

OPERATIONAL RELIABILITY OF CYLINDER COVERS OF DIESEL ENGINE

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ABSTRACT

A statistical analysis of failures of cylinder covers of diesel engines with different operating conditions was carried out. The histograms of their failures were constructed with subsequent interpolation for an objective assessment of the effect of the operating regime on reliability of the nodes being tested. It was found out that under the conditions

close to nominal, the temperature tension of the bottom becomes decisive for efficiency of the cylinder cover. When the operating loads decrease, the influence of the ambient temperature comes to the fore. The objectivity of the conclusion is confirmed by the fact that the research was carried out on the same brand of diesel engine under various operational conditions.

Keywords: diesel locomotive, diesel engine, cylinder cover, operation, failure statistics, interpolation, heat stress, temperature conditions, safety, reliability, prolongation of service life.

Background. The failure-free operation of a diesel engine depends primarily on proper operation, maintenance and serviceability of a cylinder-piston group. In the zone of elevated temperatures and mechanical loads there is a cylinder cover – a complex structure and a loaded part of this group.

A lot of research has been carried out to increase the service life of diesel engine cylinder covers and to study complex processes occurring in it. In most publications, only the effect of structural features on the longevity of cylinder covers of locomotives is considered. For example, in [1] the main reason for the failure of the cylinder cover is precisely its design. The violation of technology of manufacturing, repair and operation mode, in the author's opinion, is fairly easy to be identified. In work [2] it is assumed that the reliability of cylinder covers of diesel engines is increased by reducing the temperature gradient directly in the fire bottom.

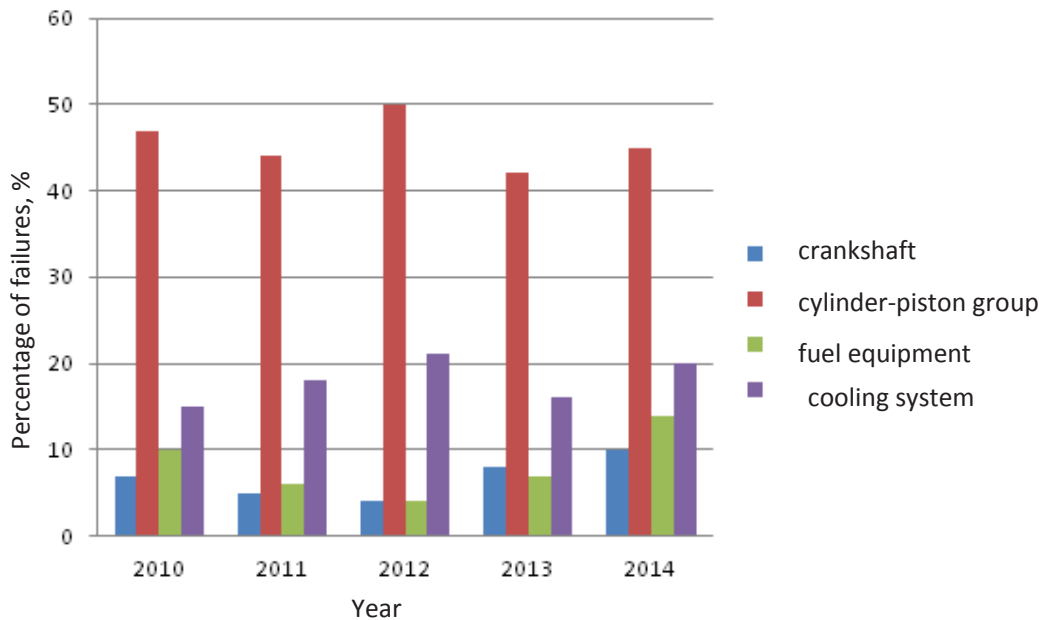
In solving problems of thermal conductivity and thermoelasticity of cylinder covers, various analytical methods are used that allow one to estimate the heat stress of the zone of interest to us. However, in most

cases, mathematical models do not take into account the influence of operational factors.

Analysis of publications on this subject indicates a slight effect of the features of operation of diesel locomotives on the reliability of cylinder covers [3–6].

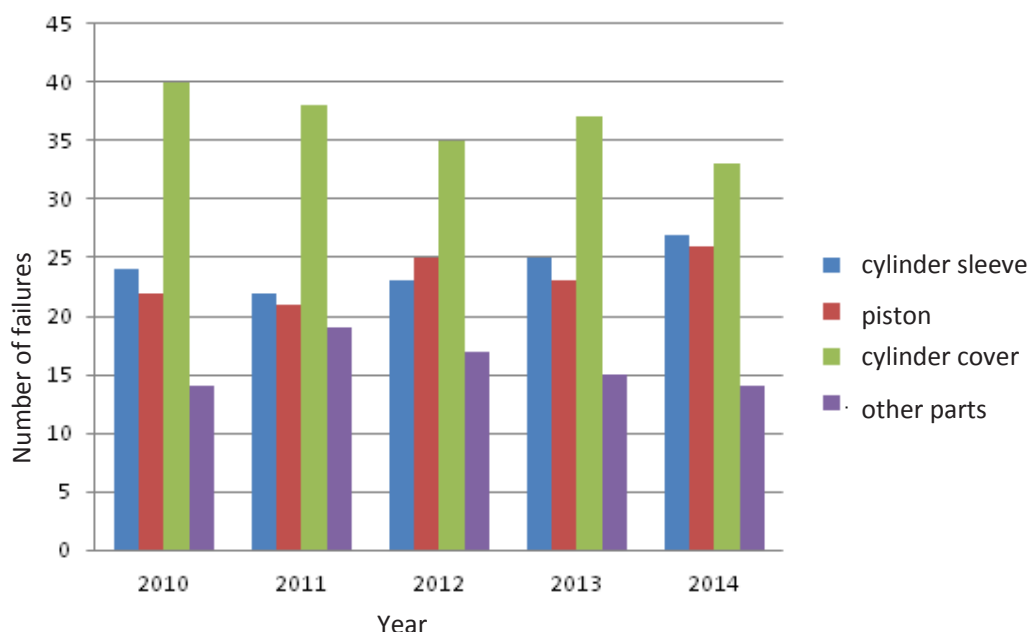
Objective. The task was set to determine the effect of structural features on the reliability of the cylinder cover of a D49 diesel engine. To determine the relationship between the operation characteristics, the type of diesel locomotive, the technical condition, the influence of climatic conditions and the trouble-free operation of the cylinder cover, in order to develop a set of measures aimed at extending the life of the nodes of the cylinder-piston group of diesel engine D49.

Methods. To obtain an objective assessment of the causes of cylinder covers failures, an analysis of statistical data in locomotive depots with various operating conditions of diesel locomotives was carried out. Two depots with a registered fleet of diesel locomotives 2TE116 were taken in passenger and cargo traffic, as well as a depot with a fleet of diesel locomotives TEM7 on heavy open pit-export work.

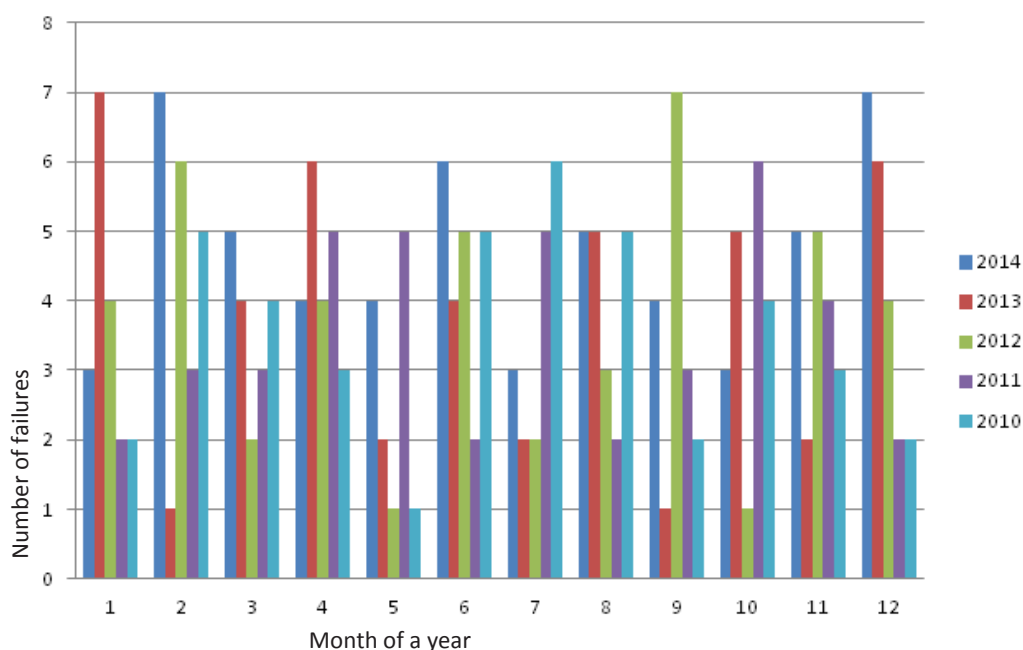


Pic. 1. Distribution of malfunctions of diesel engine nodes and their systems.





Pic. 2. Distribution of malfunctions of parts of the cylinder-piston group of diesel engine type D49.



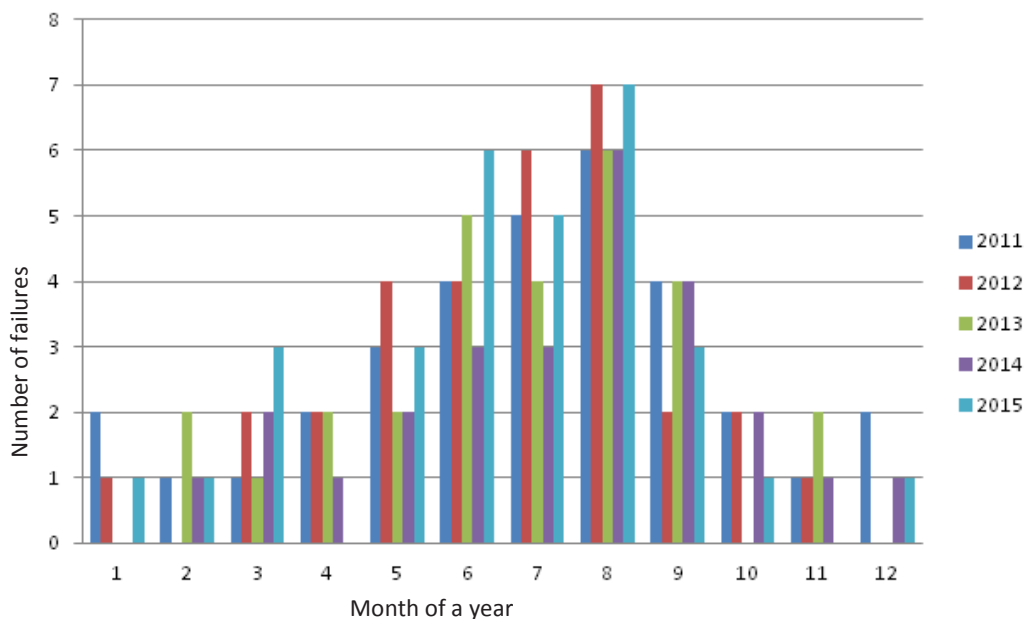
Pic. 3. Statistics of failures of cylinder covers of diesel locomotives 2TE116 depot of registration Debaltsevo-Sortirovochnaya.

Results. Based on the data obtained during the period 2010–2014, it can be concluded that the least reliable node of a diesel engine is a cylinder-piston group. It accounts for up to 40–50 % of failures (Pic. 1), and in this proportion about 40 % of the damage falls on cylinder covers (Pic. 2).

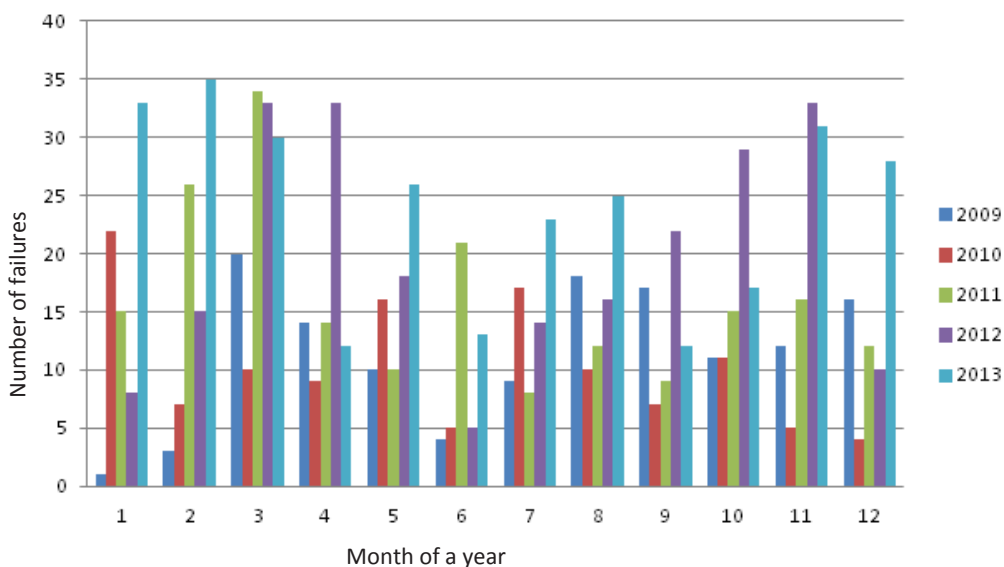
For an objective assessment of the reasons for failures of cylinder covers, the nature of failures was analyzed in Debaltsevo-Sortirovochnaya

depot (Pic. 3), where diesel locomotives are predominant in passenger traffic, and Volnovakha depot for the period 2009–2013 (Pic. 4), where diesel locomotives are operated predominantly in freight traffic.

The histograms show that the main peak of failure occurs in the cold season, with the maximum temperature gradient between diesel and the environment, in contrast to the summer period, when the temperature gradient is lower. This



Pic. 5. Statistics of failures of cylinder covers of diesel locomotives TEM7 depot of registration «ArcelorMittal Krivoy Rog».



Pic. 4. Statistics of failures of cylinder covers of diesel locomotives 2TE116 depot of registration Volnovakha.

sufficiently confirms the influence of the outside air temperature on the longevity of cylinder covers, that is, a decrease in the temperature of the outside air leads to a decrease in their service life [7].

For a more reliable assessment of the impact of operating conditions on the reliability of cylinder covers, an additional failure analysis was performed at the «ArcelorMittal Kryvoy Rog» industrial enterprise (2011–2015). In its locomotive depot, diesel locomotives TEM7 with diesel engine 2–2D49 are operated, which are in more difficult conditions (open pit and export work).

Analyzing the histogram in Pic. 5, it can be concluded that the greatest number of cylinder

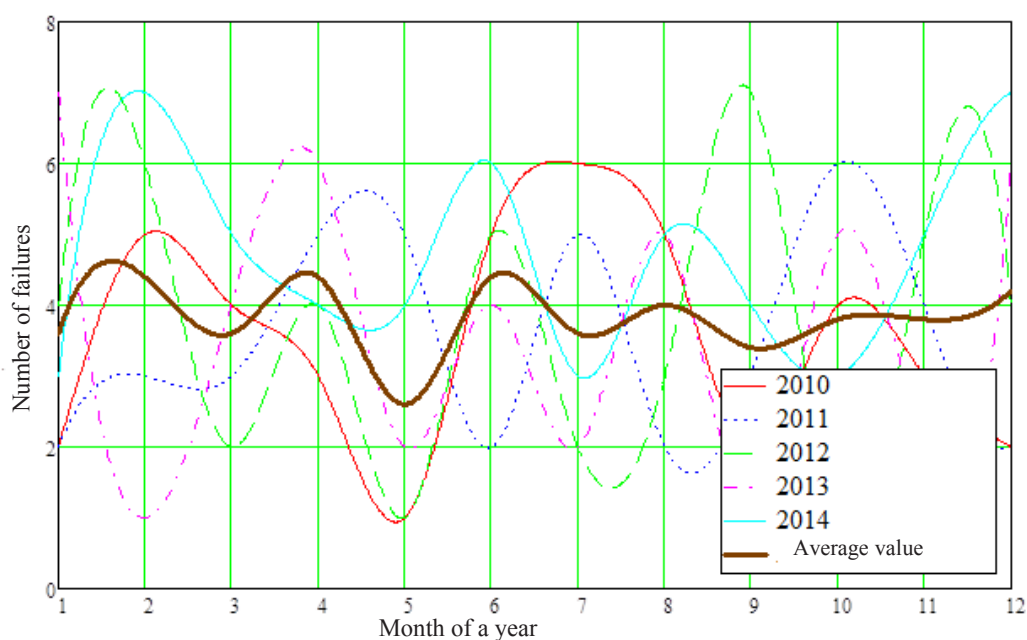
covers failures occurs in the summer. This is due to increased ambient temperature and production loads, which entails overheating of the diesel engine.

To confirm the hypotheses, an interpolation of the analyzed histograms was carried out.

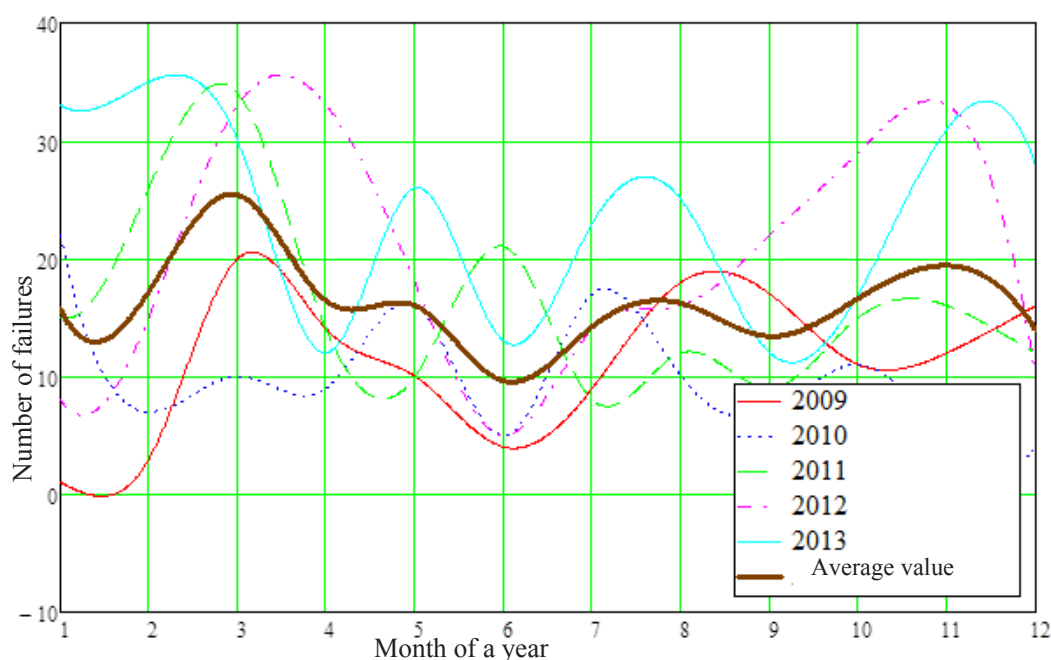
The interpolation of statistical data on Debaltsevo-Sortovo depot (Pic. 6), Volnovakha depot (Pic. 7), «ArcelorMittal Kryvoy Rog» depot allows us to state that there is no clearly defined dependence of the cylinder covers failures.

In first two cases, the largest number of failures occurs during the winter period. It can be assumed that in winter the failure of cylinder covers is due





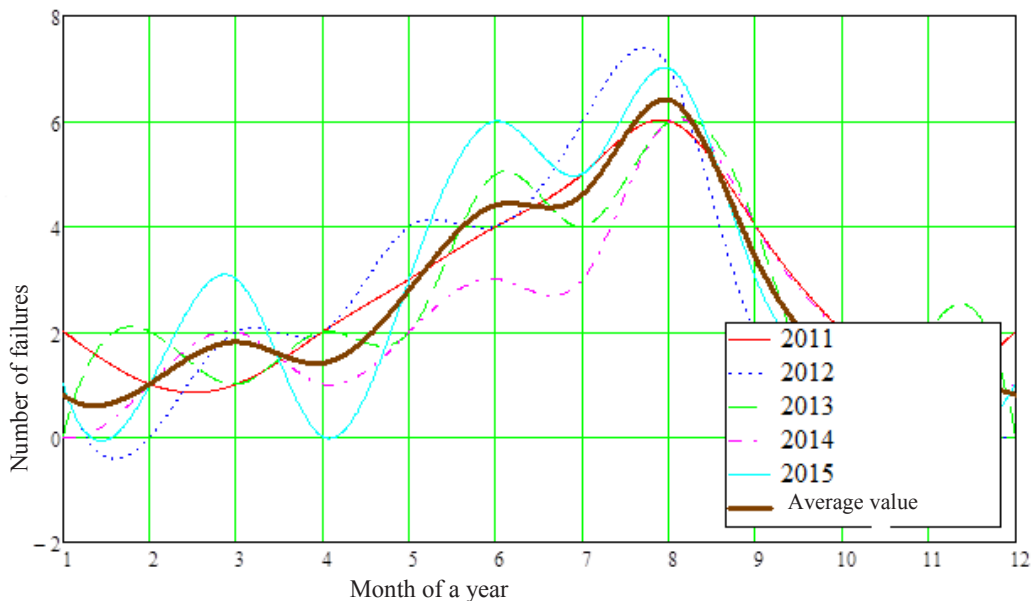
Pic. 6. Interpolation of statistical data of cylinder cover failures of diesel locomotives 2TE116 depot of registration Debaltsevo-Sortirovochnaya.



Pic. 7. Interpolation of statistical data of cylinder covers failures of diesel locomotives 2TE116 of depot Volnovaha.

to a large temperature difference between the diesel engine and the environment, for this entails the emergence and development of microfractures of the fire bottom. The summer period is characterized by frequent failures of the same cylinder covers due to overheating of the diesel engine.

According to the interpolation of statistical data of «ArcelorMittal Kryvoy Rog» depot, the greatest number of failures of cylinder covers falls on the summer period (Pic. 8). This, as already noted earlier, is due to overheating of the diesel engine, which arises due to a number of objective reasons (the peculiarity of the construction of the body of



Pic. 8. Interpolation of statistical data of cylinder cover failures of TEM7 locomotives of depot «ArselorMittal Kryvoy Rog».

the TEM7 locomotive, the severe operating conditions, and the unsatisfactory state of the cooling system).

Conclusion. The totality of the received data testifies to insignificant influence of structural features of cylinder covers of diesel locomotives type D49 on their reliability, which does not confirm the generally accepted point of view.

Based on the results of the study, it was possible to determine the influence of the ambient temperature and load conditions of the diesel engine on the longevity of the cylinder covers. It was established that under conditions close to nominal, the temperature tension of the bottom plays a decisive role here. With a decrease in operational loads, the influence of the temperature conditions of the medium comes to the fore, as evidenced by repeated studies and cross-checks of the experimental data.

The safety and reliability of the cylinder covers are affected not only by the design features, the material of manufacture, but also to a large extent by the temperature regime of the environment, operating characteristics and the type of locomotive.

Therefore, a differentiated approach is needed in determining the factors affecting the longevity of the cylinder covers. Taking into account the whole complex of factors in the development of the mathematical model of the heat stress state of the cylinder covers will allow us to more reliably calculate the range of operating conditions for the details of the cylinder-piston group of diesel engines and the extension of their service life.

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