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NEW METHODS OF MARINE POWER PLANT DIAGNOSTICS

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Abstract

Up-to-date, of high-tech design techniques of machine operation require constant monitoring on some levels. Generally, the monitoring today is limited to failure detection and machinery components check.

The Marine Engineering Faculty of Gdynia Maritime University designed the System for Marine Engine Operation Assistance on the basis of Sulzer Diesel AL 25/30 testing station.

The engine modernization and wider research and survey capabilities resulted in engine operation quality improvement, marine power plant research enhancement. The project broadens the research range and engine failure expertise as well as takes into consideration innovative marine fuel emissions. The goal has been achieved in the way of the test equipment modernization including: effective pressure sensors, high pressure fuel sensors, monitoring and visualization of the engine systems' parameters, electronic indictors adopted to continuous operation at all cylinders in the same time, and high class decision aid computer equipment. Engine modernization and data base extension allow for carrying out a wide scope of research.

Additionally, the article presents innovative diagnostic solutions together with their applications.

Keywords: *diesel engine, diagnostics, roughness, surface*

1. Marine Diesel Engine Sulzer AL 25/30 test bed

The diagnostic system for marine diesel operation includes the diesel engine, which drives the generator and the EMOS working station of the highest grade. The EMOS enables the monitoring and registration of the working parameters.

The diagnostic system consists of the following elements:

– AL 25/30 Cegielski Sulzer four-stroke, 3-cylinder, 396 kW diesel engine coupled with VTR 160 Brown Boveri turbocharger,
– GD8-500-50 synchronous electricity generator of 500 kVA,
– EMOS service station,
– Electrical distribution board,
– Electronic indicator with Kirsler combustion sensors,
– Cooler fan,
– Fuel distribution system,
– Purifier.

1.1. Diesel engine

The 3 AL 25/30 marine diesel is a four stroke, non-reversible, self-ignition, turbocharged engine, manufactured by HCP Cegielski in Poznan, under licence of Sulzer (Fig. 1).

Main engine parameters:

– type – 3AL 25/30,
– no. of cylinders – 3,
– bore [mm] – 250,
– stroke [mm] – 300,
– swept capacity [cm^3] – 14726,

– power rate [kW] – 408,
– rotational speed [rpm] – 750,
– compression ratio – 1:13.

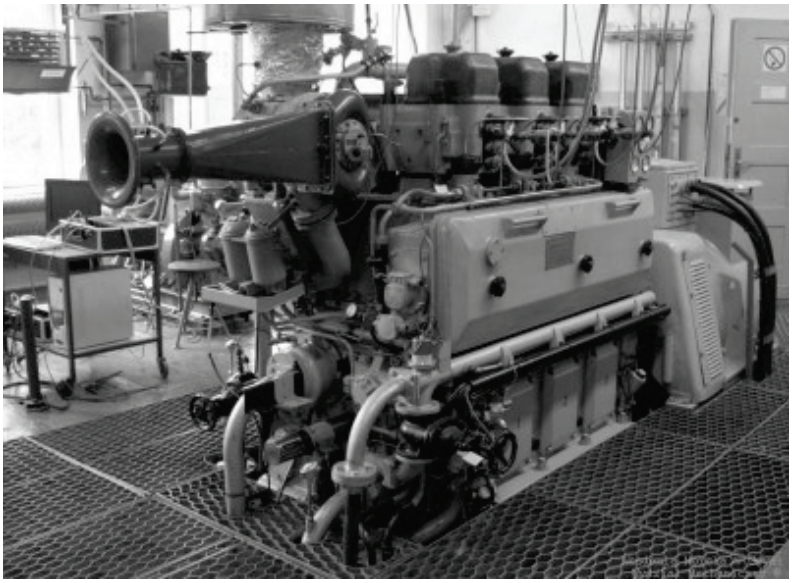

Fig. 1. Marine diesel type 3AL 25/30

1.2. EMOS operating station

The EMOS station (Fig. 2) is designed not only for the current engine control but also for the visualization and archiving of the engine working parameters.

The station is equipped with a computer and a control panel with a set of control lamps and other engine control units.

Fig. 2. EMOS working station

The station is to perform the following functions:
– operator access to all controlled working parameters,
– possibility of setting four alarm threshold levels for analogue signals,
– possibility of setting time delays of alarm signals,
– acknowledgement of appearing alarms using the keyboard or the mouse,

– data export to outer receivers for subsequent analysis and processing,
– configuration change of measurement channels, selection of measurement ranges,
– constant data archiving and simple mode of files outlook,
– analogue data trends and changes recording,
– independent work of two monitors enabling the display of two pictures at the same time.

The lab enables the implementation of technologically advanced research projects within the scope of technical engineering diagnostics, safety engineering, machine reliability analysis, surface engineering and tribology.

2. The Technical Diagnostic Laboratory

The following devices can be classified for application in up-to-date marine power plant technical diagnostics:
– FLIR E95 thermo-visual camera,
– PAC unit for acoustic emission measurement method,
– Hommel profilometer – Etamic W20,
– Smartzoom 5 digital microscope,
– LEXT OLS 4100 confocal laser microscope.

2.1. Thermo-visual camera

Thermo-visual systems are widely used in industry diagnostics for wall thermal insulation identification, for electric wire examination, crack detection in machine heating or cooling components and for heat distribution determination in electronic instruments.
Thermo-visual camera application makes the control process easier, faster, more precise and not dependent on the distance and access.

The FLIR E95 portable thermo-visual camera is equipped with 464x348 element detector. It has 0.03°C lens-dependent, thermal sensitivity. It is able to register 3 temperature ranges: -20°C to 120°C, 0°C to 650°C and 300°C up to 1950°C. As the device has an embedded 5 000 000 resolution photo camera, it can videotape images.

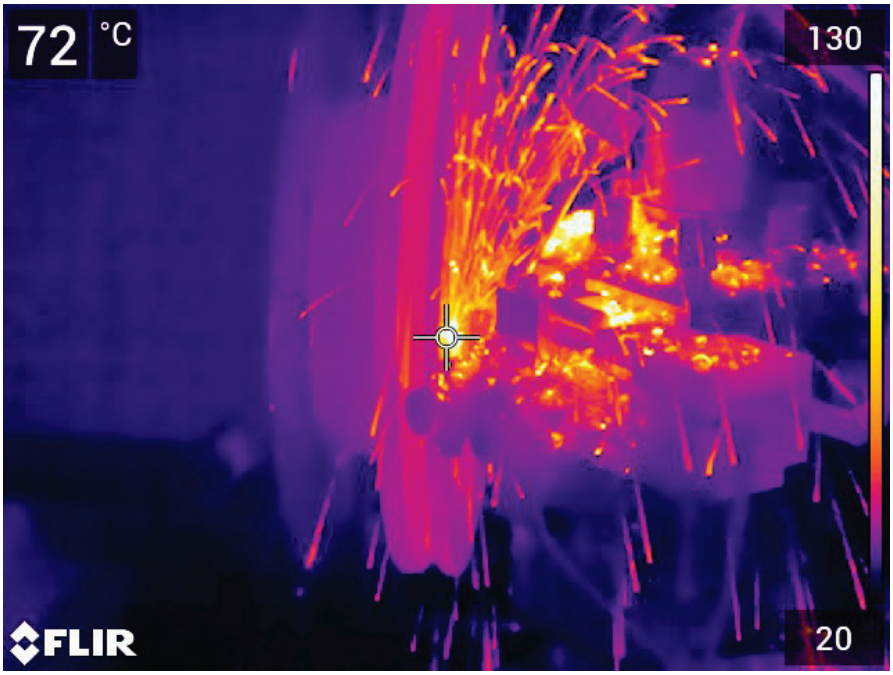

Fig. 3. Temperature measurement during machining

2.2. PAC acoustic emission measurement method unit

This method detects and studies an acoustic signal sent from any material under mechanical load. The emission is created by physical processes taking place in materials and on their surfaces.

Acoustic emission happens in plasticity deformation, cracking, phase and structural changes, corrosion, leakages and in composite material fibre cracking.

The acoustic emission method set consists of 1283USB AE Node signal recorder, 75 kHz - 1.1 MHz, 26 dB pre-amplifier and acoustic emission measurement sensor of 100-450 kHz (Fig. 4). The unit is connected to the PC by means of USB and does not require any extra power supply, which is vital while operating outside. The set is provided with dedicated software for data recording and analysis.

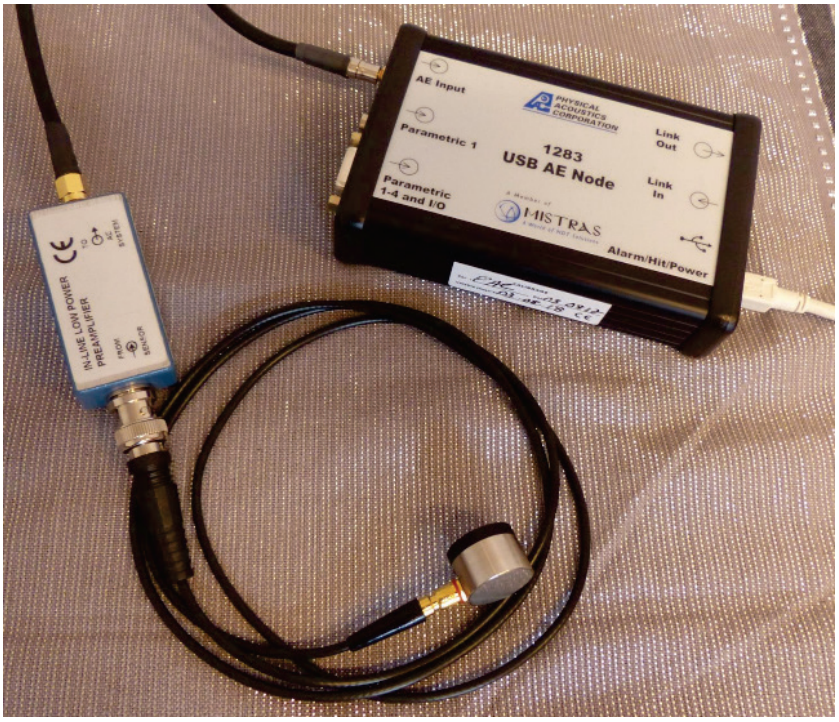

Fig. 4. Set of acoustic emission PAC

The set allows for destruction and disassembly-free measurements of machine components wear; the components like fuel injectors, water hydraulic pumps, hull plating and piping, which are exposed to strains, deformations and loads.

2.3. Hommel Profilometer – Etamic W20

This is a portable device designed for roughness, corrugation and profile parameter measurements. Its technical data are as follows:

– measurement range ±300 μm,
– maximum measurement sensor shift 20 mm,
– the shift length of the sensor according to ISO/JIS: 1.5; 4.8; 15 mm; to MOTIF: 0.64; 3.2; 16 mm,
– the instrument allows for the choice of four elementary sections: 0.08 mm; 0.25 mm; 0.8 mm; 2.5 mm,
– roughness, corrugation and profile measurements.

The W20 instrument is fitted with a sensitive touch screen. Seven measuring programmes plus one for verification purposes is built-in together with 4 basic functional keyboard.

Fig. 5. Roughness measurement by W20 profilometer

The W20 profilometer roughness tests of marine engine inlet valve seats allow for the preliminary choice of the proper method, determination of the materials and valve regeneration technology Conditions (Fig. 5 and 6).

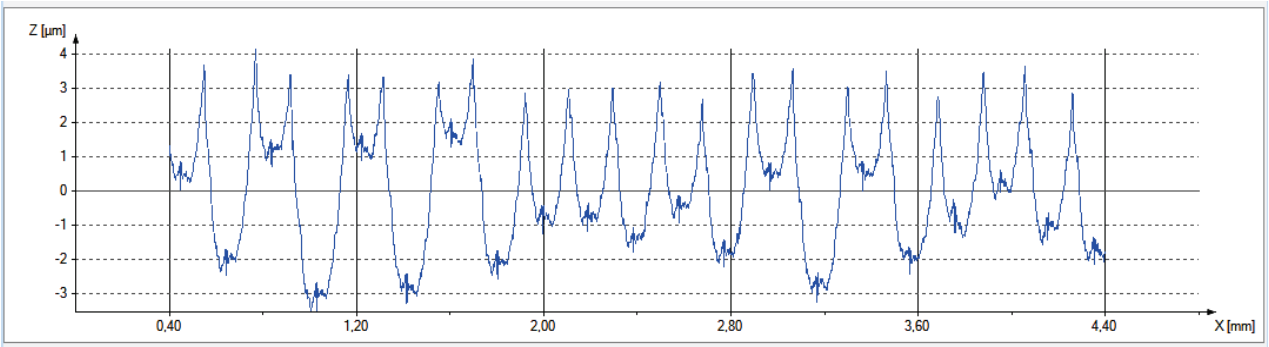

Fig. 6. Profile of the roughness parameter

The unique instrument features include:
– waveline 20 measuring unit with a head,
– capability of upside-down measuring position,
– the head 90° rotation,
– a groove for round object measurement in the device casing,
– colour touch screen displaying parameters, profiles and statistics,
– fast and easy extra data rekeying,
– embedded printer.

2.4. Smartzoom 5 digital microscope

It is a precise industry microscope for 1 x 10^{-3} mm measurements. It is fitted with an optical system with 1000 times zoom. The automated table features direction movement range of 130 mm for x-axis and 100 mm for y-axis.

While taking measurements, the following methods of the object illumination can be used:
– LED ring illuminator embedded into the lens; segments can be illuminated,
– LED co-axial illuminator,

– Mixed illumination (co-axial and ring illumination used simultaneously) with the independent intensity regulation of each type,
– Diode illuminator for the working area.

The microscope enables to take both 2D and 3D by means of optical trimmings. A broad measuring area can be acquired as the result of 2D image merging in the xy plane (Fig. 7).

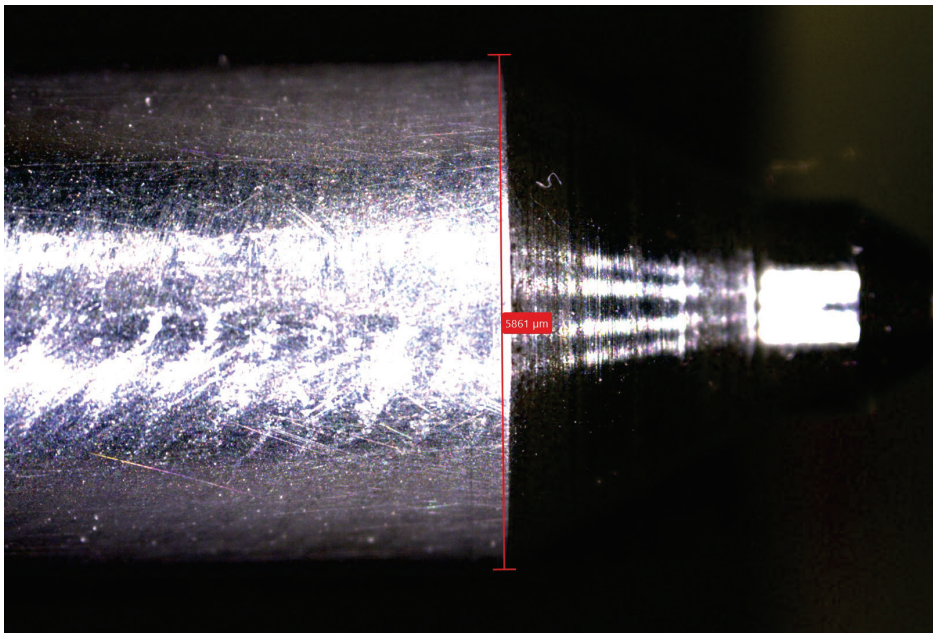

Fig. 7. Injection nozzle diameter measurement

2.5. LEXT OLS 4100 laser confocal microscope

The microscope allows for taking photos of sample optical cross-section. It analyses the light coming from one of the planes, eliminating the light from upper or lower layers. The results in the image of higher resolution and increased contrast.

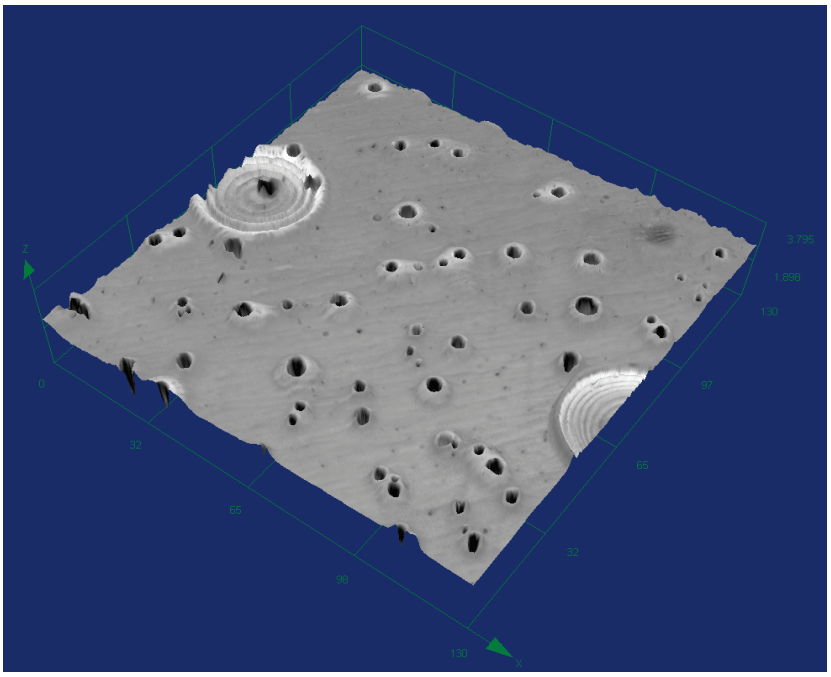

Fig. 8. 3D topography view

This method permits for continuous optical analysis of cross-sections either on the sample surface or in its depth. Thanks to this, 3D image constructions are possible.

Due to 405 nm wavelength UV laser light application together with the confocal scanner, the optical capability limit was crossed. The sample surface is scanned pixel by pixel. A photocopier is used for the signal detection. The confocal shutter placed in front of it cuts off the light reflected off the surface and originating from the outside of the focus surface. The photocopier measures the light intensity in every point. The 3D feedback information about further surfaces gets from lens movement along z-axis. Z-axis movement control is extremely precise because of linear system with 1 nm growth. The intensity map created in this way is used to translate the sample surface into the 3D image.

3. Conclusion

Engine modernization and data base extension allow for carrying out a wide scope of research, for example:

- diagnostic research of operational engine systems, in particular, of turbocharging and fuel injection systems,
- measurements employing combustion pressure curve diagrams, acoustic emission analysis designed for marine engine diagnosis,
- the operational engine mode influence on the engine component conditions,
- the research of possibility to apply data base information for automatic knowledge collection,
- engine operational component wear and roughness measurements,
- surface condition tests, particularly of precision pairs with measuring microscopes.

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