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ANALYSIS OF THE ACTUAL DAMAGES TO THE MARINE ENGINES FROM THE POINT OF VIEW OF DIAGNOSTIC SYSTEMS' CAPABILITIES

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Abstract

In the article there are presented different operating events leading to the same consequences, i.e. permanent engine damage. The analysis has been carried out of diagnostic actions performed by the operators, of the usefulness of diagnostic systems existing on these ships as well as analysis of the operating values of the latest diagnostic systems in respect of possibility to prevent the described consequences of operating events

***Key words**: piston engine of the main ship drive, technical state of engine, diagnostic parameters, diagnosing system, operating events, efficient operation of ship engine*

1. Introduction

Task of the diagnostic system (SDG) is to provide the diagnostic data concerning a ship engine (diagnosed system - SDN). SDG and SDN form a diagnostic system. Efficiency of SD depends on a possibility to obtain accurate and reliable diagnostic information, which enables a mechanic to make accurate and reliable operating decisions.

In the presented operating events such information was missing, what resulted in considerable damages and threat to the crew and ship safety.

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1. Examples of damage to marine engine identification

1st Example

In the four-stroke engine if the ship propulsion plant the crack and tear off of the connecting-rod big end bottom cover took place.

After visual inspection of the engine it has been established that a cause of the failure was damage to the bottom cover of a connecting-rod big end.

►Results of the accident examining board inspection:

"Cause of a fatigue crack of the cover was repair by pad welding of discontinuity found in manufacture process after forging and machining operation.

As it results from examination of the damaged part, a cause of failure was the faulty heat treatment in manufacturing process. After pad welding no actions were performed in purpose to eliminate thermal stresses. The fact was neglected that the above element was not among the consumable elements and that it was supposed to serve through a whole period of the engine operation, but it was damaged after 4 years despite it had certificates of two recognised classification societies.

The engine elements getting out of the crankcase caused damage to the oil and fuel pipes. Before black-out occurred in result of stoppage of the engine coupled with a shaft generator, the fuel and oil had been sprinkled around the engine room in result of a pressure generated by the fuel and oil pumps driven by electric motors. It should be admitted that there was an unbelievable luck that the ignition did not occur and fire did not break out, which could have had disastrous consequences".

"Consequences.

In result of the occurred event a crack of piston no. 4 took place, a piston and crank system was pushed outside (Fig.1), the crank bearing cracked, camshaft case was torn off the cylinder block along 3000 mm length, camshaft was bended, material was torn out in the lower part of cylinder sleeve guiding, the sleeve was planished and wedged up with a connecting rod, the crank-pin no. 4 was deeply damaged, the rotating masses of the system connecting rod were damaged, the fuel pipe cracked and heavy fuel mixed with lube oil (loss of approx. 6.5 t of oil), crankcase base fastening the fuel pumps no. 2, 3, 4 and 5 was torn out, the pistons, sleeves and connecting-rods of a system no. 4 + 5 were crushed.

Explosion did not cause any victims. Despite the fuel fumes the fire did not break out."(Fig.2)[1]

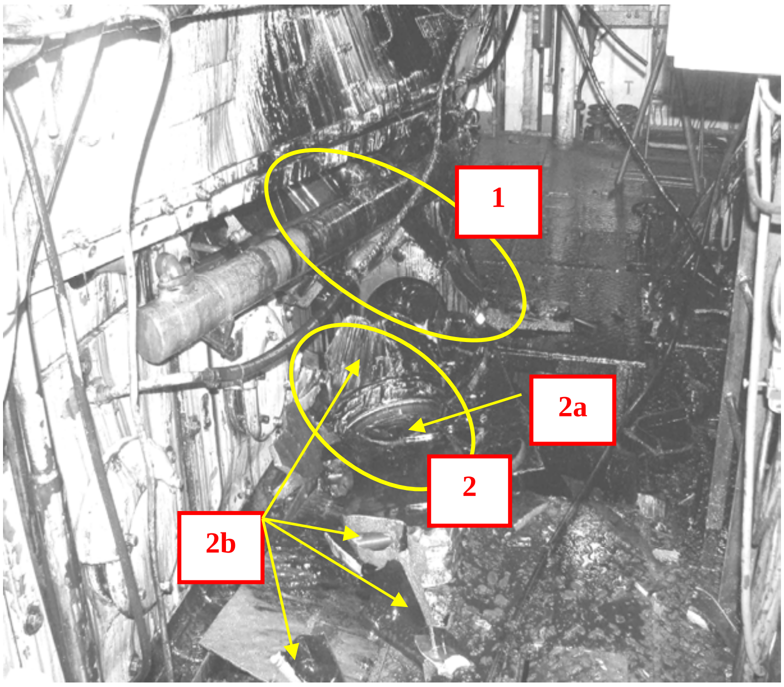

Fig.1 Visible connecting rod – broken and pushed outside the crankcase (1) and broken piston (2): head (2a) and fragments of piston skirt (2b) [1]

Indirect results in form of a cost of spare parts, the costs of withdrawing the ship from operation, indirect costs related to lack of propulsion.

► Applied diagnostic system has not raised a warning about exceeding of the limit values..

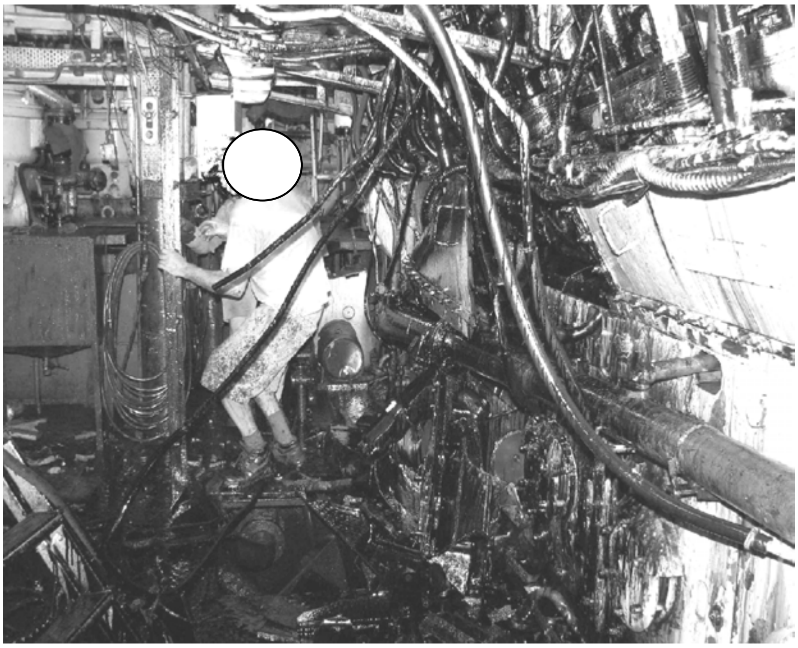

Fig.2 Fuel spilt around the engine causes fire risk; starboard [1]

2nd Example

The fuel piston ring was broken and after two days of voyage piston was seized and the connecting rod was pushed outside of the crankcase.

► Results of the accident examining board inspection.

Breaking up of the fuel piston ring resulted in deterioration of the process of lube oil collection from the cylinder sleeve bearing surface and damaging of the sleeve bearing surface by the damaged ring. Excess of lube oil caused origination of oil carbon deposit on the piston skirt, in the ring grooves in the piston crown and, in consequence, the piston rings were stuck with carbon deposit (Fig.3). Lockup of the broken oil ring caused spring crack, which was pushed into a space between the piston skirt and cylinder sleeve. The spring damaged a hardened sleeve surface layer and was pressed into the sleeve.

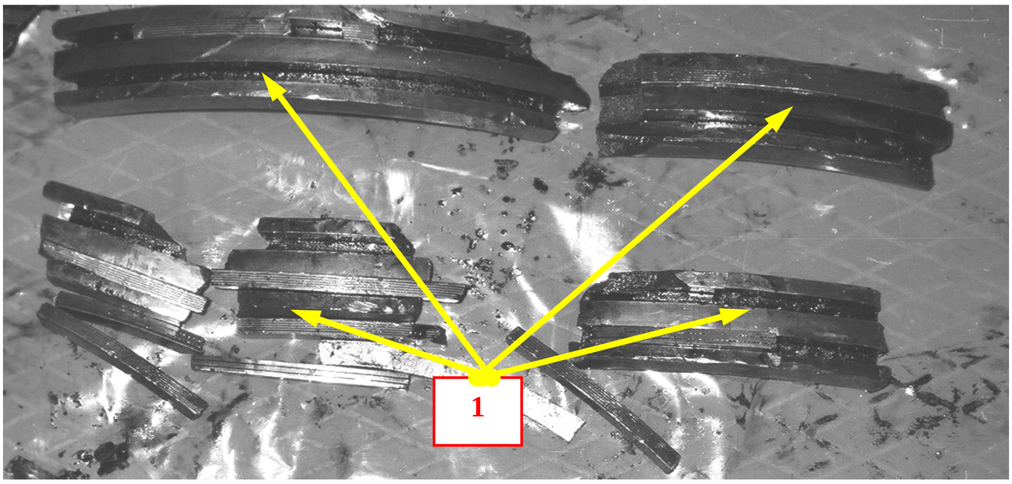

Fig.3 Origination of oil carbon deposit on the piston skirt, in the ring grooves in the piston crown [source: Ch.Eng. Marceli Stelmaszczuk]

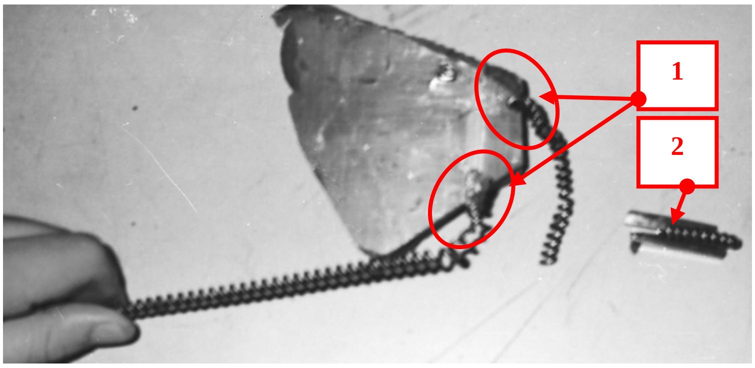

Fig.4. The spring set in the material of cylinder sleeve (1), oil ring spring lock with a fragment of broken spring (2)
[source: Ch.Eng.Marceli Stelmaszczuk]

In effect of friction forces and released heat the spring material was melted into the piston material, what is shown in Fig. 4, 5. Piston seizing caused breaking off the pins fastening a bottom cover of a connecting rod big end with the connecting rod and pushing the connecting-rod outside the casing, causing the effects analogous to those caused by crack of the bottom cover of a connecting rod big end presented in the 1st Example.

In the last phase of failure a noise could be heard when the connecting-rod with a piston were being pushed outside the casing.

Pressure drop of the recycle stock and high temperature of cooling water at the outlet from seized sleeve caused the emergency engine stoppage and 'black-out' (the main engine was driving a shaft generator).

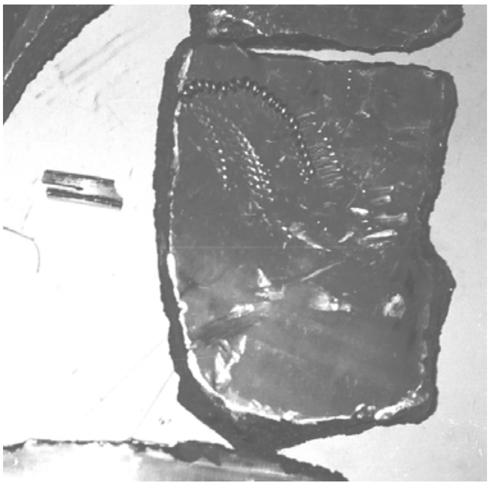

Fig.5. Spring from the piston ring pressed into the cylinder sleeve; visible black carbon deposit originated in result of incomplete combustion of cylinder oil [source:Ch.Eng. Marceli Stelmaszczuk]

► Applied diagnostic system has not raised a warning about exceeding of the limit values.

2. Diagnostic capabilities of the modern SDG

In recent years the possibilities of engine action monitoring by the technologically advanced diagnosing systems have increased.

▸ Electronic analyser of combustion process, which monitors the engine action periodically, allows faster detecting of the changes in combustion process parameters

▸ Temperature sensors detect lower rises of combustion gases temperature at the outlet of the damaged system head,

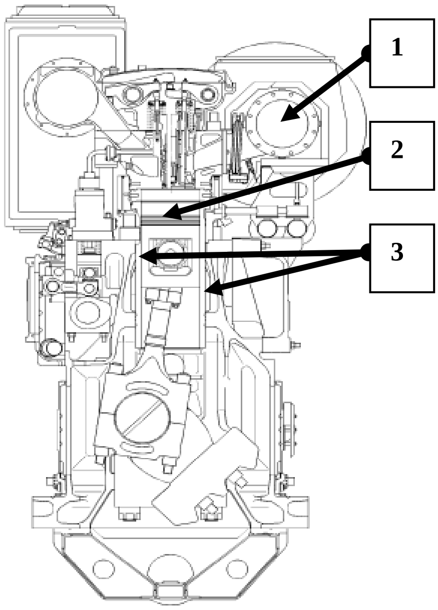

Fig.6 Four-stroke engine section with the places marked, where the sensors are mounted – 1) combustion gases temperature meter, 2) combustion process analyser, 3) detector of piston rings wear, 4) sensor of cylinder sleeve metal temperature [3]

▸ The systems like SIPWA-TP allow fast detection of temperature rise of the cylinder sleeves metal (Fig.7)

▸ Diagnosing systems like MAPEX – PR allow fact detection of piston rings wear (Fig.7)

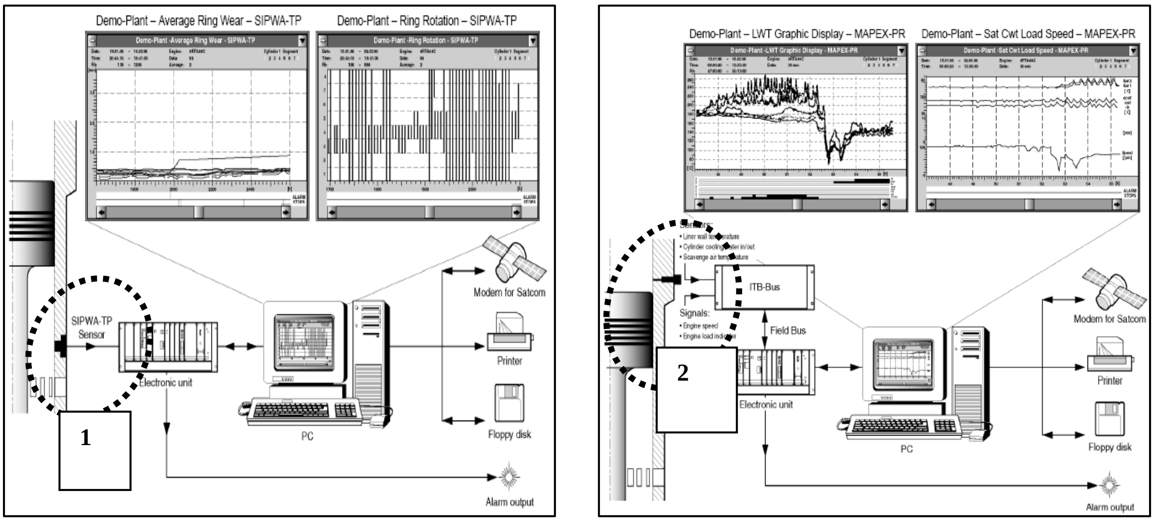

Fig.7 Monitoring of the sleeve metal temperature, a temperature sensor is marked (1), MAPEX – PR system – monitoring of the piston ring wear (2) [2]

▸ Use of advanced electronics to monitoring of engine action. Data are sent to a ship owner and engine manufacturer (Fig 8).

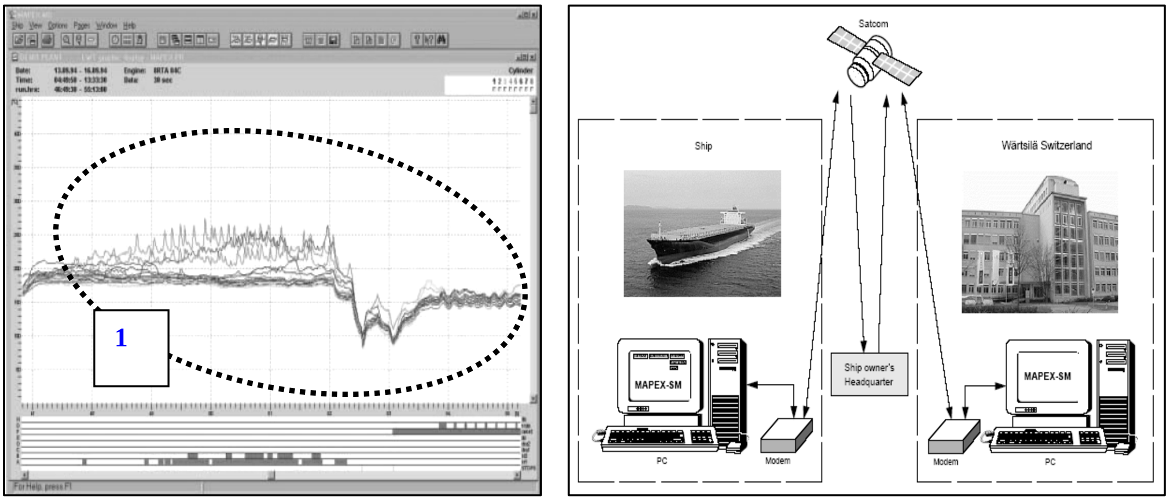

Fig.8. MAPEX – PR programme shows differences between actual measurement and the planned values, e.g. measurement of piston rings wear (1), monitoring of diagnostic parameters by the manufacturer and ship owner office (2) [2]

Increase of a number of the diagnostic data, development of a method of their analysing and processing, are leading to multicriteriality of assessment of the engine technical condition [4,5,6]. In result, probability value of the relation between the diagnostic parameters and engine technical conditions represented by them increases (Fig.9) [7]

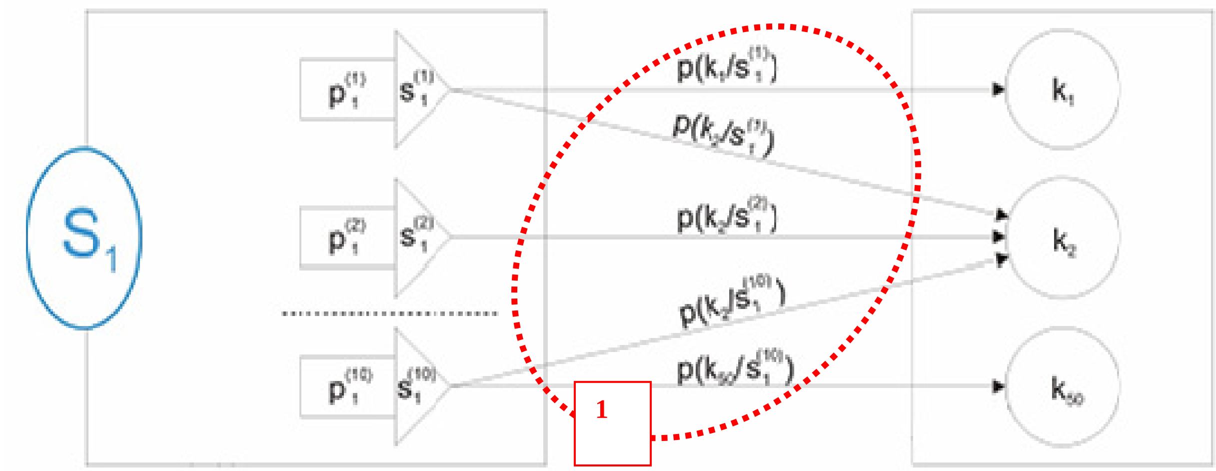

Fig.9 Probabilities of relation occurrence between the diagnostic parameters and engine technical conditions represented by them (1) [7]

Conclusions

1. During engine operation the events occur, which can not be detected in actual time and the consequences of their occurrence can not be limited (E.1)
2. The event described as E.1 should be recognised as a human error, resulting from lack of experience and knowledge, and lack of the basic safety principles.
3. Electronic combustion process analyser allows faster detecting of the change in engine running parameters, forcing a mechanic to analyse the reasons of these changes.
4. Use of sensors of the sleeve metal temperature allows detecting the temperature rise faster than with indirect method through measurement of temperature of the sleeves cooling water

5. Application of a system determining an extent of the piston rings wear would probably allow early detection of the oil ring damage (E.2)
6. On basis of the quoted examples it is obvious how important it is to use safety procedures at every stage of engine manufacturing and operating
7. Despite the development of diagnostic systems (SD), both SDG and SDN, a very important factor in making operating decisions is an accurate and reliable diagnosis worked out by a mechanic on basis of information from SD (as good as knowledge of a design engineer and manufacturer) and resulting from his knowledge and experience
8. Development of both SDN and SDG (including application of the respective mathematical models) increases probability value of relation between the diagnostic parameters and technical engine conditions represented by them

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