POSSIBILITIES TO BEARINGS DIAGNOSIS OF THE GAS TURBINE ENGINE LM 2500 ON THE BASIS OF OIL RESEARCH ON

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Abstract

While operation a gas turbine engine more modest method of research are brought into effect. But one of a basic method of estimate a technical condition of gas turbine engines bearing is oil analysis. To estimate a technical condition of gas turbine engines bearing systems on the basis of oil research on, an x-ray method of radio-isotope fluorescence was used. This method has been also satisfactorily used in aircraft engine diagnosis.

This paper presents the method of diagnosis bearings of marine gas turbines on the basis of studies of mechanical contamination in oil. Results of mechanical contamination research in oil vs time of engine work are presented. On the basis of experiments results the analytical function that makes calculating the future value of a process possible was chosen.

Keywords: *friction heat, operation, bearing, friction work, oil system, gas turbine engine*

1. Introduction

The looking for a new solution of propulsion system for the fast warship have conducted to apply in the power ships gas turbine engine. Such positive factors like a small mass and overall dimensions, a big power and a start speed have been used on warships of various classes. Gas turbine engines on warships operate in very difficult conditions. Exploitation of that propulsion systems in the sea condition need an ability to continue their operate during roll continues of ship. Results of influences on the gas turbine engine many outside and inside factors, technical condition of engine are changed, which uncontrolled develop can cause their destroy [3]. Their reliability depending to a great extent on oil installation ability. Throughout exploitation some friction elements including bearings whose consumption products are oil transported get worn and torn. Majority damages of ball-bearings of gas turbine engine depend on the conditions of oil system. Damages and get worn and torn of bearings during exploitation are showed grow of contents molecules of roll elements in the oil. Emitting of metallic parties by gas turbine friction elements give an overall view of these elements technical condition [6].

While operation a ship's gas turbine engine friction elements like engine bearings play a main role in. The good technical condition of bearings has influence on the reliability of the engine and a warship's combat readiness.

The reason of an engine's failures are very often bearings damage whose products are gathered in oil. The example of damaged bearings of gas turbine engines are shown in the Fig.1.

The direct reason of tribological system wear acceleration is always bad quality of lubricate. Hence a change of both physical and chemical characteristic of oil and concentration of mechanical contamination (a size and a morphology foreign body substance) included in oil can be index of the assessment of the oil useful characteristic. Therefore oil is a very valuable carrier of information about wear reasons and processes of both, the engine tribological system and oil.

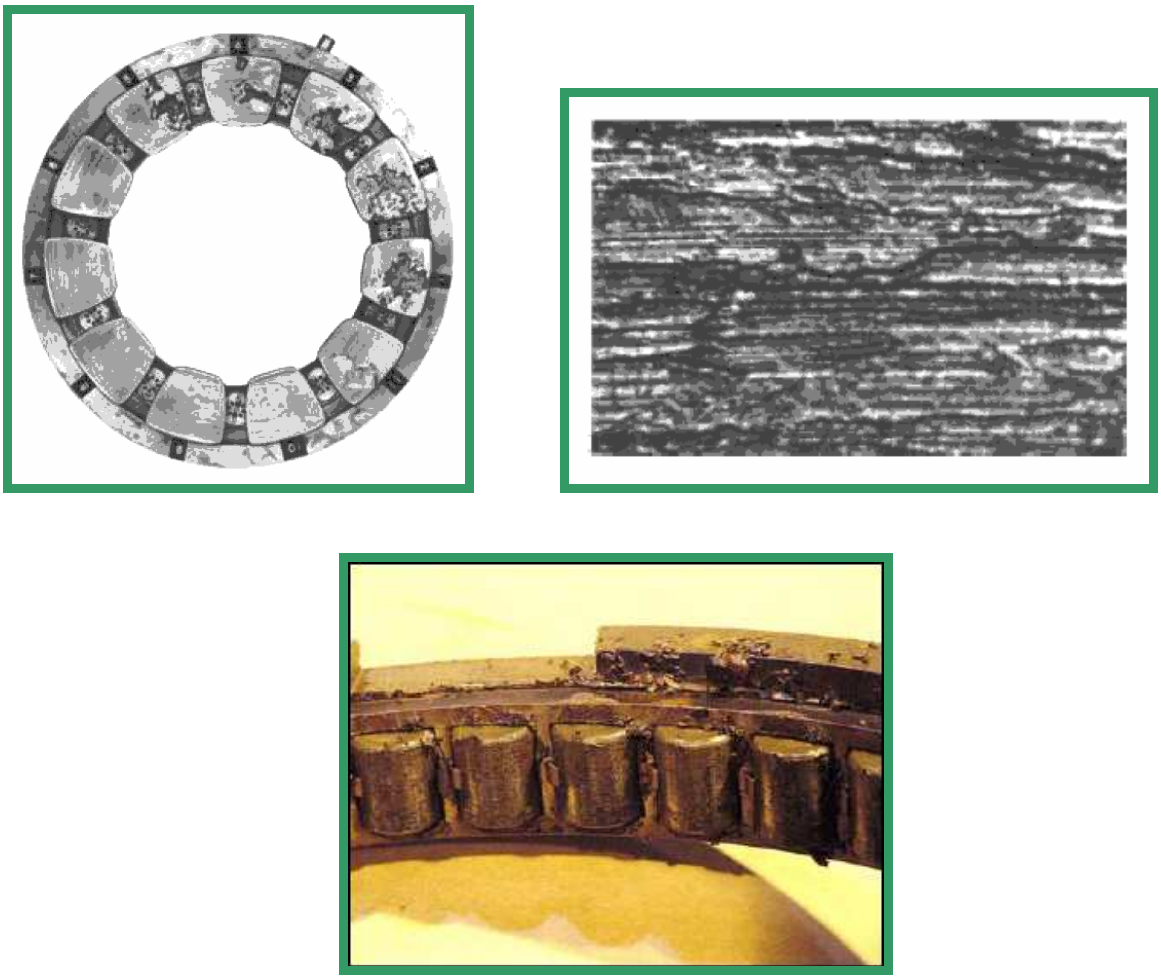

Fig. 1.The examples of bearings damage [7]

On the basis of the analysis of the chemical composition oil samples from the oil system, the monitor a change of mechanical contaminants and conduct assessment of the technical state of interact engine parts is possible.

2. The method of oil experimental research on

Using up of technical condition of bearings during exploitation is a continue process. The systematically control of mediation appears as the quantity metallic contamination in oil can estimate technical condition of bearings and find diagnostic symptoms which characterise damage threat of engine. The information of friction processes proceed include bearings or actual technical condition of elements are obtained from research of consumption products in oil.

The detection of the state before the damage of interact tribological system parts of gas turbine engine or an index of oil wear is possible on the basis of permanent or temporary contamination detection include in oil. The mechanical parts discharged from the engine tribological system gives the information about their technical state. The moving of both oil and contaminants can detect these contaminants direct in oil system or at the laboratory after taking oil sample from the engine. The research on contaminants in oil are conducted at the laboratory of The Naval Academy.

The X-ray radioisotope fluorescent method was used to estimate a quantity change of mechanical contaminants in oil. Thanks to induce and measurement of the characteristic intensity radiation, of this method, the chemical composition of oil samples was analyzed. The quantity

analysis, it means identification of element, was conducted on the basis of measurement energy radiation this element but quantity estimate was led on the basis of the intensity radiation energy line.

The characteristic radiation measurements are made by measuring system shown in the Fig. 2.

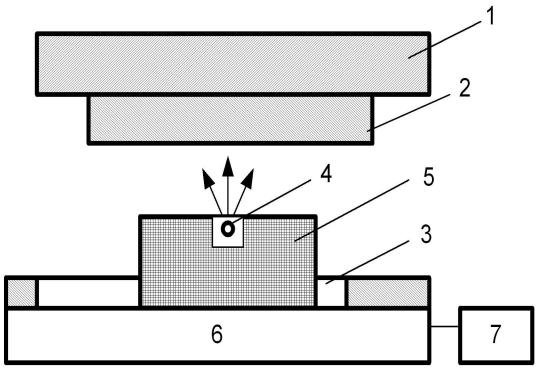

Fig. 2. XRF measuring device scheme:1 - filter, 2 - isotopic radiation source, 3 - Al or Co filter, 4 – detectors window, 5 – detector

There are filters used to reduce the influence of other elements on the results of the analysis:
- cobalt (Co) filters for determining of iron quantity,
- aluminium (Al) filters for determining of copper quantity.

3. Methodology of estimating the oil contamination

Oil samples for the analysis are collected after every return the ship from the sea. The scheme of the stand for mechanical impurities in oil analysis is shown in the Fig. 3.

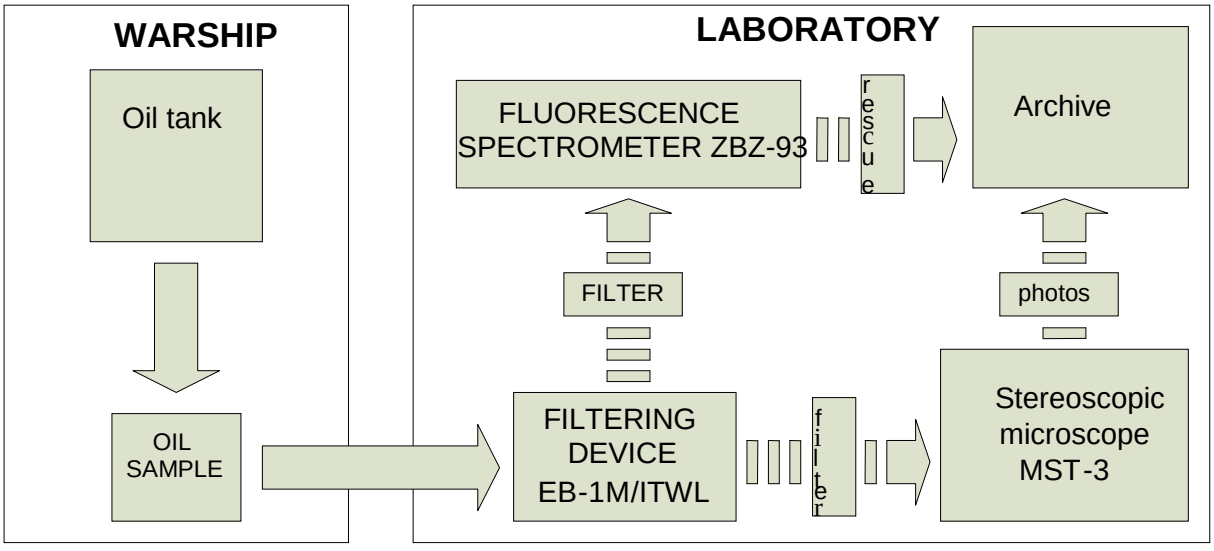

Fig. 3. The scheme of the stand for mechanical impurities in oil analysis

Two methods were adopted to determine quantity and quality of wear products in oil samples in the basic diagnostic system of marine gas turbine engines:
- stereoscopic microscopy,
- x-ray radioizotopic fluorescence.

Oil collected from the ship was filtered in filtering device EB-1M/ITWI using filters „coli-5”. After twenty four hours it was watched under the stereoscopic microscope MST-3. Owing to that

types and sizes of wear particles and changes in their quantity were determined with high precision. Optical examination allows to estimate the contamination of oil with water, graphite and makes it possible to identify the type and place of wear arising. The photo of the contaminant in a oil drain is shown in the Fig. 4.

Fig. 4. The microscope view of the contaminant on the oil sample

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The microscope observation of both a shape and a structure of contaminant element shows that majority part of contaminants from oil have a dimension to 5 μm with the shape like a grain of sand. Against the fine background there are some single and bigger particles with irregular shape. These particles have usually sharp edges and their dimension measurement approximately 30-50 μm but sometimes event to 100 μm. The majority of them are stopped by the oil filter.

Adding up the total number of particles on filter is very difficult. Therefore x-ray radioisotopic fluorescence (XRF) method was used to determine the quantitative changes. To determine the mechanical impurities concentration in oil the fluorescence spectrometer ZBZ-93 was used. It is appropriate to determine Fe and Cu concentrations in oil, which are the characteristic products of bearing wear process. The fluorescence spectrometer ZBZ-93 is presented below in the Fig. 5.

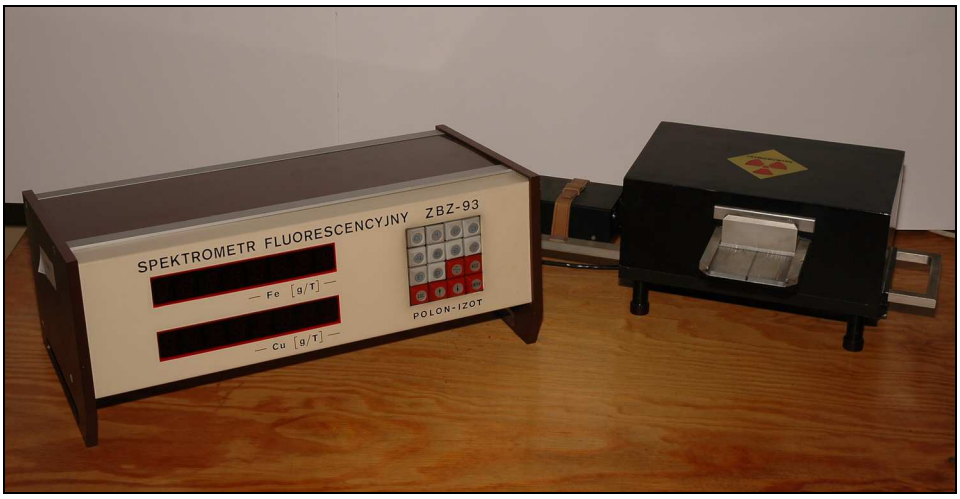

Fig.5. The fluorescence spectrometer ZBZ-93

The iron and the copper concentrations changing process, which is necessary to estimate engine bearings technical condition, was followed by analysing the chemical composition of periodically collected and properly prepared oil samples.

Each oil samples was researched on X-ray radioisotope fluorescent method three time to increase a rescue credibility and precision. The average rescue value of contaminants Fe and Cu each oil sample was given the content – related analysis.

The oil samples were taken from the four engines type LM 2500 which are propulsion of two warships.

Example of the results of Fe and Cu concentration changes in function of time of engine work is shown in the Fig. 6. Analysing the run of changes in Fe and Cu concentrations we can see that it is typical for attrition wear.

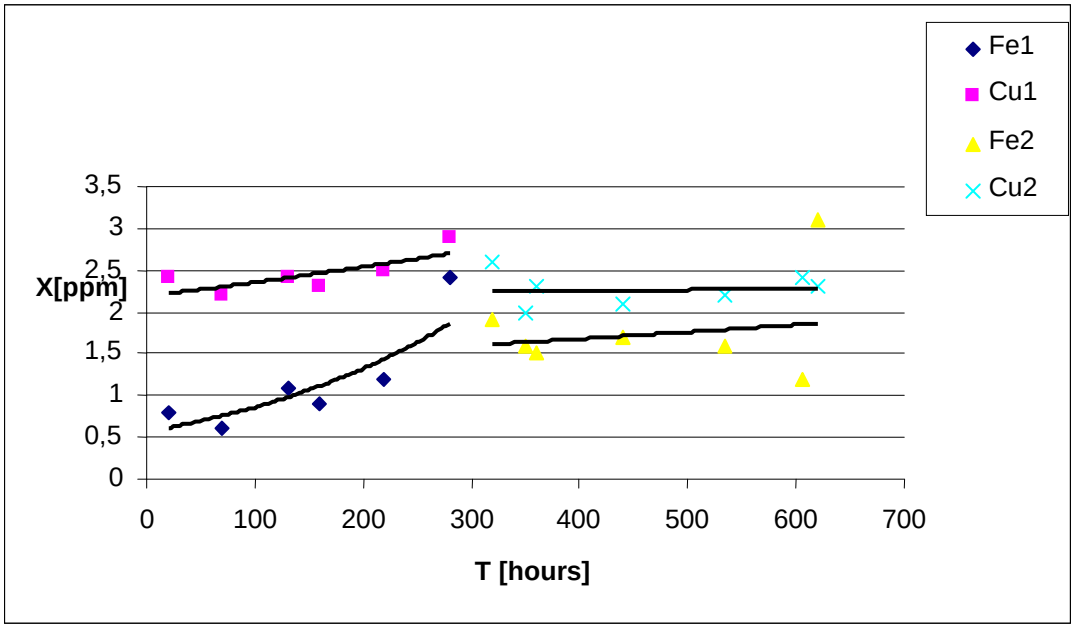

Fig.6. The graph of Fe and Cu impurities in oil in function of time of engine work

The methodology used to the assessment oil contaminants makes possible of changes following Fe and Cu concentration but it do not inform about the impurities value generated from the individual source. Therefore, the choice of the place to take oil samples from the oil system was the important stage of the research. After the carefully analysis of the oil system construction and take into consideration the possibility of bearings technical condition estimate two places were chosen:

- the bearings oil supply; from the oil supply filter,
- the bearings scavenge oil; from the oil pomp.

The scheme shown below in the Fig.7 presents the engine oil system with chosen places to take oil samples.

The value of Fe and Cu concentration in oil samples taken from marked places is shown as the form of graph in the Fig. 8.

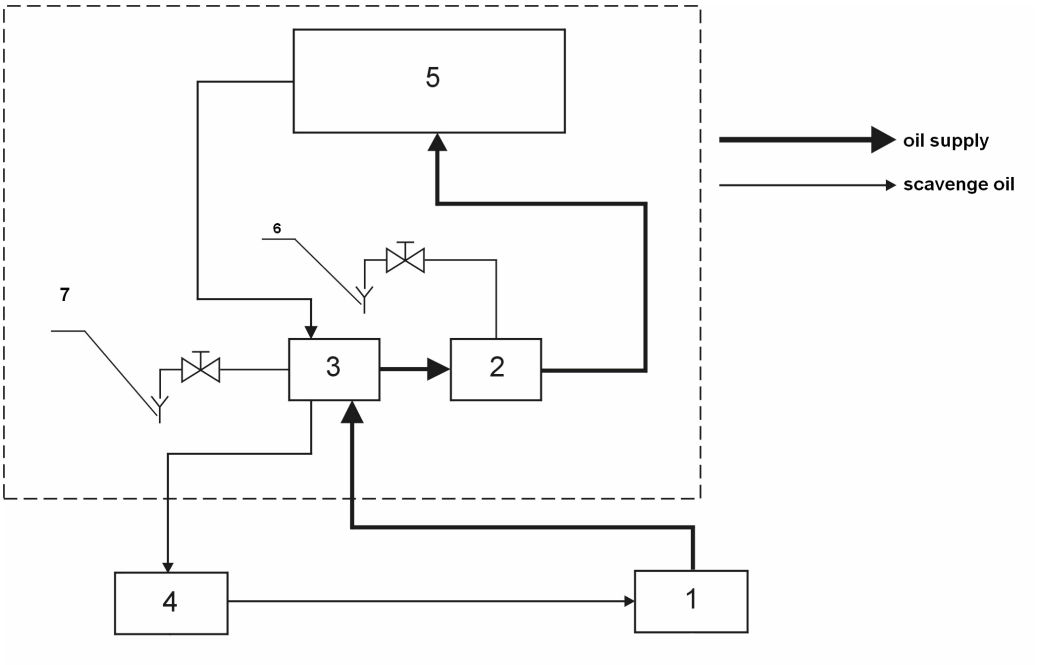

Fig.7. The lube oil system block diagram with the marked places to take oil samples;
1 – the oil tank; 2-the lube supply filters; 3-the oil pump; 4-the scavenge filters; 5-the gas turbine engine.

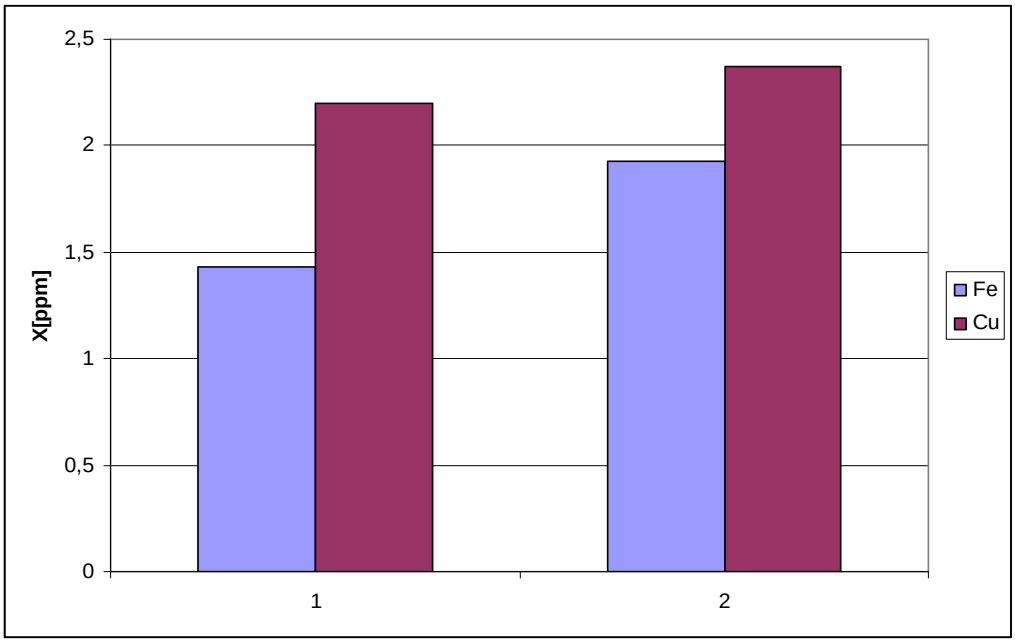

Fig. 8. The graph of Fe and Cu impurities in oil taken from chosen places of oil system:
1- oil sample taken from the lube supply filter, 2 – oil samples taken from the oil pump.

On the basis of the received results we can conclude that the main source of contaminants generation to oil are the engine's bearings. Hence, to estimate a technical condition of gas turbine engines bearings we should to observe a difference of both, Fe and Cu value, in the oil samples taken from the oil supply filter and the oil pomp. This difference marked as ΔX parameter and calculated from the mathematical formula (1) can be the diagnosis measure of the gas turbine engine bearing system [5].

$$\Delta X = X1 - X2 \qquad (1)$$

where:

X1- the Fe and Cu concentration in oil taken from the lube supply filter;
X2- the Fe and Cu concentration in oil taken from the pomp.

On the basis of the research on Fe and Cu concentration in oil sample the example of ΔX parameter calculated according the mathematical formula (1) is shown in the Fig. 9.

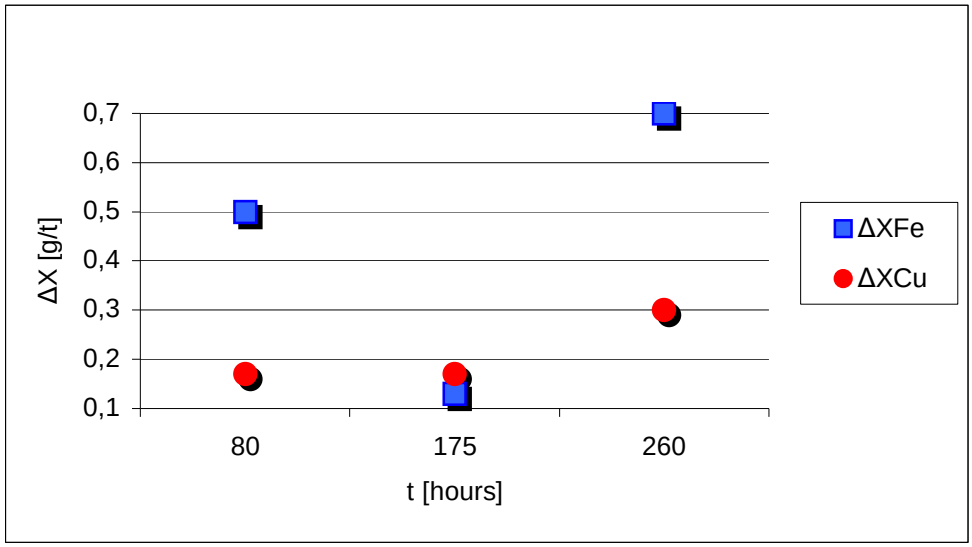

Fig. 9. The graph of ΔX parameters

To receive diagnosis results of engines bearings, contaminants oil research on ought to led on the basis of oil samples taken from the oil supply filter and oil pump. The observation of change of the diagnosis measure ΔX of gas turbine engine bearings, while exploitation the engines process, enables the assessment of technical condition its bearings. On the basis of experiments' results the analytical function that makes calculating the future value of a process possible can be worked out.

The conclusions

The results of experimental research confirmed the accuracy of measuring the Fe and Cu impurities concentrations levels in oil for diagnosis of marine gas turbine engines bearings.

The analysis of concentration of wear products in grease oil samples by x-ray radioisotopic fluorescence (xrf) enables the control of wearing away the rubbing parts of an engine smeared with oil.

The worked out mathematical formula of ΔX parameter changes properly corresponds to a run of wearing processes taking place in bearings. It enables to forecast the failures of the bearings.

The worked out methods compared with traditional methods make possible to estimate the technical condition of marine gas turbine engines bearings without with drawl of ships from exploitation and without disassembly of the engines.

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