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The implementation predictive maintenance method applied to operational maritime ships. Case study: training ship”Mircea”

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Abstract. IT technology development has allowed the progress of numerous computer-aided applications in the maritime industry. Thus, a new maintenance concept has emerged, namely, predictive maintenance which, with the help of IT technologies, automatically monitors and evaluates the operation of the equipment. In the maritime industry this concept of maintenance is at the beginning, being present, especially, in new ships. The implementation of predictive maintenance on ships in operation involves the installation of an automatic monitoring and alarm system. The article presents an algorithm of the implementation stages of the on board automatic monitoring and alarm system of the ships in operation, providing the authentic example of implementation from the sailing-training ship”Mircea.” The article highlights and demonstrates the advantages of implementing the board ships a predictive maintenance method in the current competitive conditions on the freight market.

Keywords: predictive maintenance, ship, monitoring, alarming, Mircea ship.

1. Introduction

Preventive or conditional maintenance is currently used on ships. This maintenance method is based on the number of operating hours at which maintenance work is proposed by equipment manufacturers, as well as on previous experience and expertise. Even if preventive maintenance of equipment is conducted in time, unexpected failures can sometimes occur, which, depending on the importance of the equipment on board, can affect the ship's availability and the associated logistical process due to supply chain disruptions and increased costs operational. Competitive pressure in the freight market requires companies to increase the availability of ships by keeping on-board equipment in operation for a long time [3]. Therefore, it is important to consider the information on the actual technical condition of the equipment on-board the maintenance of the equipment on-board the ship. Approaching information on the technical condition of equipment in maintenance activities requires the implementation of the predictive maintenance (PM) method on-board ships. This method is a new maintenance concept that has emerged because of the development of IT technologies and their applications in the industry. In this regard, for the introduction of this method on-board ship, it is necessary to implement data acquisition systems and dedicated software for monitoring the main equipment on board. Although the predictive maintenance method offers benefits in terms of keeping the equipment on-board operational, practical adoption is difficult, especially in the case of ships in operation, as the equipment has not been designed for this purpose and the construction complexity of these, being built from several subsystems, which in turn are built from several components (or even several levels of subsystems), will make the monitoring of all components complex and not feasible [6]. Therefore, the solutions for the implementation of the PM method depend on the technical specifics of each ship in operation and consist in selecting only the equipment that can affect the availability of the ship by their untimely failure. Also for each equipment, only those parameters must be selected that through monitoring can provide relevant information about its technical condition. This article presents how to implement on-board NS Mircea of a computerized system for monitoring and alarming essential equipment. NS Mircea is a sailing ship whose mission is to perform the annual practice of students from the Naval Academy in Constanța.

2. Method for implementing predictive maintenance

The automatic monitoring and alarm system are based on the monitoring of the functional parameters of the equipment on-board the ship. The main functionality of the system is the integration of alarms and operating information from the monitored equipment to maintain the technique in optimal working parameters without endangering the safety of the ship.
The system architecture is based on the flow of information between sensors that are mounted on equipment, local operating modules, and data processing and storage units (figure1). Local operating modules are intelligent modules used to acquire information, monitor it, and change output values. These modules differ depending on the type of input signal (analog, ON / OFF).
The processing unit is connected via a redundant CAN-BUS system from the local operating modules and has an accessible interface using representations of the equipment and their measured values or alarms. Alarms can be displayed in the local control room, navigation room, accommodation for staff with duties in the electromechanical field, etc. [2].
The monitoring system can retain alarms and be printable.

Figure1. Schematic of the automatic and alarm system at NS Mircea [7]

In the design of the computerized equipment monitoring system from NS Mircea, the algorithm presented in figure 2 was used [2]. This algorithm can be used for any ship in order to design and install the computerized predictive maintenance system, the difference between the ships being the specific conditions of availability and safety.

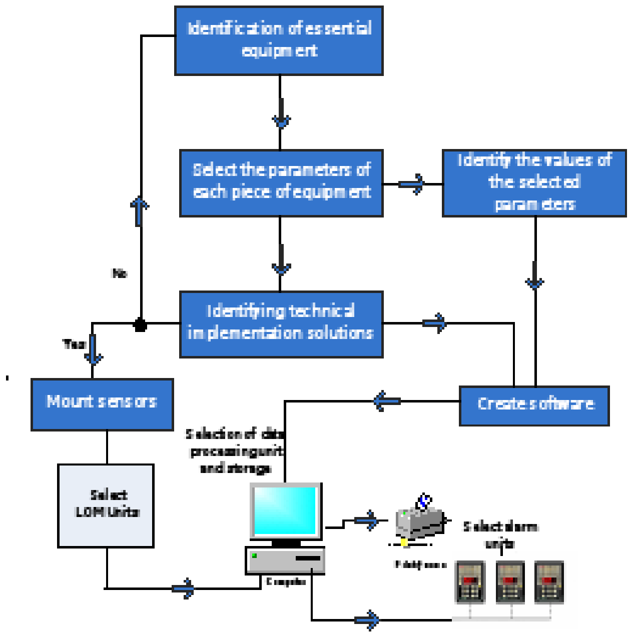

Figure 2. Monitoring and alarm system

In the identification phase of the equipment to be monitored, the project team must analyse and identify the equipment and aggregates on-board the ship, which by their malfunction may affect the availability of the ship according to its missions. In choosing the essential equipment from NS Mircea, the missions they perform, the safety and comfort of the ship's crew, were taken into account. Also, in the choice of equipment, the existing signalling and alarm installation on board were taken into account. The existing on-board signalling and alarm system has been designed to identify certain critical parameters from the main equipment (propulsion engine, diesel generators, service tanks, main power distribution panel, etc.) through thermostats, pressure switches, and sensors of the level that sent ON/OFF signals to by of signals and alarm panel, in case of reaching a critical parameter (figure 3) [2]. Often reaching a critical parameter meant that the equipment was in a technical condition at the limit of operation. These types of equipment were preserved within the new automatic monitoring system to which other types of equipment were added, such as air conditioning system, refrigeration installation, air compressors, fuel separators, oil and waste water, desalination plant, etc.

Figure 3. Alarm signalling panel [2]

A total of 22 pieces of equipment, 10 fuel tanks, oil, water, and the main panel of electricity distribution on board the ship were selected [2].
After identifying the equipment that needs to be monitored, we proceeded to identify the operating parameters that can provide essential information on the technical condition of the equipment. For example, the temperature of the exhaust gases from an engine can provide us with information on the operation of the fuel supply system, the air supply system, the wear of moving sub-assemblies, etc. The monitored parameters in the existing installation were kept, and the analysis is performed for the newly selected equipment. For example, the ZEISE-LIAAEN TYPE S63 step machine required the monitoring of the step machine control oil pressure and blade position indicator [2]. Also in this stage will be identified the minimum and maximum values, as well as the establishment of the alarm values of the selected parameters, according to the specifications of the manufacturer of the respective equipment.
The identification of the technical solution for implementing the system on-board the ship consists of choosing the sensors according to the parameters to be monitored, their measurement intervals, as well as the type of signal transmitted to the processing unit (ON / OFF, analog, thermocouples). Also in this stage, the power supply of the system, the signal transmission routes from the sensors to the processing unit, as well as the solutions for mounting sensors on the equipment. At NS Mircea, at this stage, it was considered to keep the existing sensors on equipment from the previous installation, the selection of sensors was made only for the parameters of additional equipment. The signals received from the sensors are transformed into data via the LOM (Local Operation Module) modules and then transmitted to the processing unit (figure 1). The LOM modules were selected within the system according to the number and type of signal received. For example, to monitor the oil temperature of propulsion engine speed reducer, a temperature transducer was selected on the bus after the circulation electro-pump. The characteristics of this transducer are measurable value 0–120 degrees Celsius, electric current output value 4–20 mA, which is transmitted to an analog LOM module (AIM 18), optical and acoustic alarm value in operating conditions at a maximum of 85 degrees Celsius [2].
To develop the monitoring software, the minimum, maximum and critical values of each monitored parameter, the data storage method, requirements for generating information based on statistical data, the alarm mode when reaching critical values at both the local station in the car and other remote positions on the ship. The dedicated software developed by Sedni Marine Systems, Spain, was implemented at NS Mircea. The software collects various telemetry data from monitored equipment that are processed using machine learning algorithms.

Depending on the required requirements regarding the functionality of the software and the data storage capacity provided by the sensors, the minimum configuration characteristics of the processing unit will be identified.
The software interface presents representations of the equipment and the values of the monitored parameters, or their alarms. Also, for each monitored parameter, based on the collected data, a graph is generated with its evolution over time (figure 6).
Figure 4 shows the propulsion engine parameter-monitoring interface.
The alarms will be displayed at the control point in the car, in navigation control, and in the accommodation of the mechanical personnel.
The equipment is capable of holding alarms and can be printed. Figure 5 shows the interface with the alarm systems on the ship.
To have real planning for the maintenance of the ship's equipment, it is possible that the data stored on-board by using the automatic monitoring and alarm system can be transmitted to the shipowner's premises using various methods of communication in the maritime industry (eg satellite internet) or 4G, and more recently 5G) [6].

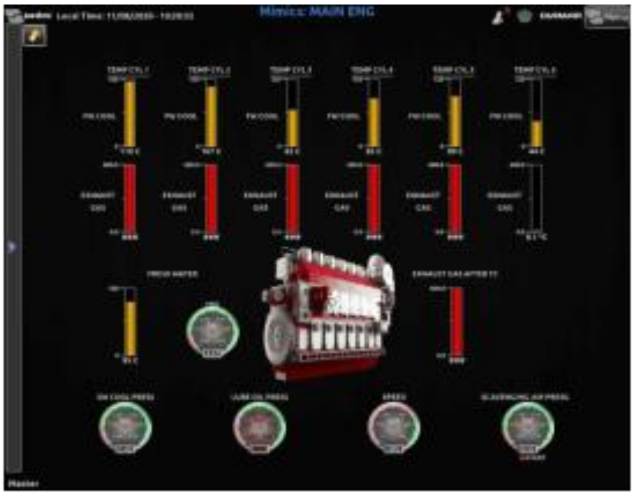

Figure 4. Propulsion engine monitoring interface[7]

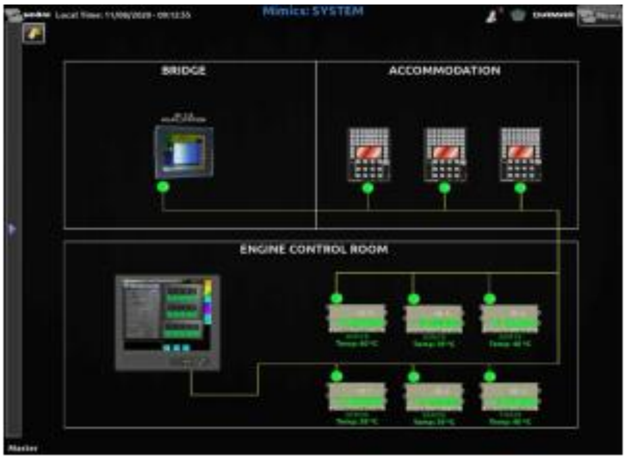

Figure 5. Interface with ship alarm[7]

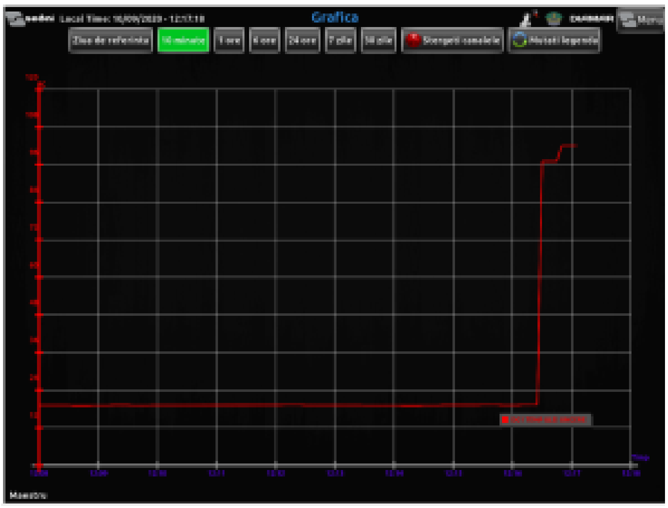

Figure 6. Interface with the time analysis graph of a parameter [7]

3. Conclusions:

The predictive maintenance method is based on a proactive approach that identifies and establishes subsequent trends in the technical condition of the ship's equipment, thus alerting us to imminent damage [5].

The method helps us decide or predict the next maintenance cycle for equipment in operation.

Therefore, the main benefit of predictive maintenance on ships is the ability to schedule corrective maintenance before ships make a voyage, where repairs during it are more difficult and expensive [6].

Other advantages of the predictive maintenance method arising from the main benefit are

- low maintenance and repair costs because of timely information on the need for repairs and spare parts purchases, which also means reducing on-board equipment failures;
- increase the productivity of the ship by increasing the availability of the on-board equipment;
- Increase the safety of the ship and its crew by avoiding damage to essential equipment on board while the ship is in voyages.
- a reduction in the number of crew members because of the elimination of permanent supervision in the engine room of the equipment during the operation.
- the actual planning of on-board maintenance activities through the company's real-time access to on-board equipment-operating data [1,4,6].

The implementation of the predictive maintenance method on-board ships in operation involves high costs because of the purchase and installation of equipment on board, but these costs will be amortized over time for the efficiency and safety gains of the ship generated by this method.

Therefore, the predictive maintenance method needs to be implemented on board the ship so that, with the preventive maintenance method, it ensures long-term availability of the ship with benefits on reducing operating costs and increasing ship safety.

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