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THE EVALUATION OF THE VIBRATION MEASUREMENT USABILITY OF ELECTRONIC INDICATOR LEMAG „PREMET® C"

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Abstract

The measuring possibilities of modern compression and combustion pressure analyzers are extended with additional functions. One of them is parallel to the pressure measurement, the measurement of vibrations in the region of the cylinder head. The paper presents a general assessment of the vibration measurement function of the electronic indicator LEMAG „PREMET® C". This feature is very rarely offered by manufacturers of these devices. Based on experience summarizes the advantages and disadvantages of this method with the use of this device.

Keywords: *vibration, engine timing, diesel engine indicator*

1. Introduction

Since the service life every complex system, which is a piston diesel engine (in particular - the main drive) cannot be a clear measure of the use of its components and the high reliability of this engine ensures eg. the safety of a ship, rational exploitation requires flow of information on the current state of technical and development in this area relevant predictions.

In recent years, in spite of the remaining formal - legal restrictions concluded min. in the classification rules, the concept of exploitation of marine energy systems changes. Due to the increasing running costs of maritime transport trends to implement at least the elements of condition based maintenance strategy are becoming increasingly clear.

This is not possible without existing operating system monitoring tool. Implementation of hardware - software diagnostic system allows you to control the process of ownership by [3]:

- the possibility to change the current power state of the engine according to the current state of technical and external conditions e.g. hydrometeological,
- identification of the servicing needs through understanding the diagnosis and prognosis of engine condition,
- the possibility of quality assessment of the service.

The basic indicators of engine performance on his property, environmental and ergonomic are largely determined by physical and chemical processes that make up the operating circuit. Therefore, in the research on the functioning of marine diesel engines as well as during use, a key role in the evaluation of the implementation of each operation circuit of the piston diesel engine play indicator diagrams and their analysis.

Information pictured in the indicator graph (Fig.1) enable to assess the quality of implementation of the conversion of the chemical energy of fuel into mechanical energy, and apply for the engine condition.

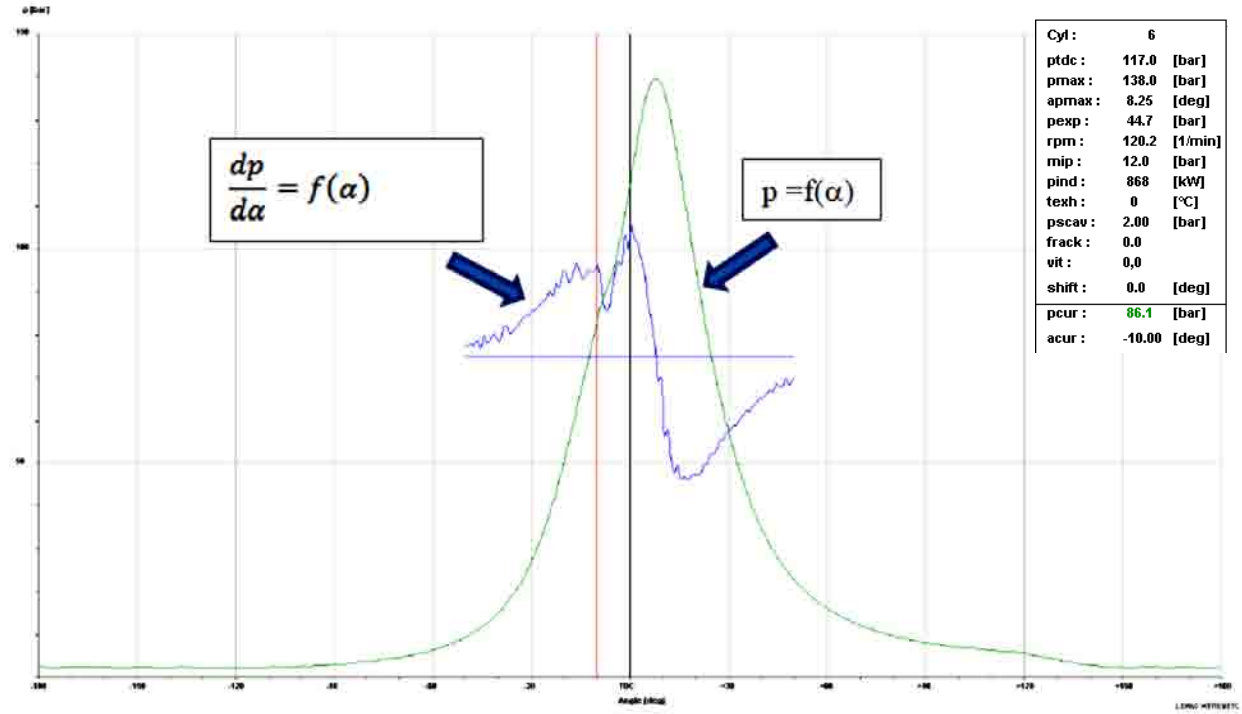

Fig. 1 Sample indicator diagram obtained using LEMAG „PREMET C"

Measurement capabilities of contemporary indicators are complemented by integrated software tools that enable the processing of measurements obtained during the data measurement and derive the basic indicators to assess the implementation of the operating circuit, such as mean indicated pressure - p_i (Fig. 2a), or the deviation from the mean value (Figure . 2b) in a clear and readable form, usually graphically with marked values relating to all of the engine cylinders.

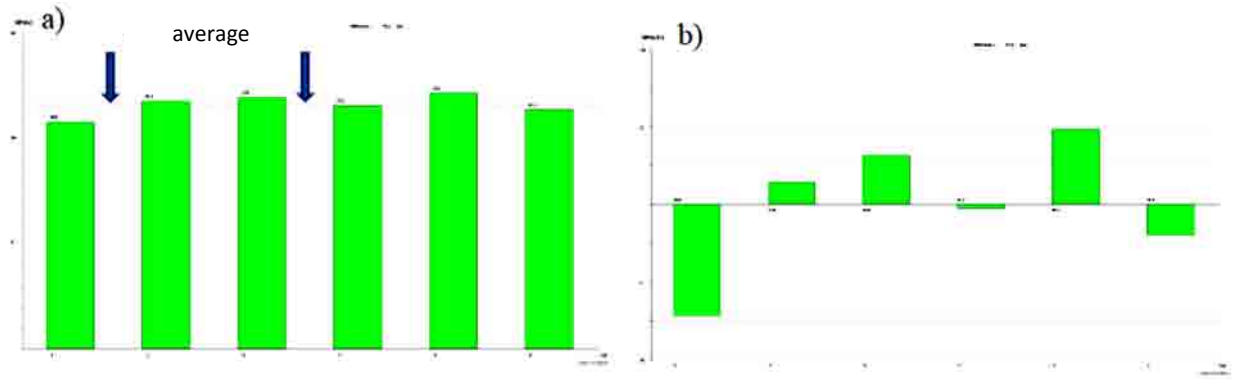

Fig. 2 Mean indicated pressure values (a) and the deviation from the mean (b) for specific cylinder of 6-cylinder engine .

The market offers a lot of this type of pressure analyzer as [7], [8], [9], [10], [11], [12], and all exhibit similar capabilities, which typically include:

- measurement of the pressure in the working space and optional fuel injection pressure,
- measurement of the speed of the crankshaft, pressure sync with TDC,
- similar pressure measurement accuracy,
- option to archive the results of measurement,
- the possibility of manual adjustment of TDC point for each cylinder,

- user-friendly interface
- interface (USB or RS232) to export the data to a computer,
- adapted software
- battery power.

The basic advantage of this kind of solution is it's mobility and wide range of use, non-limited to one type of engine.

The need for a number of additional activities during indication cylinder, above all, pressure sync with the current position of the piston, and the growing requirements for obtaining a variety of information in a single diagnostic test using the mobile system, encourages the manufacturers to equip the additional features. One of them seems to be very useful but rarely offered the ability to measure vibrations in the vicinity of the cylinder head.

2. The use of vibration signals in the evaluation of the technical condition of the timing gear

Vibroacoustic processes are the result of activation of the different types of equilibria disorders in mechanical functioning of the technical system. Disorders may be the result of periodic excitations at the input of the system or part of a utility process [1], [2]. Phenomena characterizing these processes are emitted at the output of the system that represents the device and they are manifested mainly in the form of mechanical vibration and acoustic, as well as a time-varying dynamic loads and deformation of the device.

The reciprocating diesel engine the implementation of operating circuit are accompanied by physical and chemical processes that cause the vibration pulses. From the point of view of operational diagnostics for the most important of these phenomena should be considered [2], [4], [5]:

- movement of the piston rings in the grooves of the ring,
- opening and closing of the injectors,
- impact valves in valve seats
- combustion process.

The nature of these phenomena and engine design make the vibration signal, eg. in the form of vibrations registered includes information about their conduct. From the operational point of view, particularly valuable are diagnostic information about the engine camshaft. It thus seems fairly simple matter, to complete a routine measurement of pressure inside the cylinder by an additional measurement channel, which in turn will significantly increase the utility of these diagnostic tests.

Additional prerequisites pleading for using such a solution should be a number of scientific publications on this topic and a very high demand from users (especially older structurally marine engines) for this type of testing the technical condition of the engine.

Making therefore the analysis of the availability of such analyzers in commercial solutions appears a kind of surprise. Leading manufacturers of marine engines dedicated devices (eg. Leutert, Kongsberg Maritime) generally do not offer anything in this regard. The few exceptions to use in a wider scale, you may encounter (eg. diagnostic system developed at the Naval Academy in Gdynia [6]) do not change the situation fundamentally.

If the criteria of the effectiveness of diagnostic methods are the widespread use of the method, the acceleration measurements in the region of the head during the cylinder indication time prove to be highly ineffective method, limited to individual and experimental applications.

The statement above will, of course, cause the appearance of a natural object, due to the existing state of knowledge about the of the vibroacoustic diagnosis and it's applications. Does not it change the fact that the unit uses these tools in the diagnosis of marine diesel engines operating.

3. Description of measurement abilities of electronic indicator LEMAG PREMET® C XL

Electronic indicator PREMET® C in XL version [8] is a modern, mobile, very solid and reliable pressure analyzer offered with adapter software WPREMET (tab. 1, fig. 3).

Tab. 1 Basic information about PREMET C XL electronic indicator

Ignition pressure range	0 – 25 MPa
Speed range	40 – 1800 rpm
Max. number of cylinders	20
Max. number of measurements/cylinder	30
Manufactured according to ISO 9001	yes
Compensation of temperature	yes
PC connection	USB
Stainless steel housing with isolated thermogrip	yes
High resolution colour display	yes
Accuracy	better than 1,6

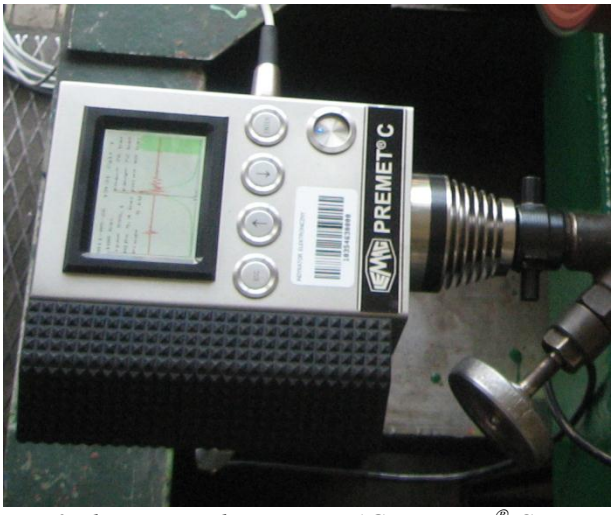

Fig. 3 Electronic indicator LEMAG PREMET® C

In terms of options for measuring and analyzing the pressure inside the cylinder the device allows standard features that determine the value of common indicators to assess the course of operating in the cylinder e.g. the average indicated pressure. The distinguishing feature of the analyzer is described equipment manufacturer offer it in accelerometer (typically mounted on the engine with a magnet – fig. 4), which allows parallel, synchronized with the position of the piston, the measurement of vibrations.

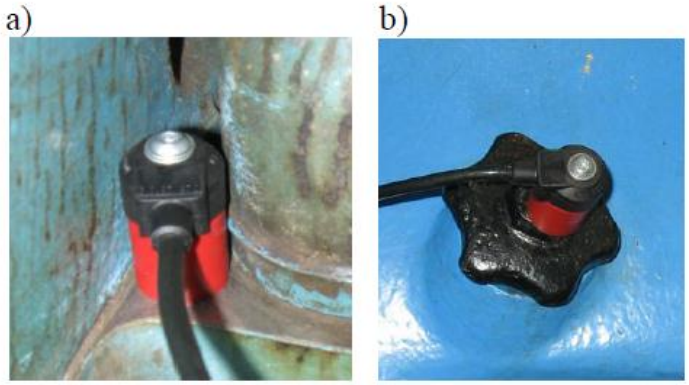

Fig. 3 Magnetic mounting of sensor: a) cylinder head mounting, b) valves cover mounting

Tab. 2 Basic information about Bosch 0261231118 accelerometer

Frequency range	0 – 20 kHz
Measuring range	0 – 400 g
Sensitivity at 5 kHz	26 ±8 mV/g
Dominant resonant frequency	> 25 kHz
Self - impedance	> 1 MΩ
Operating temperature range	-40 – 150 °C

In view of the statements of the previous chapter it is so important difference compared with other commercial devices of this type that should decide a kind of monopoly in the market of universal analyzers.

As can be seen from the experience of the author, indeed indicators of this type are quite commonly used by engineering crew on board, (not without influence in this case, so-called. the certificate of approval of the indicator, the leading classification societies such as Germanischer Lloyd), whereas the use of the monitoring function vibration is minimal.

The question therefore arises - why so useful additional feature that allows for more complete information in a standard cylinder indication is so reluctant to use by users.

4. The evaluation of the results of the research

As the featured in the previous section of the article indicator PREMET® C in XL version, is since 2009, the scientific equipment - Research and Teaching Department of Ship and Land Power Department of Ocean Engineering and Ship Technology Gdansk University of Technology, it was complemented by the possibility of measuring the vibration acceleration measurement function.

Diagnostic tests of engines already in service and laboratory tests on experimental engine made it possible to collect the expertise, which to some extent are the answer to the question asked in the previous chapter.

The first thing that appears before you use the analyzer is the lack of any guidance on the use of this function in the technical unit. In fact, there is only mention of such a possibility. This probably indicates a slight experience of the manufacturer in this field and makes the average user does not realize how big the potential opportunities may involve the use of additional measurement channel.

Another essential problem is a way of displaying the results. Figure 5 shows a sample screenshot of the recorded data.

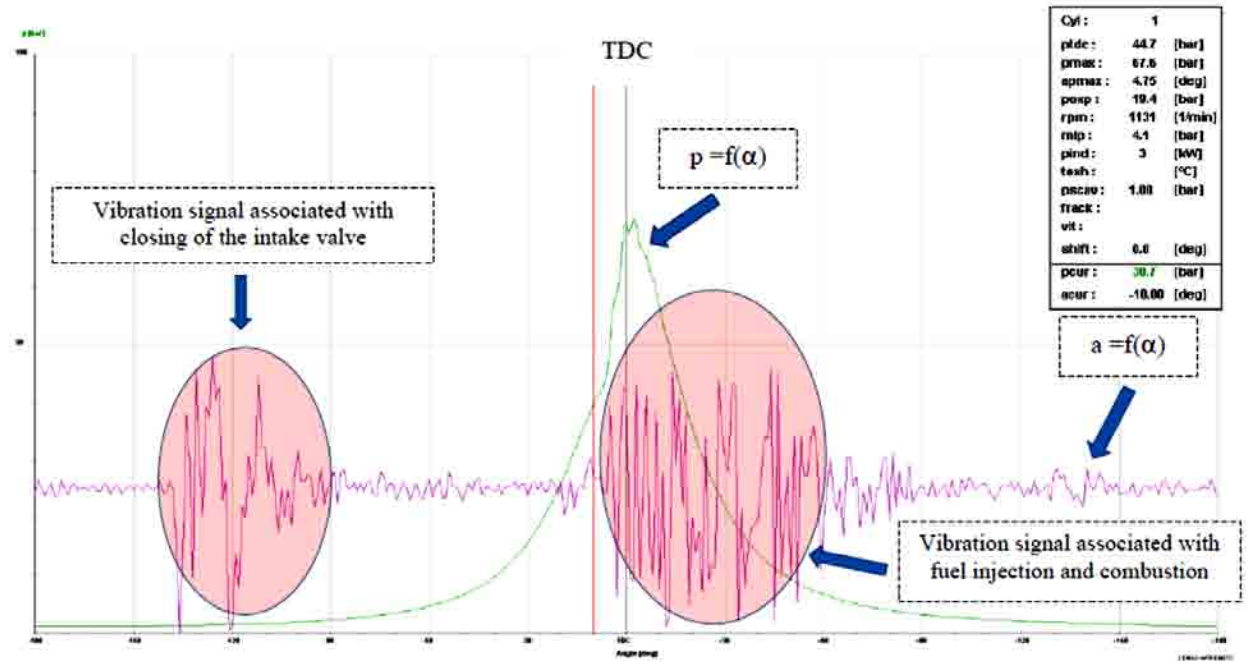

Fig. 5 WPREMET screenshot of the results of the recorded pressure p = f(α) and the vibration acceleration in the region of the head a = f(α) for diesel engine Farymann laboratory type D as a function of the angle of rotation of the crankshaft - α during compression and expansion strokes , TDC - top piston position feedback, an accelerometer installed magnetically on the screw fixing the head, from the side of the intake valve

Because as you can see in fig. 5 the results are presented in the form of "raw", very noisy, probably without any processing, their usefulness in diagnostic reasoning basically comes down to statements such as: injection took (or was not) place, the inlet valve closed at the beginning of the compression stroke, etc.

Another issue related to the use of the accelerometer is the way and the place of installation. Manufacturer standard equipped accelerometer with a magnetic holder (fig. 4), which is of course very practical and convenient way. At the indicated time, the realities of engine room, however, often turns out to be the most unreliable way, introducing significant signal attenuation or more of its components under certain conditions.

Figure 6 shows an example of extreme situation, where initially it can be concluded that neither closing the intake valve or injection and combustion in the cylinder does not happen.

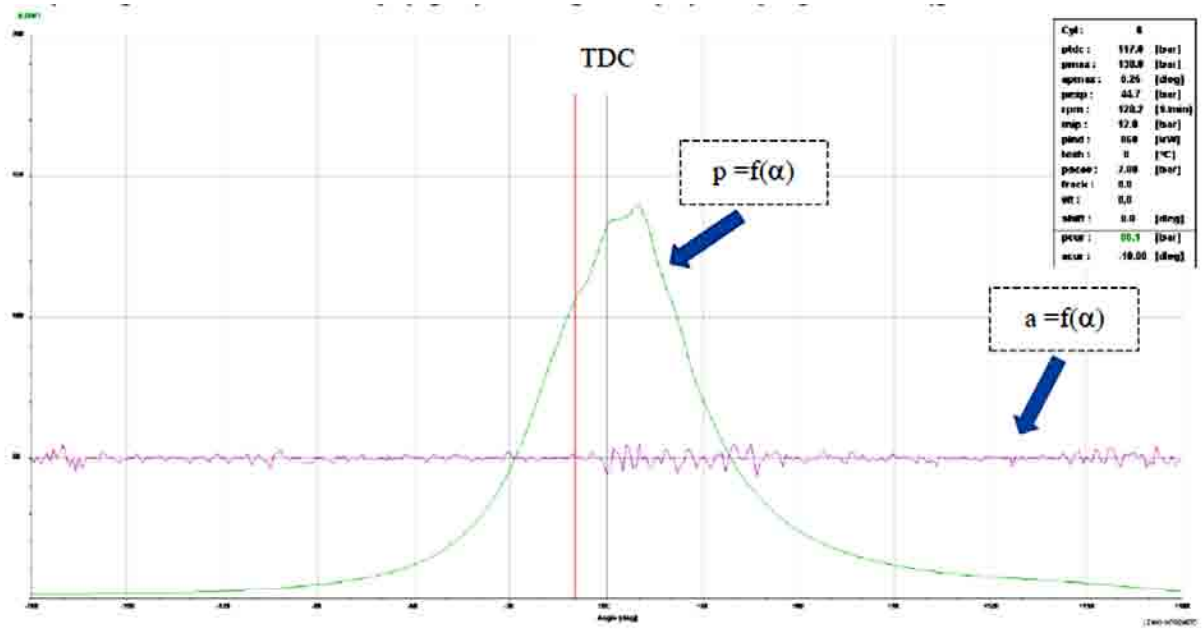

Fig. 6 WPREMET screenshot of the results of the recorded pressure p = f(α) and the vibration acceleration in the region of the head a = f(α) on the engine type SULZER 12ZAV40 S as a function of the angle of rotation of the crankshaft - α during compression and expansion strokes; TDC - top piston position feedback, an accelerometer installed magnetically on the screw fixing the valve cover from the intake valves

To avoid such cases it is advisable to modify method of installation the accelerometer. The most preferred method, which does not lose its practicality in relation to the magnetic clamping while devoid of its drawbacks, it seems as proposed in elaboration (for example, [4]) with a suitable mounting bracket. An example of such solution is shown in fig. 7.

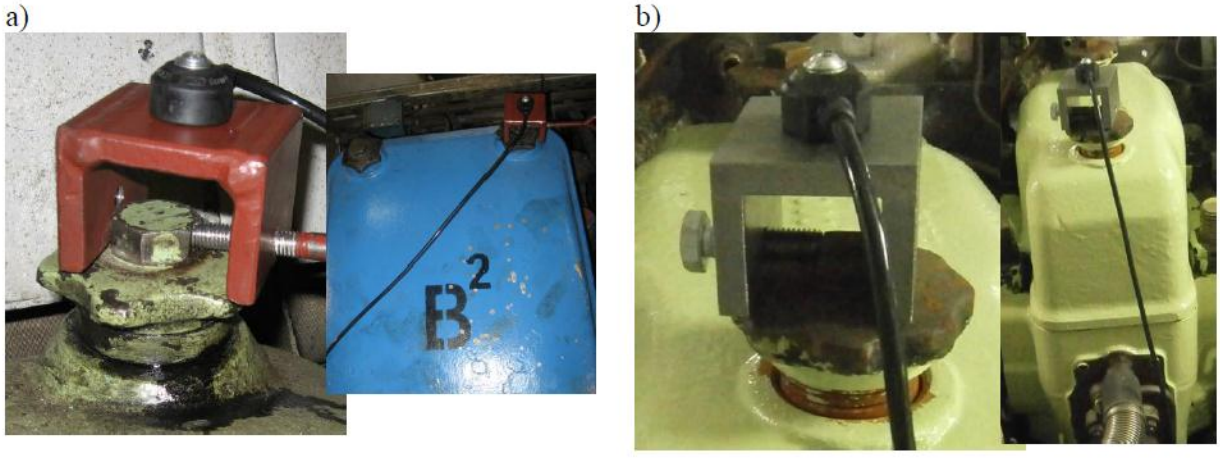

Fig. 7 Installing accelerometer of an indicator PREMET® C with mounting brackets on the covers of engine valves: a) a 12ZAV40 SULZER S, b) type 8ATL SULZER 25/30

5. Summary

In view of the results, it appears that the potential for simultaneous measurement of vibration and a cylinder indication were not used by the manufacturer of the indicator, which is recognized in the market shipping company LEHMANN & MICHELS GmbH. It can be assumed that the way to present the results

of measurements and the lack of information in the technical documentation simply discourages potential user to practical application.

On the other hand, because the measurement results are stored in plain text it is always possible to process and analyze them using digital signal processing methods (eg [1]). Data obtained in this way is much more meaningful and allow for diagnostic reasoning by a user of an average knowledge in this area.

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