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Analytical assessments of selected main engine pistons drawing out records and record of cylinder oil feed rates

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Key words: cylinder liner wear, piston rings wear, cylinder oil feed rate

Abstract

The paper presents the analytical assessment of main engine piston drawing out records and record of cylinder oil feed rates. Collated and analyzed the wear records of cylinder liners and piston rings of main engines installed in three ships on the basis of the measurements at main engine piston drawing out measured during dry dock main engine overhauls. An analytical data have been taken from operating records. Author presents a summary of the results of these surveys and analytical assessments made for selected three vessels (VLCC) with Main Engines B&W Man MC series.

Introduction

From the viewpoint of design / specification of Diesel main engines, their operating conditions as a working environment of lubricating oil for cylinder liners and piston rings are becoming increasingly stringent due to the growing demand for increased output with reduced lubricating oil consumption involving consequent higher maximum cylinder pressures and mean effective pressures. To cope with these severe design / specification constraints, engine builders have taken a variety of measures. Nevertheless, problems associated with failures of engine components relating to combustion chambers have not been sufficiently controlled yet.

The machinery failure statistics contained in the various databases reflecting the assessments conducted by the various analytical groups and shows that failures of cylinder liners, piston rings and pistons all related to combustion chambers share the highest proportion every year in main engine failure statistics by component part. Even the results of analytical assessments upon the time show no signs of improvement in reducing engine failures. Conversely, excessive wear of cylinder liners and piston rings of main engines and problems associated with scuffing have frequently occurred.

To solve these problems, it is necessary to conduct analytical assessments on a variety of data such as actual engine outputs, engine revolutions, fuel oil handling procedures, and properties and feeding rates of cylinder oil, which differ from ship to ship. As one of these activities, for a trend survey and to identify wear factors, collated and analyzed the wear records of cylinder liners and piston rings of the main engines installed in various ships on the basis of the measurements at main engine piston drawing out measured during dry dock main engine overhauls and analytical data taken from operating records. The following paper author intend to present a summary of the results of these surveys and analytical assessments made for selected three vessels (VLCC) with Main Engines B&W Man MC series.

Cylinder liner wear and piston rings wear limits

In analysis at this time, the target service periods of cylinder liners and piston rings were assumed to be 10 years and 15,000 hours respectively. Accordingly, permissible wear rates for respective target service periods (hereafter referred to as “permissible wear rates”) [1, 2, 3]:

a) Cylinder liner: The permissible wear limit was set at 0.6% of the cylinder bore, assuming that the minimum running hours are 70,000 hours (used for ten years at an operating rate of 85%).
b) Piston ring: The permissible wear limit was set at 20% of the thickness of a piston ring, and the minimum service period was assumed to be 15,000 hours.

Concerning wear rates, cylinder liner wear rate exceeding 0.30 mm/1000 engine running hours and piston ring wear rate exceeding 1.0 mm/1000 running hours are regard as abnormal wear rate for presented in paper engines [3, 4].

Distribution of cylinder oil feeding rates by engine type

To compare cylinder oil feeding rates by engine type, it is necessary to handle data within the standard range. For this reason, the following equation of calculation that relies on the multiple-linear proportion method to determine cylinder oil feeding rates as converted into catalogue data at the rated output, whereby actual feed rate data of individual ships were converted into values of catalogue MCR, and the results thus obtained were subjected to comparative assessments (hereafter the feeding rates converted into catalogue data at the rated output using the multiple-linear proportion method are referred to simply as "feeding rates") [3].

Feeding rate Q_c [g/kW/hr]:

$$Q_c = \frac{Q_A \cdot 1000 \cdot \gamma \cdot 100}{N_c\left(\alpha \cdot n_A(\%) + \beta \cdot N_A(\%)\right) \cdot 24} \tag{1}$$

where:

Q_A (L/Day/Cyl.) – actual feeding rate;

n_A (%) – actual/catalogue rpm ratio at actual operating point;

N_A (%) – actual/catalogue output ratio at actual operating point;

α – weighting coefficient for physical factor (rpm linear proportion factor = 0.7);

β – weighting coefficient for chemical factor (output linear proportion factor = 0.3);

γ – density of cylinder oil at cylinder oil temperature at feed rate measurement (approximately 0.922);

N_c – maximum continuous output on the catalogue.

Main Engine Output and thermal load calculation

For calculation of Main Engine Output and thermal load proportional methods have been used as a power measuring devices have not been available on all of presented and evaluated main engines of three ships.

The method was applied where the calorific value of using fuel oil was known.

The output [%] of a main Diesel engine was calculated by the under mentioned proportional formula (2) [2, 3]

$$\text{OUTPUT}[\%] = \frac{\text{Fm} \cdot \text{SG@Fm} \cdot \text{LCV(FO)} \cdot 100}{42.7 \cdot \text{SFOC} \cdot \text{MCR}} [\%\,\text{MCR}] \tag{2}$$

where:

Fm – the reading value of F.O. flow meter for main engine [L/hr];

SG@Fm – F.O. specific gravity at the temperature at flow meter;

SFOC – fuel consumption ratio at shop trial at MCR [g/kW/hr];

LCV – fuel analysed Low Caloric Value [MJ/kg];

MCR – Maximum Continuous Output(Rating) [kW].

Thermal load [%] has been calculated from power output at any particular speed using formula as following [2, 3]:

$$\text{THERMAL LOAD}[\%] = \frac{\text{Actual Output / Actual RPM} \cdot 100}{\text{MCR / RPM@MCR}} [\%\,\text{MTL}] \tag{3}$$

where:

Actual Output – Actual power output calculated [kW];

Actual RPM – RPM prevailing at Actual Output [1/60s];

MCR – Maximum continuous output at shop trial [kW];

RPM@MCR – Shop trial RPM at MCR [1/60 s];

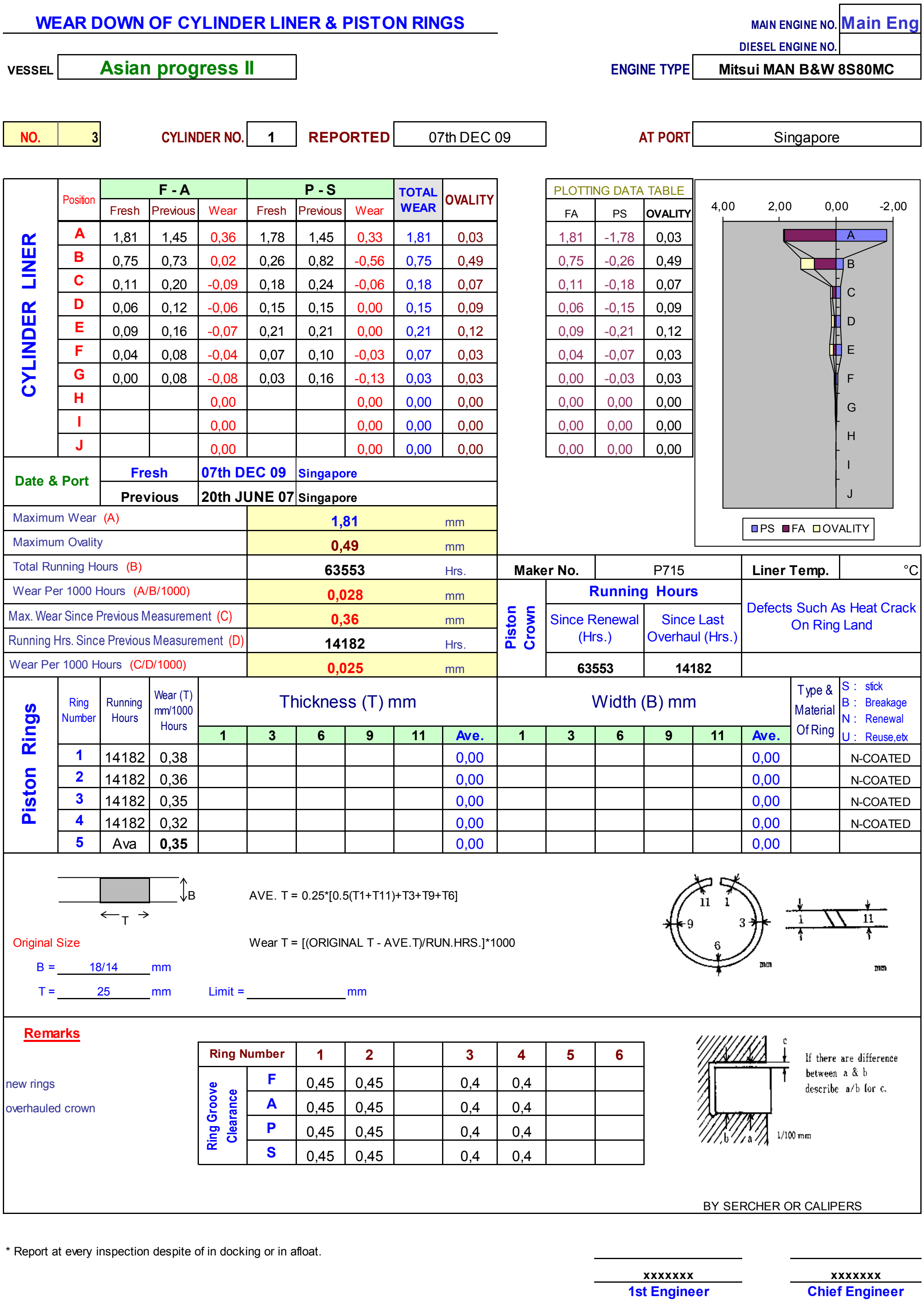
MTL – Maximum Thermal Load at MCR.

Records of fuel consumption, power output [%] and thermal load [%] of analysed engines have been calculated daily and recorded daily in the Engine Room Log Books. Data have been collected for the purpose of this analysis.

Measurements of m/engines cylinder liners and piston rings wear

Measurements of main engine cylinder liners and piston rings wear for all three presented in the paper engines have been done during dry dock period. During dry dock period overhauls of main engines driving gears have been done. During overhauls all units have been opened up and pistons down out. Measurements of thickness of piston rings and cylinder liners calibration have been performed. All obtain data have been recorded in form "Wear down of cylinder Liner and piston rings". Example of the form is presented on figure 1 [3].

Pistons drown out usually is performed during dry dock period. It happening every 2.5 years or around 15,000 main engine running hours. Measurements are usually performed by experienced persons to avoid serious mistakes and ensure that measurements are reflecting to real condition of engine.



WEAR DOWN OF CYLINDER LINER & PISTON RINGS

VESSEL	Asian progress II
MAIN ENGINE NO.	Main Eng
DIESEL ENGINE NO.	
ENGINE TYPE	Mitsui MAN B&W 8S80MC
NO.	3
CYLINDER NO.	1
REPORTED	07th DEC 09
AT PORT	Singapore

CYLINDER LINER

Position	F - A Fresh	F - A Previous	F - A Wear	P - S Fresh	P - S Previous	P - S Wear	TOTAL WEAR	OVALITY
A	1,81	1,45	0,36	1,78	1,45	0,33	1,81	0,03
B	0,75	0,73	0,02	0,26	0,82	-0,56	0,75	0,49
C	0,11	0,20	-0,09	0,18	0,24	-0,06	0,18	0,07
D	0,06	0,12	-0,06	0,15	0,15	0,00	0,15	0,09
E	0,09	0,16	-0,07	0,21	0,21	0,00	0,21	0,12
F	0,04	0,08	-0,04	0,07	0,10	-0,03	0,07	0,03
G	0,00	0,08	-0,08	0,03	0,16	-0,13	0,03	0,03
H			0,00			0,00	0,00	0,00
I			0,00			0,00	0,00	0,00
J			0,00			0,00	0,00	0,00

PLOTTING DATA TABLE

FA	PS	OVALITY
1,81	-1,78	0,03
0,75	-0,26	0,49
0,11	-0,18	0,07
0,06	-0,15	0,09
0,09	-0,21	0,12
0,04	-0,07	0,03
0,00	-0,03	0,03
0,00	0,00	0,00
0,00	0,00	0,00
0,00	0,00	0,00

Date & Port			
Fresh	07th DEC 09	Singapore	
Previous	20th JUNE 07	Singapore	

Maximum Wear (A)	1,81	mm
Maximum Ovality	0,49	mm
Total Running Hours (B)	63553	Hrs.
Wear Per 1000 Hours (A/B/1000)	0,028	mm
Max. Wear Since Previous Measurement (C)	0,36	mm
Running Hrs. Since Previous Measurement (D)	14182	Hrs.
Wear Per 1000 Hours (C/D/1000)	0,025	mm

Maker No.	P715	Liner Temp.	°C
Piston Crown – Running Hours: Since Renewal (Hrs.)	Since Last Overhaul (Hrs.)	Defects Such As Heat Crack On Ring Land	
63553	14182		

Piston Rings

Ring Number	Running Hours	Wear (T) mm/1000 Hours	Thickness (T) mm 1	3	6	9	11	Ave.	Width (B) mm 1	3	6	9	11	Ave.	Type & Material Of Ring	S : stick B : Breakage N : Renewal U : Reuse,etx
1	14182	0,38						0,00						0,00		N-COATED
2	14182	0,36						0,00						0,00		N-COATED
3	14182	0,35						0,00						0,00		N-COATED
4	14182	0,32						0,00						0,00		N-COATED
5	Ava	0,35						0,00						0,00		

AVE. T = 0.25*[0.5(T1+T11)+T3+T9+T6]

Original Size

Wear T = [(ORIGINAL T - AVE.T)/RUN.HRS.]*1000

B = 18/14 mm

T = 25 mm

Limit = ____ mm

Remarks

new rings

overhauled crown

Ring Groove Clearance / Ring Number	1	2		3	4	5	6
F	0,45	0,45		0,4	0,4		
A	0,45	0,45		0,4	0,4		
P	0,45	0,45		0,4	0,4		
S	0,45	0,45		0,4	0,4		

BY SERCHER OR CALIPERS

* Report at every inspection despite of in docking or in afloat.

xxxxxxx
1st Engineer

xxxxxxx
Chief Engineer

Fig. 1. Example of wear down of cylinder liner and piston rings measurement data

Cylinder liner / piston ring wear rates versus cylinder oil feeding rates, thermal loads and outputs

Figures 2–6 show cylinder liner / piston ring wear rates, cylinder oil feeding rates, thermal loads and outputs versus engines running hours. Data presented were used for analysis of trends. Cylinder oil feed rates, thermal loads, piston speeds and power outputs used here are based on the operating records of engines in the 6-month period close to the dates of measurements taken at the time of piston drawing out [3, 5].

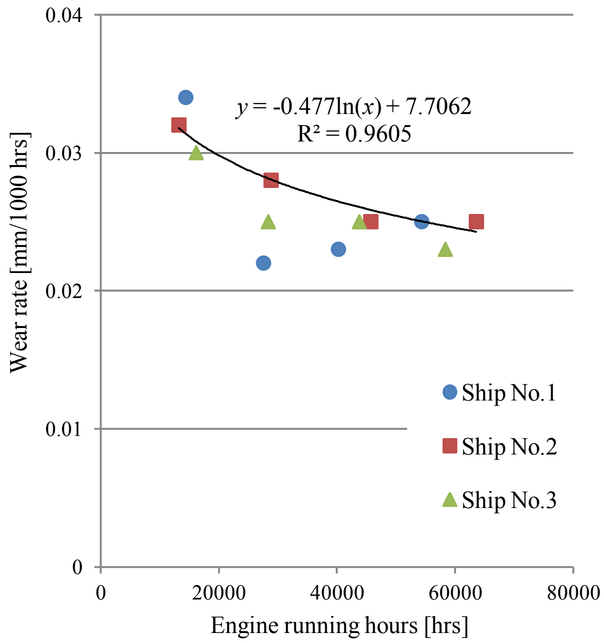


Fig. 2. Cylinder liner wear rate versus M/E running hours

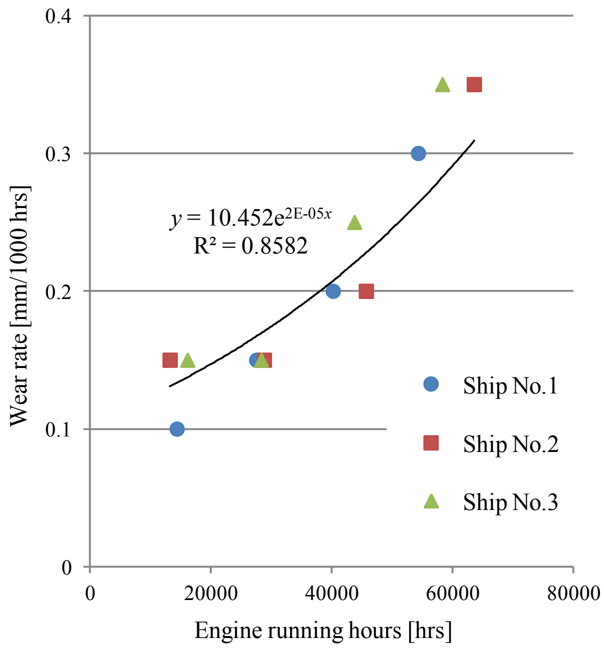


Fig. 3. Piston rings wear rate versus M/E running hours

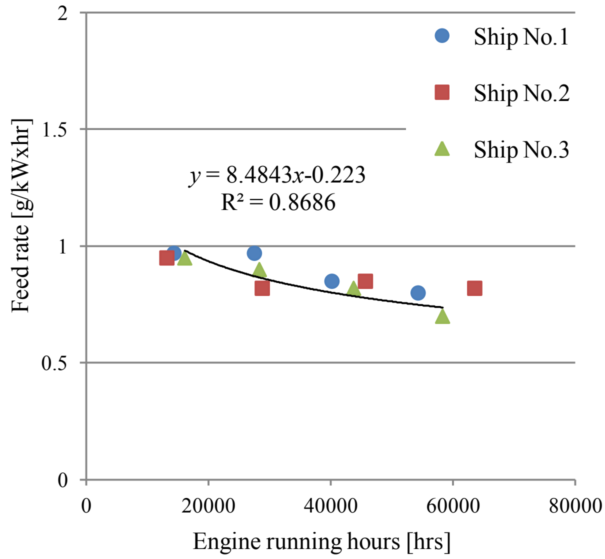


Fig. 4. Cylinder oil feed rate versus M/E running hours

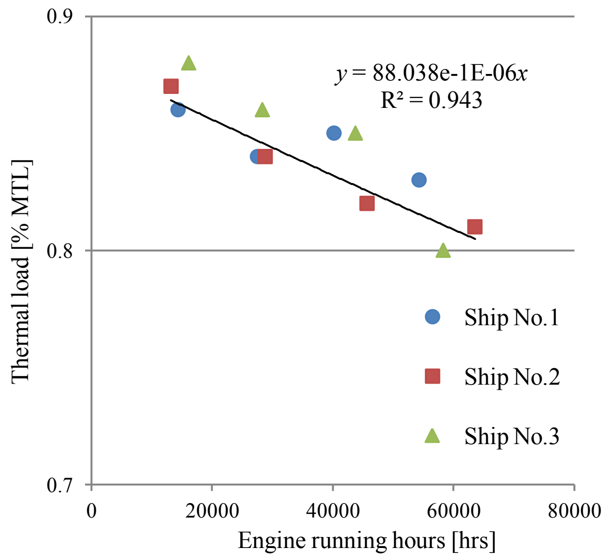


Fig. 5. Main engine thermal load versus M/E running hours

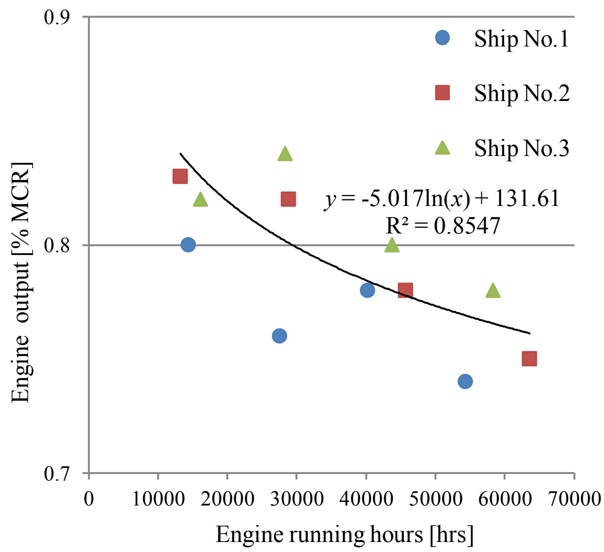


Fig. 6. Main engine output versus M/E running hours

Conclusions

Actual cylinder oil feeding rates, cylinder liner / piston ring wear rates of selected engines, and the relations between the operating conditions of engines and wear rates are described above. The results of these observations and analytical assessments are summarized below:

1. Wear rates of cylinder liners; i.e. more then 0.03 mm/1000 hours are faced in the first period of engines operation but later on wear rate of cylinder liners drops down after first 2.5 year of engine operation, however, do not reach permissible wear rate. It can be explained that during first period (2.5 years) of engine operation braking – in and proper adjustment of cylinder oil feed rate.
2. Wear rate of cylinder liners drops down after first 2.5 year of engine operation and increases after 7.5 years of operation.
3. Wear rates of piston rings during analyzed periods for all engines meet requirements, never overpass permissible wear rates. However, wear rates increase after first 2.5 year of operation of engines due to cylinder liners wear down. Piston rings are reliable part of engines.
4. Cylinder oil feed rate found stable during all analyzed period. Feed rates meet engine maker requirements but due to higher wear cylinder liners / piston rings after first observed period increase of cylinder oil feed rate to be considered.
5. Main engines outputs and thermal loads during analyzed period meet requirements and usually output do not overpass 85% of MCR and thermal load 95%.
6. Main engines outputs and thermal loads drop down upon the time of engines. It is obvious due to ageing of engines which have influence for their performance.
7. Along with the recent development of innovative cylinder lubrication systems such as Alpha Lubricating System, efforts are being made to reduce cylinder oil feeding rates, but any move towards the unified application of the new systems to reduce cylinder oil feeding rates without paying due regard to inherent differences among various engine types and sizes is highly questionable. It is, therefore, necessary to manifest and establish specific cylinder oil feed rates or indexes, taking into account, in an integral manner, the typical operating conditions of various types of engine (piston speeds, output ranges, etc.), service lives of cylinder liners and piston rings that are demanded by users of engines.

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