency, etc.).

Fig. 3 shows control of cylinder oil dosage proportional to the sulphur percentage in the fuel. A minimum dosage

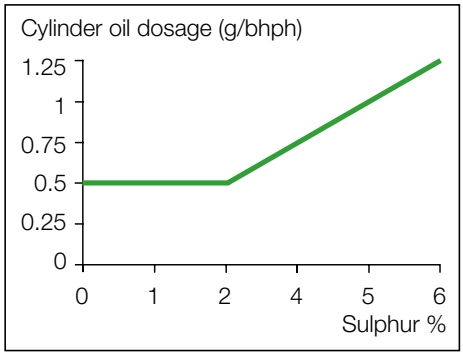


Fig. 3: Cylinder oil dosage proportional to sulphur percentage in the fuel

of 0.5 g/bhph is indicated. This minimum value is preliminary and, given the efficient lubrication achievable with the Alpha Lubricator System, we expect to be able to further reduce this minimum value in the future.

The control according to Fig. 3 is based on a standard TBN 70-80 cylinder oil. For operation in long periods with fuels with a sulphur content below 1%, we recommend changing to a cylinder oil with a lower TBN (i.e. TBN 40-50 cylinder oils).

The environmental impact is clearly demonstrated: Owners who wish to operate on 'green' fuel (low-sulphur fuel) will, at the same time, have the possibility to operate with 'green' cylinder lubrication.

Fig. 4 describes the control of the cylinder oil dosage proportional to the engine load, together with rpm-proportional and mep-proportional lubrication. At part load, load-proportional cylinder oil dosage will provide large cost savings and also reduce the environmental impact from excessive lubrication. Below 25% load, the load-proportional lubrication is stopped, and rpm-proportional lubrication takes over, as seen in Fig. 4.

The above described Alpha ACC is implemented with the so-called " Sulphur Algorithm", see Fig. 5, in the Alpha Lubricator System. In the present version of the Alpha Lubricator System, the crew onboard the vessel inputs the so-called "HMI-setting" based on the sulphur percentage of the fuel used and a conversion table, see Fig. 5. This is done by one input on the HMI-panel of the Alpha Lubricator System each time the fuel specification is changed.

Economic and Environmental Advantages

In order to illustrate the advantages of Alpha ACC, we have chosen, as an example, a vessel from the fleet involved in the testing programme. The vessel is a 6,800 teu container ship equipped with a 12K90MC engine. The Alpha ACC was implemented on this vessel in early December 2001.

Since then the vessel has been operating with cylinder oil dosage control according to Figs. 3 and 4 (the Sulphur Algorithm).

The results from the first five months of operation is seen in Fig. 6. The uppermost part of Fig. 6 shows the load variation and the sulphur content in the fuel.

Both the load variation and the variation in sulphur content are typical for this kind of vessel. The middle diagram in Fig. 6 shows the total amount of sulphur entering the cylinders with the fuel. On the lower part of Fig. 6, four curves are shown for comparison:

- Typical feed rate (mechanical lubricator), 1.2 g/bhph, rpm-proportional control
- Basic feed rate (mechanical lubricator), 0.9 g/bhph, rpm-proportional control
- Basic feed rate (Alpha Lubricator System), 0.8 g/bhph, mep-proportional control
- Alpha ACC (Sulphur Algorithm), 0.25 g/bhph/S%.

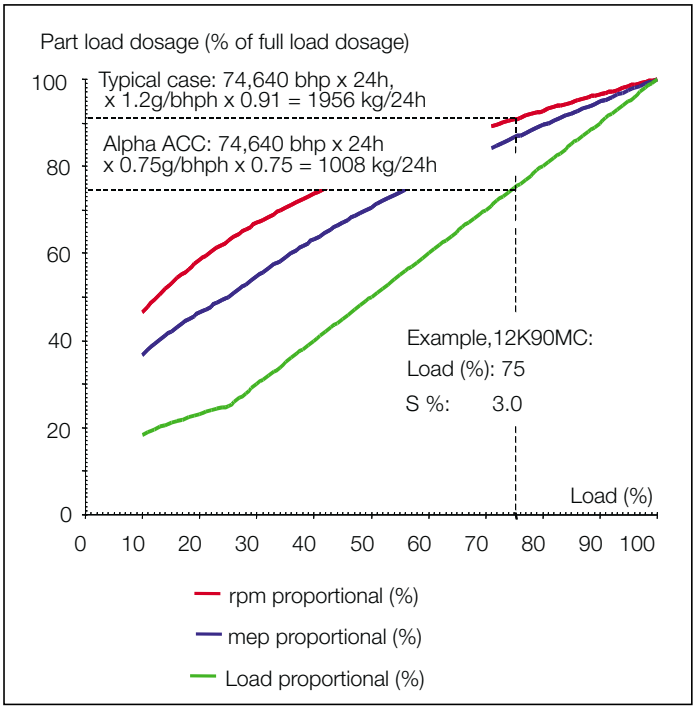
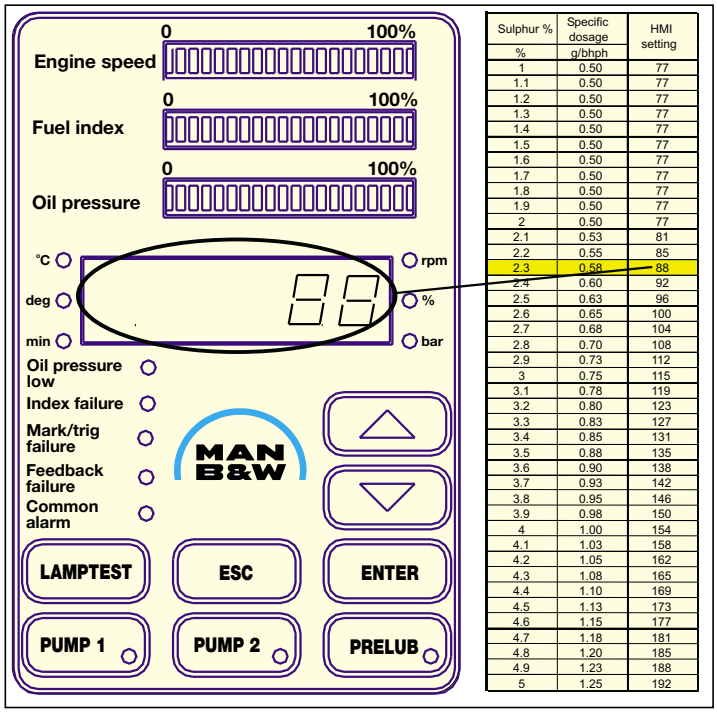


Fig. 4: Load-dependency of cylinder oil dosage. Alpha ACC uses load-proportional cylinder oil dosage



Sulphur %	Specific dosage	HMI setting
%	g/bhph	
1	0.50	77
1.1	0.50	77
1.2	0.50	77
1.3	0.50	77
1.4	0.50	77
1.5	0.50	77
1.6	0.50	77
1.7	0.50	77
1.8	0.50	77
1.9	0.50	77
2	0.50	77
2.1	0.53	81
2.2	0.55	85
2.3	0.58	88
2.4	0.60	92
2.5	0.63	96
2.6	0.65	100
2.7	0.68	104
2.8	0.70	108
2.9	0.73	112
3	0.75	115
3.1	0.78	119
3.2	0.80	123
3.3	0.83	127
3.4	0.85	131
3.5	0.88	135
3.6	0.90	138
3.7	0.93	142
3.8	0.95	146
3.9	0.98	150
4	1.00	154
4.1	1.03	158
4.2	1.05	162
4.3	1.08	165
4.4	1.10	169
4.5	1.13	173
4.6	1.15	177
4.7	1.18	181
4.8	1.20	185
4.9	1.23	188
5	1.25	192

Fig. 5: "The Sulphur Algorithm" in the Alpha Lubricator System

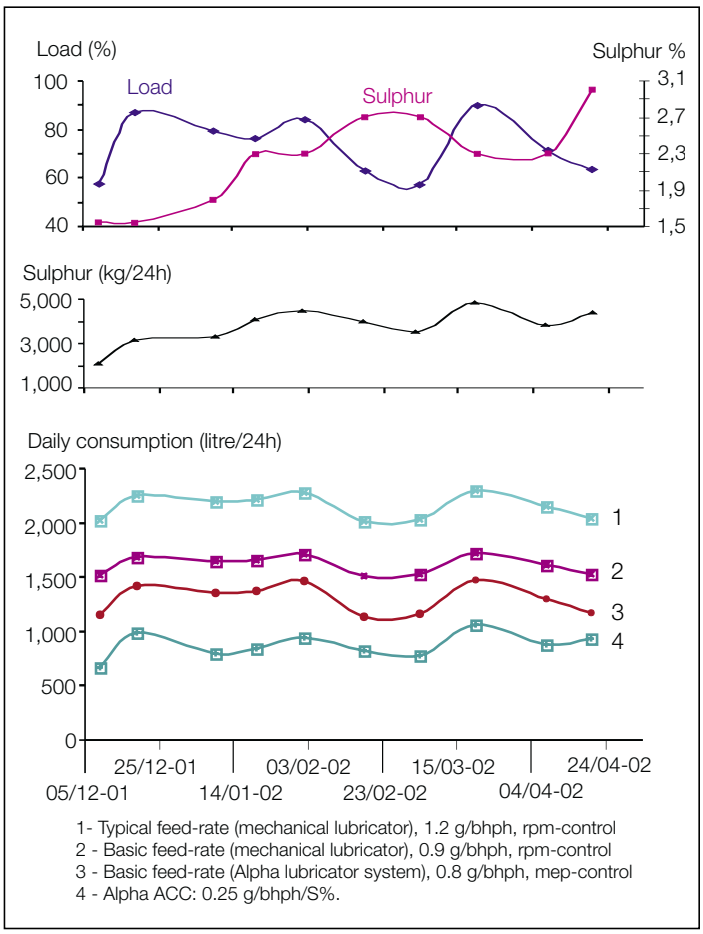


Fig. 6: Typical operating profile for a large container vessel equipped with 12K90MC

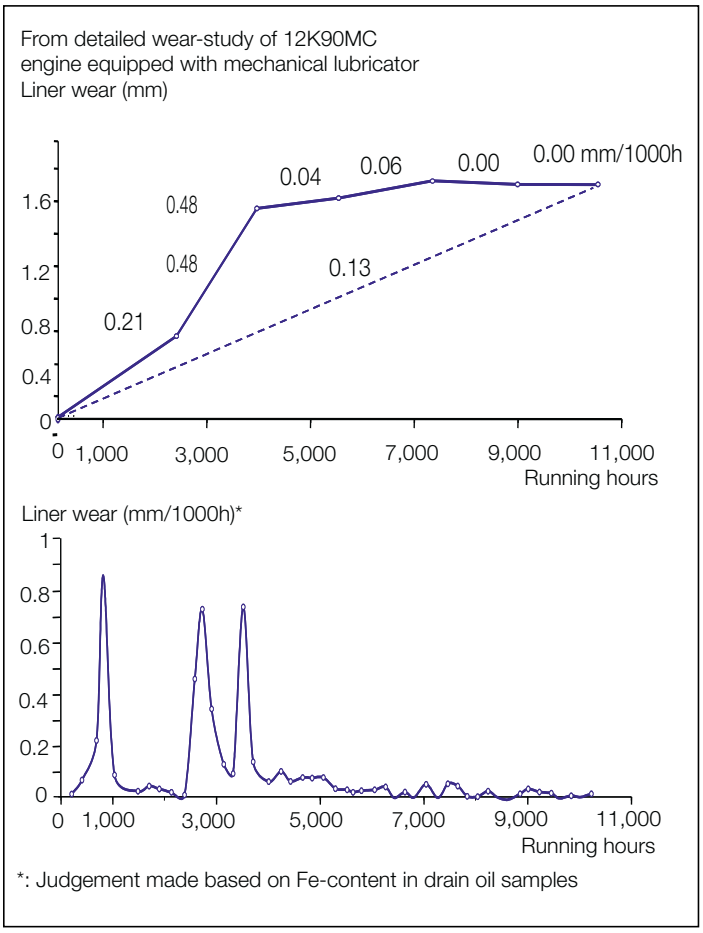


Fig. 8: Detailed wear study on a 12K90MC equipped with mechanical lubricators

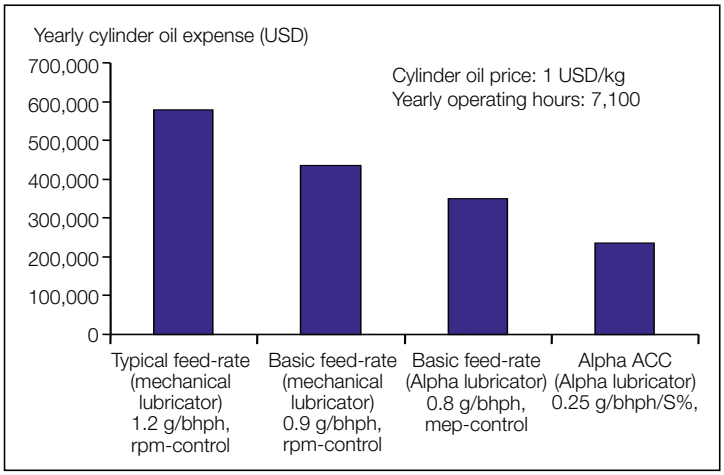


Fig. 7: Yearly cylinder oil expenses with various cylinder lubrication principles

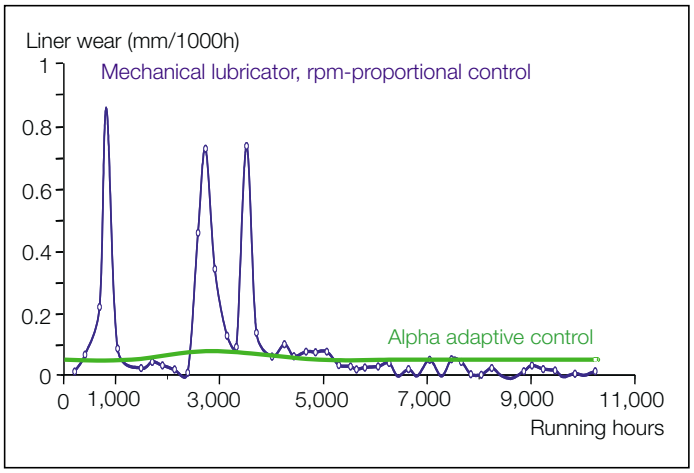


Fig. 9: Cylinder liner wear, comparison between wear with traditional lubrication and Alpha ACC

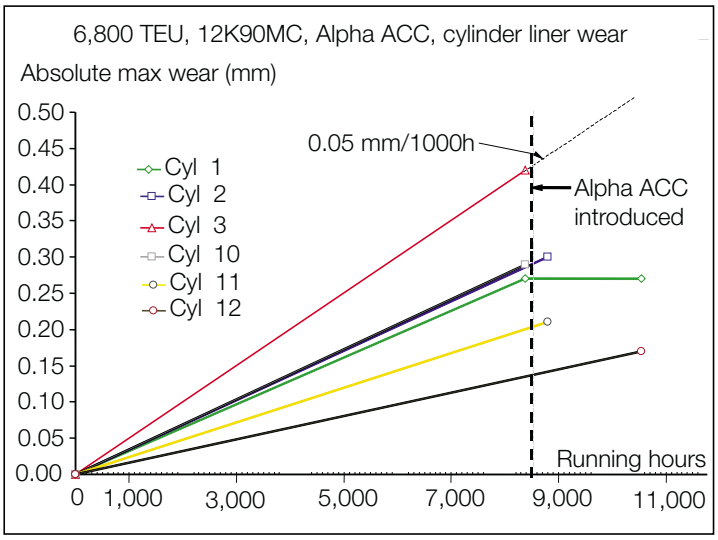


Fig. 10: Cylinder liner wear before and after introduction of Alpha ACC

Engine type :	**6S70MC**
Layout point: SMCR	22,920 bhp
Load point NCR = 90,0% of SMCR	20,628 bhp
Fuel oil sulphur content	3 %
Cylinder lubricating oil consumption with mechanical lubricators	1.20 g/bhph
Cylinder lubricating oil consumption with Alpha lubricators	0.75 g/bhph
Running hours per year	7,000 hours
Lubricating oil price	100 Cent/litre
Lub. oil consumption with mechanical lubricators	186 ton
Lub. oil consumption with Alpha lubricators	108 ton
Saving in cylinder lub. oil consumption	78 ton
Saving in cylinder lub. oil consumption	84,333 litres
Saving in USD	**84,333 USD**
Exchange rate	7.55 DKK/USD
Price for Alpha lubricator system	641,400 DKK
Price for supervision during installation	89,000 DKK
Price for fitter's assistance	130,000 DKK
Total price for Alpha lubricator system	860,400 DKK
Total price for Alpha lubricator system	**113,960 USD**
Pay backtime	**1.35 Years**

Fig. 11: Retrofit of Alpha Lubricator System with Alpha ACC on 6S70MC

As can be seen, very significant savings on the daily consumption of cylinder oil were achieved with the Alpha ACC during the five-month period. These savings will have very significant economic implications, see Fig. 7, with annual savings of 340,000 USD on cylinder oil.

In addition, environmental impact in this case goes hand in hand with the economic advantages.

Naturally, the above savings on cylinder oil must be obtained while maintaining acceptable cylinder liner wear figures.

Previous studies into the nature of cylinder liner wear on a similar 12K90MC engine have shown that the major part of liner wear takes place during short intervals where a low cylinder oil feed rate (due to high load) and a high sulphur percentage are combined.

Fig. 8 shows the results registered on a 12K90MC engine with mechanical lubricator (0.65 g/bhph) with rpm-proportional control. These results were revealed through very frequent cylinder liner wear measurements and even more frequent drain oil sample analyses. Naturally, the wear- peaks can be avoided by increasing the cylinder oil dosage. However, such a simple increase will increase the expenses on cylinder oil dramatically and, furthermore, it will increase the risk of scuffing during periods of operating at part load and/or with low-sulphur fuel ('bore polish').

With Alpha ACC, such risks are eliminated, and it is expected that cylinder liner wear will become stable and predictable over time and low on average, Fig. 9.

The first cylinder wear measurements taken on the 12K90MC equipped with Alpha ACC indicate that liner wear is very low, even with the very low cylinder oil consumption, Fig. 10.

Conclusion

Alpha ACC is currently being tested in a large-scale in-service test on a wide range of different MC/MC-C engines. The preliminary test results are very promising with respect to savings on cylinder oil, impact on, in particular, particle emissions and combustion chamber wear figures.

Alpha ACC can be implemented for all MC/MC-C engines equipped with the Alpha Lubricator System.

As a retrofit on vessels in service, the Alpha Lubricator System with Alpha ACC will have a payback period of less than two years on most types of MC/MC-C engines. An example is given in Fig.11.

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