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CONCEPTION OF THE DEVICE FOR MONITORING THE FUELS DOSES EVENNESS OF THE MARINE DIESELS ENGINES

ABSTRACT

In the paper a proposal to use the method of the spectral analysis of vibration of torsion lines of embankments for signaling was described qualities of work of the arrangement of feeding with the fuel oil of the marine diesel engine. Loss of the evenness of the dose of fuel was treated as the first signal of arising damage. In the presented conception devices were applied previously diagnostic measure drawn up (*SWH* — rate of harmonic contents). The paper is finishing the description of the action of discussed device.

Keywords:
marine diesel engine, torsional vibrations, shafting, fuel oil feeding system

INTRODUCTION

The main purpose of researches which are actually picked up in Faculty of Mechanical and Electrical Engineering of Naval University in Gdynia is modernization and further extending operating and already tested diagnostic system. That system is being amplified of basic control elements of piston engines structure, especially for piston-cylinder liner group [5].

The essence of the research is setting dependence between changes of diagnostic parameters of fuel oil supplying system. In peculiarity it was pointed out on injection system, quality of fuel's dosing and changeability progress of torque of shaftings.

On the most of Polish Navy warships there are medium- or high-speed, four-stroke, marine engines which are used as main engines or generator engines.

Various tasks executed through ships, often in extremely adverse conditions cause the different course of the degradation process of the technical condition of the installation of feeding of engines with fuel oil with the passage of time. The fuel oil installation is the most neuralgic functional module of the engine (about 46% of total of damage). About the half of cases of damage concerns injectors. The high accuracy of making fittings and the complexity of her structure at the great sensitivity of elements to any interferences cause, that damage to her elements more often appears than of other functional modules of the engine. It is possible to prevent many damage having at its disposal the knowledge about the deteriorating technical condition of elements of the system of fuel oil feeding. An uneven dose of fuel powering cylinders of the engine is most often a met dysfunction of the arrangement of fuel oil system. In the end thermal straining cylinders of the engine is changing, and consequently, a course of the value of the torque of a propeller shaft is undergoing the distortion. Using information included in torsion vibration of a propeller shaft is one of possibilities of acquiring this knowledge.

SPECTRAL ANALYSIS OF SHAFTINGS TORSIONAL TORQUE

Processes of changes of shafting's torsional torque were brought under spectral analysis. Since values of the torque are left collected in the field of the time with the constant sampling rate in appropriately long time of the measurement, there is possible to make a spectral analysis (FFT) [3, 4]. The method of achieving of selective harmonic rate (SW_H) was described in [1, 2].

In the figures 1 and 2 there were shown the courses of SW_H rate for analyzed fuel supplying system technical conditions (status 1 — efficient; status 2 — out of order; status 3 — major dysfunction; status 4 — minor dysfunction).

From numeral data we can see that the malfunction of engine which consists on outing of order the evenness of fuel's doses is causing vital change of SW_H rate.

That change is independent of value of crankshaft rotation and engine's load. It is said that the changes of values of selective harmonic rate SW_H in spectrum of shafting's rotational torque may be adequate diagnostic parameter in estimation of technical condition of engine's fuel oil supplying system.

Observation the trends of changes of SW_H values make possible to estimate technical condition of structure of engine's fuel oil supplying system. It is particular advantage in diagnostic of engines (not only warships) which are not equipped in indicator valves.

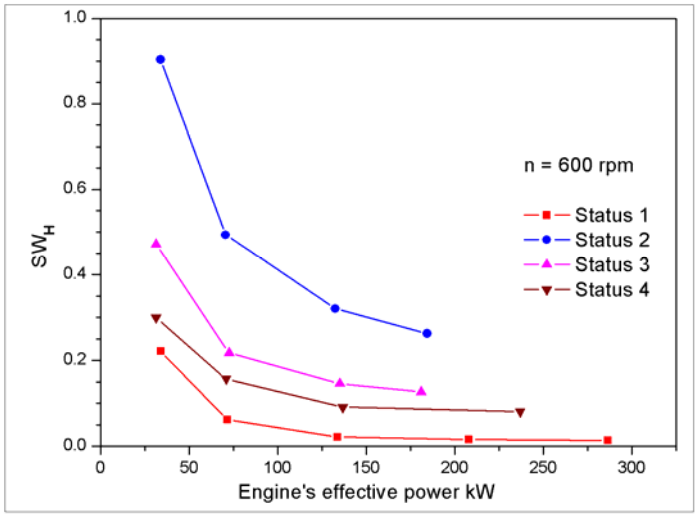

Fig. 1. SW_H rate versus engine's effective power function for 600 rpm

Source: own study.

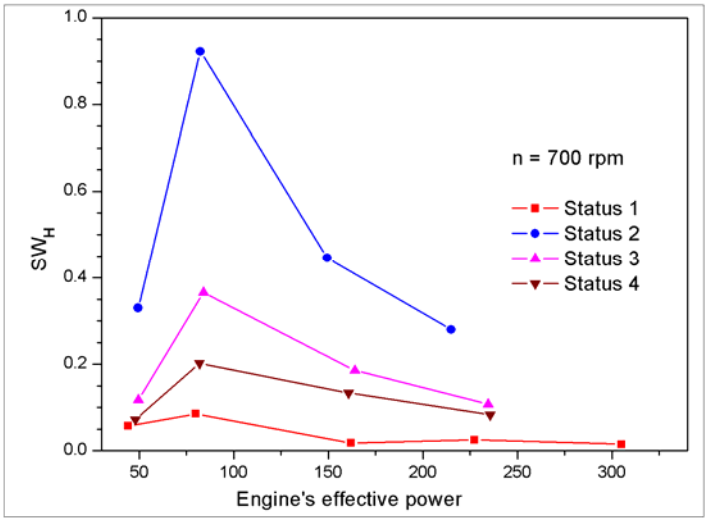

Fig. 2. SW_H rate versus engine's effective power function for 700 rpm

Source: own study.

Performing measurements of the SW_H value for exploitation states of the ship (values of the torque and the rotation speed of a propeller shaft) lets for determining tolerance limits exploitation (Fig. 3).

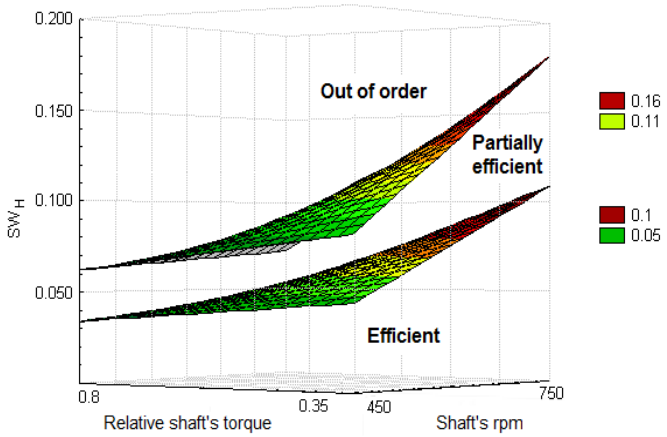

Fig. 3. Tolerance limits exploitation of technical conditions of the supplying fuel system as the function of the rotation speed and the relative torque of a propeller shaft

Source: own study.

Explicitly it results from long-term examinations that two identical driving arrangements aren't being come across, even amongst serial individuals. And so borders described on the Fig. 3 of exploitation states are individual and building them requires measurements of the SW_H rate for all exploitation states of the ship.

THE STRUCTURE AND THE ACTION

In the project to organize applications and experience acquired under construction were exploited of diagnostic former systems of ship's piston internal-combustion engines used so far in diagnostics exploited on Polish Navy ships. The rule of operation was presented on Fig. 4. A measuring device making up is on a propeller shaft around of:

— strain gauge bridge;
— strain gauge amplifier;
— processor with ADC;
— arrangement of the UHF transceiver with the aerial.

An UHF radio signal containing measuring data is finding its way to the receiving part, for which they are components:

— UHF transceiver;
— controlling processor;
— Ethernet module.

For the synchronization serves the work signal taken from the flywheel by the induction sensor. Above mentioned signals are being passed to the central processing unit (CPU) consisting of the following modules:

— of microcontroller equipped among others in:
  - 32-bit core,
  - MMU (allow to run systems like Linux),
  - External Bus Interface (EBI) supports SDRAM, Static Memory, ECC-enabled NAND Flash and Compact Flash,
  - DMA controller,
  - USB 2.0 Port,
  - Ethernet of MAC 10/100 Base T;
— of arrangement of the phase loop (PLL) with divisors;
— of output stage.

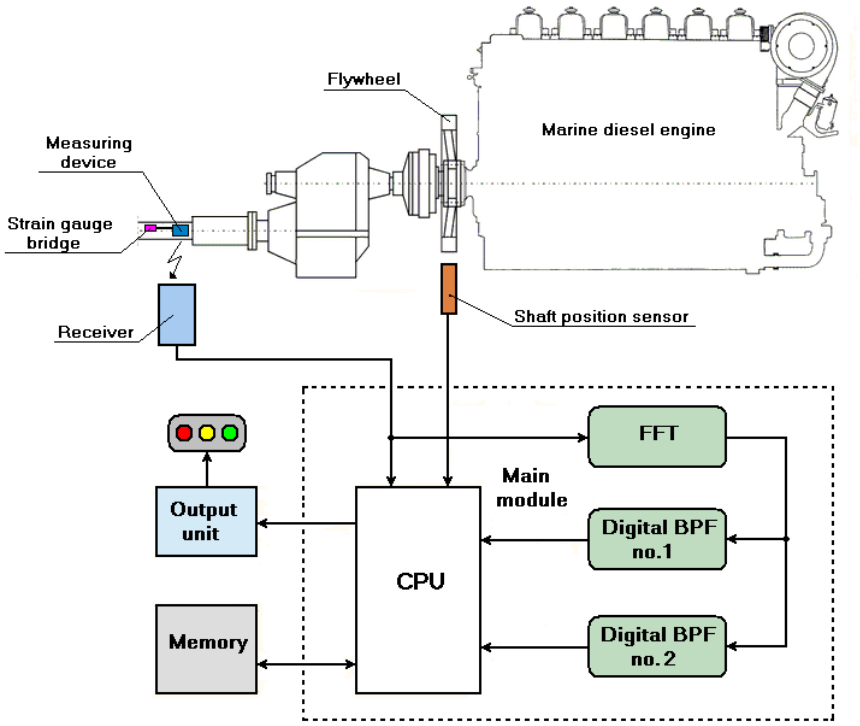

Fig. 4. Flow diagram of the device for monitoring the evenness of doses of fuel oil

Source: own study.

Changes of the value of the resistance of the strain gauge bridge (proportional to changes of the angle of screwing the shaft) there are voltage transformed in the amplifier into changes and they are going to ADC port of the processor. The processor is preparing data for the send over radio unit, is leading the information exchange and is carrying received orders out. The model course of the value of the torque of the propeller shaft showing Fig. 5. The receiving part is providing received data from the measuring part and he is directing them at CPU. Is also communicating the information in opposite direction. He will supervise work processor.

Next data is left measuring subjected to make spectral analysis with the help of the Fast Fourier Transformation (FFT) (Fig. 6). During the work of the engine a rectangular signal is generating and synchronized with teeth of the flywheel. The spectral analysis results are being passed to software digital band pass filters (BPF).

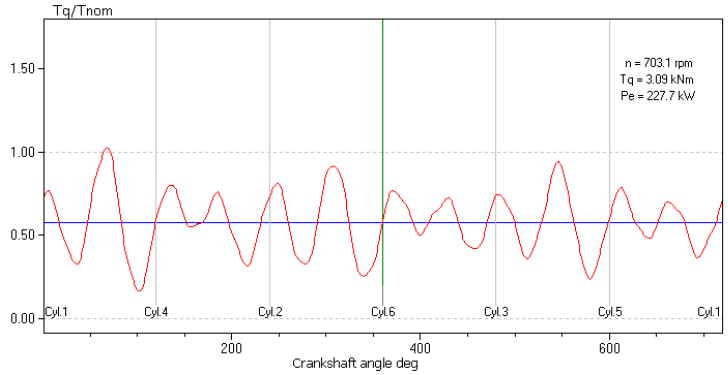

Fig. 5. Torque of the propeller shaft versus time

Source: own study.

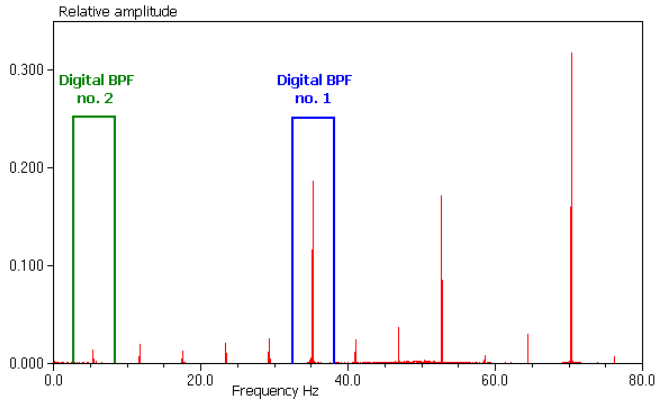

Fig. 6. Spectrum of torsion vibration of a propeller shaft (6-cyl. 4-stroke engine, abt. 720 rpm)

Source: own study.

Filters are characterized by a permanent width of band in and a changeable centre frequency, what lets distinguish from the spectrum of the signal of torsion vibration of the appropriate stripe in spite of changes of the rotation speed of the engine. Signals from Band Pass Filters, receiver and first divider are being sent to Main Module, which:

— is calculating the SW_H value according to the pattern:

$$SW_H = \frac{H_0}{H_i},$$

where:

SW_H — selective harmonic rate;
H_0 — value of the amplitude of the basic frequency in the spectrum of the signal;
H_i — value of amplitude, where i is harmonic about the number equal of the quantity of engine cylinders;

— using borders stored up in the memory of the value of technical conditions, determines a current technical condition of the fuel oil supplying system;
— is informing the exploiter of the engine through the output device of the result of calculations (for example a visual signaling);
— is accepting outside orders and carrying them out.

SOFTWARE

Applying the module with the processor of the ARM 9 type using clock 400 MHz is necessary for the accomplishment of described previously tasks with appropriate peripheral devices. Such a solution allows for Linux starting the operating system and enables:

— compilation of the program directly in the module;
— using executive programs;
— remote exchange of the executive programs;
— remote exchange of model data included in the memory;
— remote inspection of action of the system and remote reading of current results.

The opened architecture of providing peripheral devices software allows for the cooperation around practically with any system of the monitoring of the ship's engine room. The described device can communicate with the neighborhoods using the TCPiP protocol or MODBUS.

CONCLUSIONS

In the article there is proposal of using selective harmonic factor SW_H to estimate fuel oil supplying system technical condition. Getting the larger diagnostic quantity

of the information is possible particularly when there is no alternative option of intra-cylinder pressure measurement (engine are not equipped in indicators valves).

With next problem which one should untie it is a problem of the synchronization, for which determining which cylinder receives the wrong dose of fuel is a purpose.

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KONCEPCJA URZĄDZENIA DO MONITOROWANIA RÓWNOMIERNOŚCI DAWEK PALIWA OTSS

STRESZCZENIE

W artykule przedstawiono propozycję wykorzystania metody analizy widmowej drgań skrętnych linii wałów do sygnalizowania jakości pracy układu zasilania paliwem okrętowego tłokowego silnika spalinowego. Utratę równomierności dawki paliwa potraktowano jako pierwszy sygnał powstającego uszkodzenia. W przedstawionej koncepcji zastosowano uprzednio opracowaną miarę diagnostyczną (SW_H — współczynnik zawartości harmonicznych). Artykuł kończy opis działania omawianego urządzenia.

Słowa kluczowe:

okrętowy tłokowy silnik spalinowy, drgania skrętne, linia wałów, system zasilania paliwem.