

## Opportunity some relationship tribo between plasma and service life of machines and mechanisms

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**Abstract.** The paper proposed the formula for calculating the residual life of the engines without disassembly using the method of spectral analysis of oil. The basis for calculation is the average change in the content of elements of deterioration in the operating oil for a certain period of time of the engine.

### 1. Introduction.

Service life of the machinery is directly dependent on the degree of wear of the friction units. Wear - that change the size, shape, weight or state of the surface of the product due to failure (deterioration) when its surface layer friction. Basically there are 3 types of wear. It - corrosive wear, mechanical wear and tear under the influence of an electric discharge. If the first 2 types of wear are fairly well known and sufficiently studied, the last kind few people paid attention.

In recent decades, there have been some studies that reveal the essence of the processes taking place in the friction units of machines and mechanisms in the presence of them tribo drugs [1 - 4]. It turned out that these processes play a major role in the resulting contact points mating surfaces friction unit electrical discharges. The lifetime of a single spot can be  $10^{-7} - 10^{-8}$  s [5]. On a single spot having short-term individual temperature flashes. As a result, a very short period of time, a thin layer of molten material, and even in the high-energy state, similar plasma or magma. This "MAGMA-plasma" later called "Triboplasma". The energy of the electrons emitted by the separation of solid surfaces reaches relativistic values [6].

We must assume that triboplasma occurring at break of the contact mating surfaces will be the main component of the process of wear friction unit. And wear a determining operating life of machinery. If you predict the service life of the units of cars, depending on the wear and tear, you can look for ways to improve the use triboplasma resource characteristics of machines and mechanisms.

Questions to predict the service life of the machinery is widely discussed in [7 - 9].

### 2. Methods of research.

In this paper we used the method to study emission spectral analysis to predict performance without collapsible parts.

### 3. Results and discussion.

The initial data for forecasting the residual resource can have different parameters and indicators of the technical state of the system. However, the most frequently used parameters such as wear.



The basis for the prediction of wear are probabilistic mathematical model of the process of wear, which wear can be presented either as a function of the random variable  $x = f(t)$  or a random function  $x(t)$ . Prediction of wear of machine parts for wear, represented as a random variable, and produced by  $m_x$  and  $\Delta_x$  or  $\sigma_x$ . This prediction does not take into account the individual characteristics of each machine wear group, resulting in an increase in the accuracy of predictions of its duration is significantly reduced, especially if the nature of the process of wear between the machines in the group varies considerably. Prediction of wear on the random function that is obtained by mixing specific implementations, carried by  $m_x(t)$ ,  $\Delta_x(t)$  and  $K_x(t, t_1)$  or  $r_x(t, t_1)$ . The normalized correlation function  $r_x(t, t_1)$  is characterized by stable dynamics of wear each car group, in view of which significantly increases the accuracy of forecasting. If the value  $r_x(t, t_1)$  is close to one, indicating that the weak mixing implementations, the prognosis can be given for a longer period. At small (vigorous stirring) prediction with the required accuracy can only be done for a short period of time. Taking this into account, when predicting the optimal solution should be found, ie, the duration of the forecast should be established of the conditions required accuracy of the forecast.

Currently probabilistic mathematical model of the process of wear are the way of statistical processing of the results of measuring the wear of machine parts with normal exploitation. The main difficulty in finding such models associated with the current measurement of wear and tear. At the widespread linear and weight measurement wear, as the most authentic and relatively simple method for estimating the wear, wear full dynamics can be set only for those parts of machines and mechanisms, the measurement of which is not related to the dismantling of the machine. In this case, you can get a family of implementations, while stirring, and which is a random function of wear, representing the most complete probabilistic mathematical model of the process. However, in most machines such measurement items without dismantling the machine can not be performed, so that the wear of these parts is evaluated by two measurements carried out at the beginning and end of the test. With such frequency measurements can not find concrete implementation, and hence it is impossible to describe the process of wear of a random function. In this case, the dynamics of the wear on the whole group studied cars are available only through the statistical processing of a large number of random measurements of parts obtained by dismantling the machine with different duration of work between their showdowns. This model  $u = f(t)$  is characterized by deterioration of the wear process, depending on the operating time as a random variable, not as a random process. Such a description of the actual pattern of wear displays it in one or another group of machines, but this map is incomplete, as part of the probability characteristics remain uncertain. Such information about the possible nature of the flow dynamics of the growth of depreciation  $u = f(t)$  are given in [10].

The initial data for the forecasting performance of parts of the machine for a certain period of time  $t$  is the measurement of wear to the original time  $t_1$ . However, such data can be obtained at any point in time we are interested only in the machinery, which is required to measure the wear full or partial dismantling of the machine. In this case, the prediction performance become difficult to achieve since any disassembly of the machine, including the associated only with the measurement, may cause some changes in the conjugation of the measured items and hence to a significant error in the prediction.

A promising and reliable method for predicting performance without collapsible parts is the method of "wear products in oil" and, in particular, the emission spectral analysis of oil (Esam) [9, 11]. This method makes it possible to describe the process of wear parts and measure the random function wear at any given time. However, the use of this method for predicting has its own characteristics and, in particular, especially in the initial estimate of the wear. If one line or the weight measurement can judge the degree of deterioration of the items, according to the result of the spectral analysis of the process during normal wear can not do this for the following reasons. Esam method determined by the mass of metal removed from the friction surfaces for the period after the change of oil to measure.

Therefore, the entire mass of metal removed from the friction surfaces, can be determined only if the measurement of wear to perform regularly with the initial moment of the machine.

Given these features of the method of "wear products in oil," prediction using this method can be performed to determine the amount of metal removed from the friction surfaces and the speed of its receipt in the working oil.

The basis of this prediction information on the amount of metal removed from the friction surfaces at any predetermined time. With the highest precision, such information when evaluating wear with spectral analysis of the lubricating oil can be obtained from the balance equation, consisting in equal number to the number worn layer of wear in the crankcase. In this case the evaluation of working capacity of details of a particular machine depends on the error description of the process of wear balance equation.

For such a prediction is necessary to have:

- Random function of wear  $G(l)$  or  $G(t)$ ;
- Information about limiting the amount of metal  $G_{lim}$  removed from the surfaces of the parts in which failure can occur.

For information about limiting the amount of metal  $G_{lim}$  can be obtained by experiment or calculation [9, 11, 12]. The difficulty in obtaining such information is as follows. Even with the normal processes of wear, wear identical machine parts is uneven. Depending on the engine design and requirements on its operation, the loss of efficiency of the machine can occur either when the maximum size of a single part, while others wear can be significantly lower, or on reaching all parts of limit or close to the sizes. In the first case, an amount of metal to be taken in the shortest possible  $G_{min}$ , and in the second case - for the maximum possible  $G_{max}$ . In the experimental finding the limits of these values must use the statistics measuring the wear and tear from vehicles entering the repair of failures. Calculated by weight of the metal is determined by volume, calculated in accordance with Diagrams surface wear and taking into account the permitted norms rejection. The accuracy of the method depends on the complexity of the geometric shape wear. A more reliable method is experimental. However it is better to combine both of these methods.

Persistence load and engine speeds allows you to approach the balance equation with aggregate. The basis for this decision put the average content of the elements of deterioration in the operating oil for a certain period of time of the engine.

The balance equation, with aggregate is as follows

$$G = \frac{G_M \cdot \frac{\sum C_i}{n}}{100} + \frac{t \cdot g_y \cdot \varphi \cdot \frac{\sum C_i}{n}}{100} + \frac{G_M \cdot \frac{\sum C_i}{n}}{100} \cdot t \cdot q_{u\phi}, \text{ g.} \quad (1)$$

where  $G_M$  - the mass of oil, g;  $C_i$  - Concentration of the element i in the oil-measurement%; t - time of the engine, watch;  $g_y$  - specific oil consumption, kg / h;  $q_{u\phi}$  - the proportion of the number of his element in the oil centrifugal filter is delayed one hour;  $\varphi$  - coefficient taking into account carryover of elements from the engine; n - number of measurements.

To calculate the need to have information on the value of the coefficient, which can only be obtained from the measurements. Reliability of determination according to equation (1) depends on the number of measurements over time. Moreover, it is desirable to make the measurement in the middle of the life of the oil.

Consider forecasting algorithms depending on the amount of available information and present the accuracy of the forecast.

The easiest time of residual life may be determined by the following formula

$$t_{\text{east}} = \frac{G_{\text{riding}} \cdot t}{G} - (t + t_1), \quad (2)$$

where  $G_{\text{riding}}$  - permissible mass element wear, g;  $G$  - the mass of the element of wear accumulated during the oil-t, g;  $t$  - follow-up the work of the engine in order to predict the resource per hour;  $t_1$  - the time of engine start up observation hour.

The algorithm of the forecast represented by the formula (2), based on the assumption that the rate of wear items arrive before the start of the observation will be the same as in the period of observation.

Therefore, the accuracy of this prediction will depend on the stability of the dynamics of wear each motor group. The reliability of the forecast can be increased if we know the point of history, ie, the values of the mass of metal lost in the previous maintenance period.

In this case, the prediction should be performed according to the formula

$$t_{\text{ocm.}} = \frac{\sum \frac{G_{\text{don.}} \cdot t_i}{G_i}}{N} - (\sum t_i + t_1), \quad (3)$$

where  $t_i$  - the length of time of i-th season of operation or harvesting (planting) on the accumulation of weight lost metal  $G_i$ ;  $N$  - the number of seasonal operation.

A significant way the accuracy of the prediction can be improved by the submission of the accumulation of elements of deterioration function  $G = f(t)$  for each engine or a random function  $G(t)$  for the engine group. These functions are obtained by fitting the results of observations by the method of least squares. The most common type of such models are linear

$$G = a_1 \cdot t + a_0, \quad (4)$$

or quadratic

$$G = a_2 \cdot t^2 + a_1 \cdot t + a_0. \quad (5)$$

In the absence of information on the amount of metal accumulated at the beginning of the observation time for the residual life of the linear model defined by the formula

$$t_{\text{ocm}} = \frac{\left( G_{\text{don.}} - \frac{t+t_1}{t} \cdot G \right) - a_0}{a_1} \quad (6)$$

and for the quadratic model by the formula

$$t_{\text{ocm}} = -\frac{a_1}{2 \cdot a_2} \pm \sqrt{\frac{a_1^2}{16 \cdot a_2^2} - \frac{1}{a_2} \cdot \left[ a_0 - \left( G_{\text{don.}} - \frac{t+t_1}{t} \cdot G \right) \right]}. \quad (7)$$

If you have information about the number of accumulated metal, forecasting for the linear model should be carried out according to the formula

$$t_{\text{ocm.}} = \frac{\left( G_{\text{don.}} - \sum_1^N G_i \right) - a_0}{a_1}, \quad (8)$$

and quadratic

$$t_{\text{ocm.}} = -\frac{a_1}{2 \cdot a_2} \pm \sqrt{\frac{a_1^2}{16 \cdot a_2^2} - \frac{1}{a_2} \cdot \left[ a_0 - \left( G_{\text{don.}} - \sum_1^N G_i \right) \right]}. \quad (9)$$

#### 4. Conclusions.

To determine the residual life of the above formula, you must have information about, ie, wear thresholds. Then the residual life of the machinery can be calculated by the expression [11, 12]:

$$G_{\text{nop}} = K_{\text{nop}} \cdot Q, \quad (10)$$

$$t_{ocm} = \frac{K_{nop}}{G_i} \cdot t_i - (t_i + t_1), \quad (11)$$

$$t_{ocm} = \frac{K_{nop} \cdot Q}{(K_j + K_0) \cdot Q} \cdot t_i - (t_i + t_1) = \frac{K_{nop} \cdot t_i}{K_j + \frac{q}{Q} \cdot \left( \sum \frac{(1 - e^{-\alpha_i}) t_i}{\alpha_i} \right)} - (t_i + t_1). \quad (12)$$

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### References

- [1] Perepelitsyn MG. Study the impact of repair compounds on the surface of the friction on the example of the cam mechanisms of automotive engines: Author. Dis. on soisk. scientists. step. cand. tehn. Sciences. /MG Perepelitsyn. - Novosibirsk, 2009. - 16 p.
- [2] Dolgoplov KN. Improving the performance of household appliances through intensification processes lubrication of friction pairs: Author. Dis. on soisk. scientists. step. cand. tehn. /KN Dolgoplov. - Mines, 2009. - 16 p.
- [3] A. Dunayev. The modernization of worn equipment with tribo drug. Monograph /AV Dunayev, SN Sharifullin. - Kazan: Kazan. University Press, 2013. - 272 p. ISBN 978-5-00019-141-5.
- [4] Anatoly Dounaev. Friction Surfaces Modification Using Tribo-Compounds /Anatoly Dounaev and Said Sharifullin //World Applied Sciences Journal. ISSN 1818-4952, 2014. - Vol. 31 (2). - Pp. 272 - 276.
- [5] Garkunov DN. Tribotechnology /DN Garkunov. - M.: Engineering, 1985. - 424 p.
- [6] Bocharov GS. The energy of the electrons emitted in the separation surfaces /GS Bocharov, AV Eletsii, VA Nikerov //Plasma Physics, 2011. - Vol. 37. - # 4. - Pp. 396 - 400.
- [7] Mikhlin VM. Prediction of the technical condition of vehicles /VM Mikhlin. - M.: Kolos, 1976. - 1. 287 p.
- [8] Belsky VI. Pre-repair diagnostics of agricultural machinery. /VI Belsky. - M.: Agrotransport, 1987. - 172 p.
- [9] Kyureghyan SK. Assessment of the wear of internal combustion engines by spectral analysis /SK Kyureghyan. - M.: Engineering, 1976. - 152 p.
- [10] Sokolov AI. Application of emission spectral analysis to assess oil wear properties of the working oil /A.I. Sokolov, NT Tishchenko. - Tomsk: Publishing House of Tomsk University. - 1979. - 208 p.
- [11] Lomukhin VB. Diagnosing Analysis crankcase oil as component without collapsible parts technology repair machinery /V.B. Lomukhin. //Diesel power plants river vessels. - 2001. - S. 21 - 25.
- [12] Cher LA. Standard enterprise. System diagnostics for diesel engines the method of comprehensive analysis of the lubricating oil STP 314. 0-01-88 /L.A. Sher, NN Sorokin, AF Kononov, VB Lomukhin. - Science, Novosibirsk, 1988. - 79 p.