Cylmate® Systems

– award winner

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ABB

Cylmate pressure transducers makes it possible to constantly measure the combustion pressure in large two-stroke engines.

Cylmate Systems – award winner

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IN JUNE 2004 at the 24th Cimac Congress in Kyoto, Japan, ABB's paper on Cylmate Systems *(see reference below)* was honored with the CIMAC President's Award for 2004, a very prestigious award in the engine industry. The motivation was: "The award was given on a basis of a practical contribution to the future success of the engine industry".

In the present report we outline some examples presented in the Cimac paper and we also show some further improvements on Cylmate that recently have been released. These new features will be very useful tools, not only for online analysis by the crew onboard, but also for offline analysis that can be performed at the home office.

The objective of the Cimac paper was to present long time continuously measured diesel engine performance data for large 2-stroke diesel engines. The unique feature is that every single stroke is measured and used in the data evaluation. It was shown how this feature makes is possible to identify errors in the engine at a very early stage, and to follow up the running conditions of the engine.

Reference:
Karlsson, L and Sobel, J: "Stroke by stroke measurement of diesel engine performance on board", Paper 23 presented at the 24th Cimac Congress in Kyoto, Japan, June 7–11, 2004.

2004 CIMAC President's award.

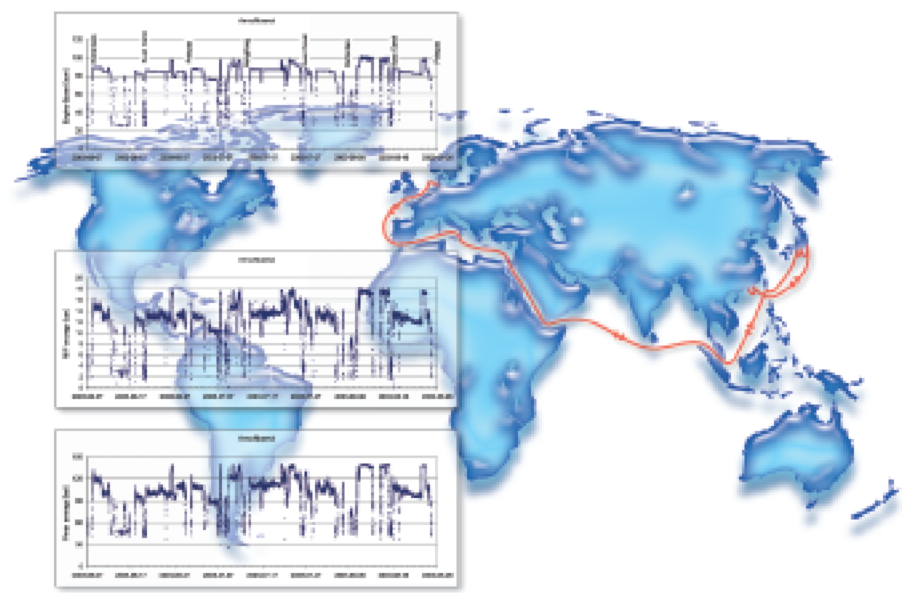


Figure 1. 7.3 million strokes per cylinder measured during 81 days.

Long time continuously measured data

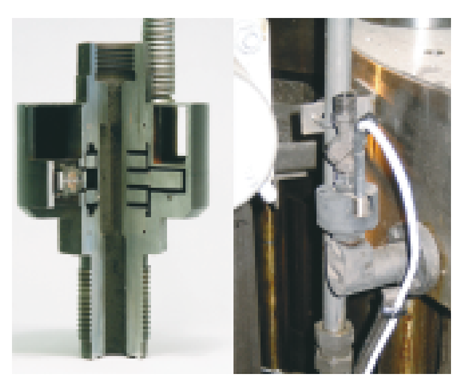
The longest period of time with continuously measured data presented is from M/V *Anna Maersk*. The data covers 81 days of operation from June 7 to August 26, 2003, where approximately 7.3 million strokes per cylinder were measured and used in the analysis. *Anna Maersk* is a large container vessel with a Wärtsilä NSD 12RTA96C engine.

In Figure 1, the engine speed, p_{max} and *MIP* as a function of time, are shown, where also the route and some of the ports are indicated.

150 million strokes

M/V *Maersk Arun* is a container vessel with a MAN B&W 7S50MC engine. Cylmate was installed in spring 2001 on *Maersk Arun* and it was the second Cylmate installation. Three of the pressure transducers on *Maersk Arun* are early prototypes and have been in continuous operation since the installation in year 2001 without any cooling, maintenance or recalibration. The number of strokes measured with these specific transducers are approximately 150 millions per transducer.

The Cylmate pressure transducer is



Cylmate pressure transducer. Cut through view after two years of operation without any sign of clogging (left). Installation example (right).

"Malmö Link"

mounted close to the cylinder cover at the indicator bore. It has a blow-through design that gives easy cleaning as the indicator valve is mounted on the top of the transducer. The transducers are operating without any cooling.

Detection of a fault in the cooling of a fuel valve

M/V *Malmö Link* is a ro-pax ferry with two Sulzer 6RND68M engines. On the port engine of this vessel, the first Cylmate system was installed early in year 2001. One year later, the starboard engine was also equipped with Cylmate.

Malmö Link identified a problem with cylinder 5 on starboard engine. For all loads, except full load, the pressure was significantly lower than on the other cylinders. Initially, the crew changed the fuel valve, but the problem came back after seven to eight hours.

In Figure 2 trend data for a nine hour trip between Travemünde and Malmö is shown using the Cylmate Operator Station. The data displayed is engine speed and p_{max} for cylinders 4, 5 and 6.

With a non-continuous measuring system, you perform measurements at nominal load, making it impossible to see and analyse this problem, which only appeared at low load.

However, in this case the crew established the cause to be a blocked water cooling tube, due to a stretched screen cover, see Figure 3. This made the fuel valve needle stick when it was fully open, and therefore too much fuel was injected in relation to the air from the turbocharger, which caused incomplete combustion. The consequences if they did not solve the problem should have been more air-pollution and an increased fuel consumption.

Early detection of faulty exhaust valve

M/V *Hanjin Ottawa* is a large container vessel with a Wärtsilä NSD 10RTA96C engine.

The pressure at Top Dead Center (TDC) of cylinder 5 was slightly lower than the other, especially noticeable at low rpm and low scavenging air pressure, see Figure 4 (left-hand side). The data displayed is engine speed (blue curve) and p_{TDC} for cylinders 1, 2 and 5 (green, brown and red curves).

After the change of exhaust valves on cylinder 5, the pressure at TDC came back to normal, see Figure 4 (right-hand side).

Figure 3. Blocked water cooling tube.

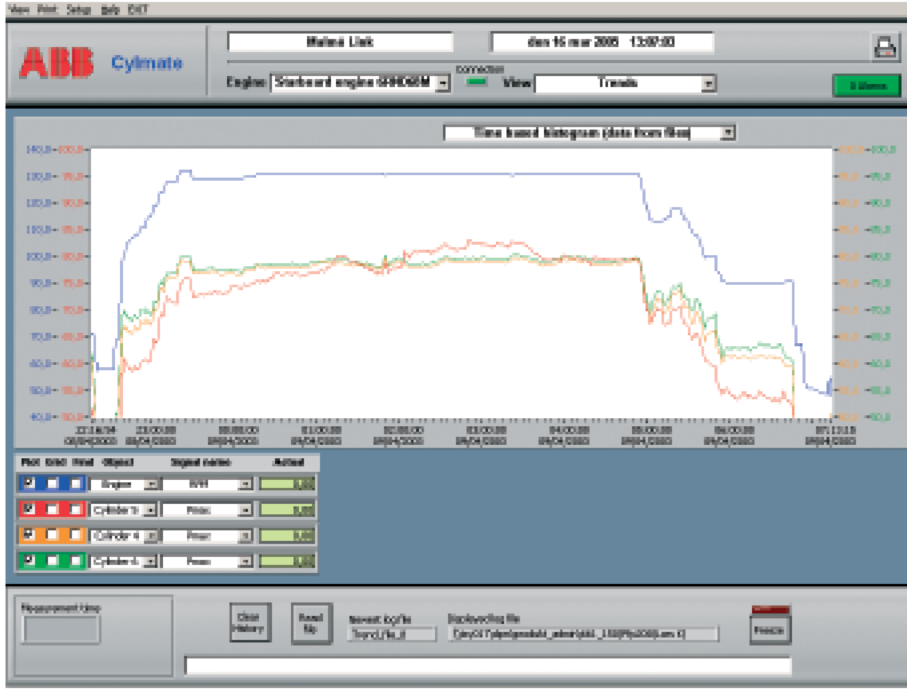


Figure 2. Trend picture from "Malmö Link".

Figure 4. Before and after change of exhaust valves.

The reason for the problem was that the closing of the exhaust valve was degenerated by a leaking air spring.

Stroke-by-stroke engine performance analysis

In Figure 5, the engine speed for *Hanjin Ottawa* is shown for the first part of a voyage between Yantian and Kaohsiung. The first part of the plot shows the vessel maneuvering out of Yantian, then speed was gradually increasing. After 40 minutes, the fuel was switched off, the vessel went down in speed, and then after some minutes the speed was increased again.

The *MIP* values for each of the ten cylinders are shown in Figure 5. The *MIP* values are strongly influenced by any error in the TDC location.

The thermodynamic TDC, computed from the pressure curve for each cylinder, is shown versus time in Figure 5, and is in very good agreement with the expected behavior as they slightly increases when the engine is getting warmer and that the thermodynamic TDC reach a value of approximately –0.1 degrees crank angle.

The conclusion is that the crank-shaft deformation model of Cylmate predicts the thermodynamic TDC of each cylinder in a very proper way, and thus the accuracy in the calculated *MIP* values is very high. Further, one can conclude that advanced engine analysis is possible on a stroke by stroke basis even under dynamic load conditions.

Follow-up of running conditions

When analyzing data from M/V *Axel Maersk*, a sister vessel of the previous mentioned *Anna Maersk*, a change in the combustion process around June 20, 2003 was identified. It was later confirmed by the crew that a change of fuel with a following adjustment of the fuel quality settings had taken place at that time. In Figure 6, presenting the average angle of maximum pressure versus Fuel Index, the influence of the change in the combustion process is clearly seen. The change of fuel did not influence average *MIP* and p_{max}, as seen in Figure 7.

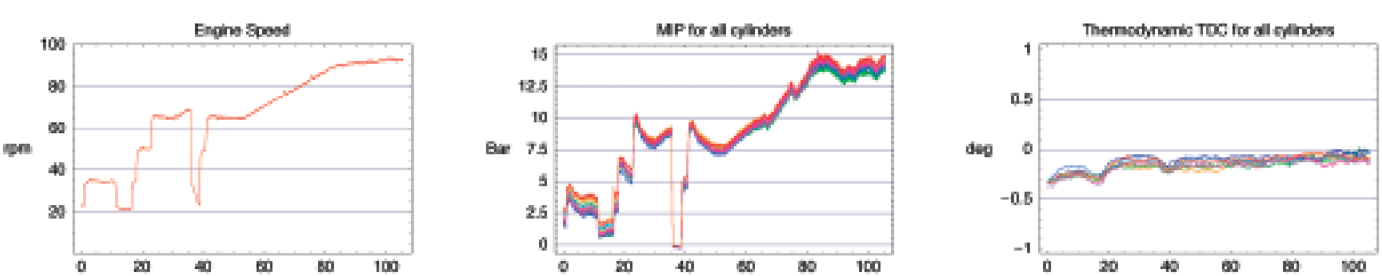


Figure 5. Engine speed, MIP and thermodynamic TDC.

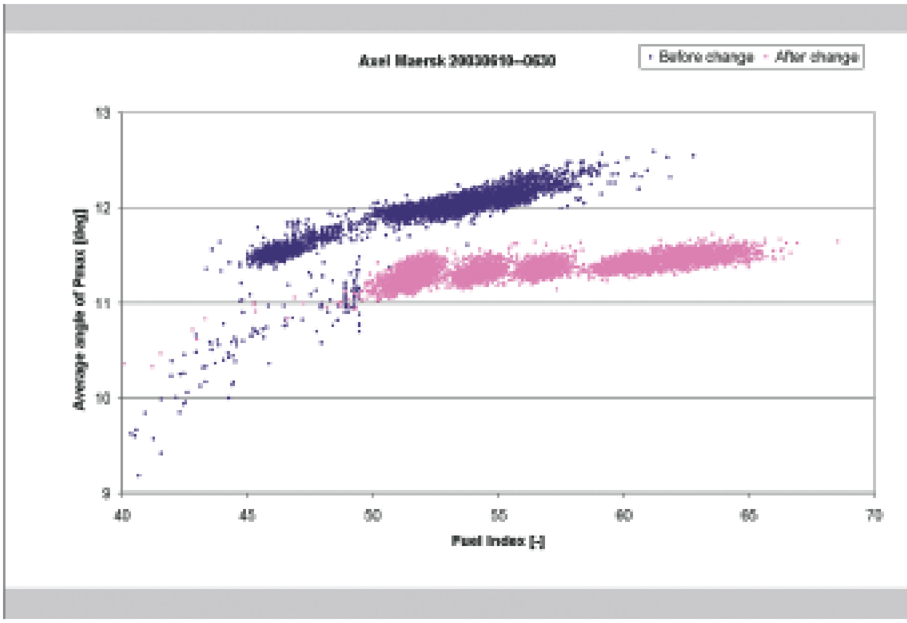


Figure 6. Average angle of p_{max} versus Fuel Index.

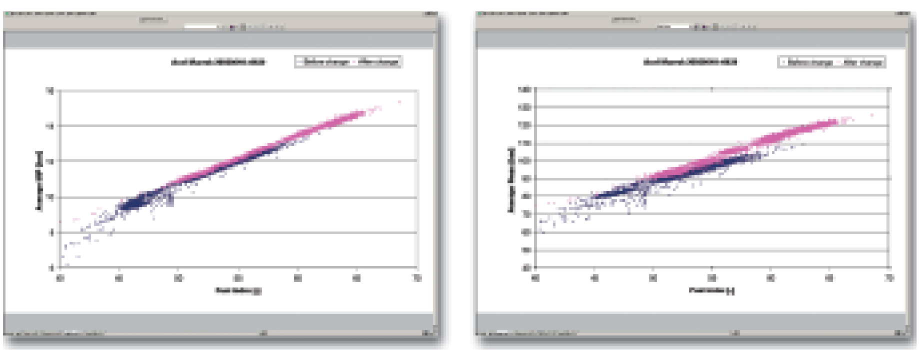


Figure 7. Average MIP versus fuel index and average p_{max} versus fuel index.

New function – Cylmate Viewer

The "Performance history – reference" report is a powerful tool for recording engine status and behavior at different load and environmental conditions. As soon as the engineer needs it, he can store a record with live date from 68 consecutive strokes. For example a recording can be taken during the sea trial, at tropical conditions, at Nordic sea conditions, after engine overhaul and so on. Each recording is stored on the hard disk and can be used as reference value for future comparisons.

This report function can also be used to record any performance deviation from normal behavior. The file with the recorded strokes can be used for later off-line analysis on board or it can be sent to the home office for expert analysis.

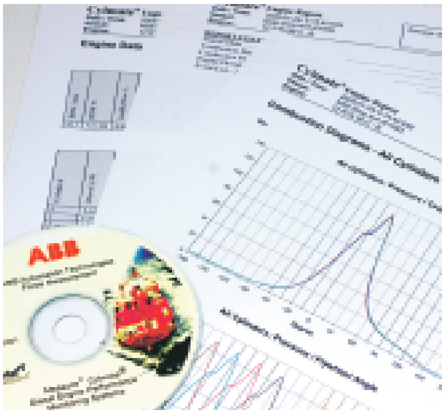
The analysis is done by means of a free-standing tool, the "Cylmate Viewer". The Viewer works like a video player. It can play the recorded stroke sequence. The strokes can be replayed from stroke 1 to stroke 68 – forward or backward. The Viewer will for each stroke show the pressure curves, crank angles, trends, deviations, scavenging air pressure, p_{max}, p_{comp}, etc.

The "Performance history – alarm" report is an indispensable tool for engine fault analysis. As soon as Cylmate has detected an engine combustion alarm a record of 68 strokes will automatically be stored. The stored file will include all combustion data for 60 strokes before the alarm, data for the actual stroke at which the fault was detected and data for seven strokes after the alarm stroke.

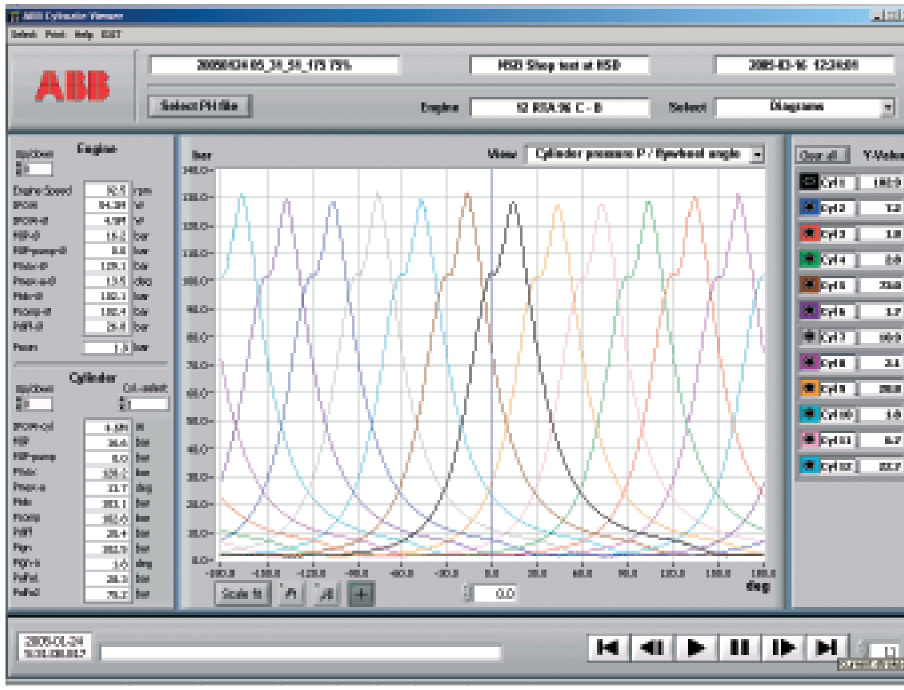
The fault analysis is done by means of the Cylmate Viewer. This is the first commercial tool on the market that has all information of the combustion process stroke by stroke – before the alarm, at the alarm, and after the alarm. That means it is possible to see the development of a fault and to get understanding of the mechanism that led to the fault. Based on this knowledge future alarms of this kind can be avoided.

New function – engine performance report

The engine performance report can be seen as an engine logbook, which clearly summarizes all important combustion parame-



Cylmate engine performance report.



Cylmate Viewer.

ters. The report can be printed, stored on the hard disk, burned to a cd/dvd and/or transmitted to a superior system.

Conclusion

The main conclusion of this paper is that it is now possible to measure, during a long period of time, the combustion pressure continuously on large two-stroke diesel engines. When measuring continuously it is possible to identify errors in the engine at a very early stage, and to follow up the running conditions of the engine. Cylmate pressure transducers, which have been in continuous operation since the installation in year 2001, are still measuring accurately. Further, new functions in the Cylmate System make it possible to also analyse the combustion process on a stroke by stroke basis off-line, for an example at the home office. ❡

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