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Normatives of Technical Operation of Agricultural Machines

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Summary. For each type of agricultural machines and their operating conditions determined the scope and frequency of maintenance. Violation of standards of maintenance leads to deterioration of a technical condition of knots and units of agricultural machines, affecting its manufacturability. toxic and economic indicators.

In the appointment of technical conditions for the limit state of the output parameters of the mechanisms are selected only those that are possible in the process of operation. If operating experience suggests that the output parameter does not change or these changes are not regulated by the resource requirements of the agricultural machines, the technical standards do not establish and its limits. It should be noted that the complexity of the processes of functioning and loss mechanism health often lead to unwarranted assignments of standards on limit state or lack thereof for a number of characteristics. In addition, the numerical tolerance values for the output parameters are often installed for new mechanisms and does not specify allowable limits of their change. Therefore it is highly important for the justification and establishment of stockpile reliability output parameters of the mechanisms. However, for modern agricultural machines is often appropriate to set standards not only limit state for output parameters, but also on the degree of damage to individual elements of the machine, determining the change of its characteristics. So are limited to the ultimate limit state for wear, according to the degree of deformation, the magnitude of the arising of cracks and other damage. There are regulations on the limit of units and units of agricultural machines, which outlines criteria and a maximum value of damage, when you reach that node and the machine in need of repair.

The quality of the documentation for operation of agricultural machines is characterized not only errors in drawings, technical documentation or deviations from standards and regulations, but also such indicators as the level of standardization and harmonization, reasonableness and progressiveness of technical solutions, manufacturability, maintainability of the structure and its metal consumption, simple structural forms, validity of technical conditions for machine elements and output parameters and other indicators of excellence of the design of agricultural machines.

Requirements for the organization operating the agricultural machines include the norms for maintenance and repairs, instructions to personnel on the measures for the prevention of accidents and elimination of their consequences on the allocation of resources during peak load conditions.

Key words: normative, probability, operation, resource, agricultural machine.

INTRODUCTION

The standard is a quantitative or qualitative indicator is required to streamline the process of making and implementing decisions [1, 2].

The appointment standards are divided into governing [3–8]:

– properties of the product (reliability, performance, capacity etc.),

– the status of this product (normal, allowable and limit values of parameters of the technical condition),

– technical requirements governing the conduct of certain operations and works of maintenance and repair,

– provision of resources (consumption of spare parts, materials, labor costs, etc.).

The level standards are divided into state (state standards, etc.), inter-industry (maintenance and repair), industry (standard guidelines, industry standards), intra-industry (quality standards of maintenance and repair, standards of enterprises) [9, 10].

The standards are used in determining the level of efficiency of agricultural machinery, planning of quantities, determining the number of performers, the need for production base [11, 12].

The most important standards of technical maintenance includes frequency of maintenance, the life of the product before repair, the complexity of maintenance and repair, consumption of spare parts and materials [13–16].

Frequency of maintenance as it is needed (in hours) between two subsequent ongoing work of maintenance.

When carrying out maintenance there are two basic methods of bringing the product to the required technical condition [17–24]:

– at the time, that is, is assigned a frequency at which the system condition is restored to nominal or specified technical documentation of the level,

– the parameter of the technical condition, that is, at a given frequency is condition monitoring and the decision to conduct precautionary technical effects to bring the technical condition of the device to the nominal or established technical documentation level.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

In general operation maintenance consists of two parts – control and the executive that must be considered when determining the complexity of t_n and cost of maintenance.

$$t_n = t_k + kt_u, \quad (1)$$

where: t_k and t_u – complexity of the control and actuating parts of a maintenance,

k – the coefficient of repeatability ($0 \le k \le 1$).

The coefficient of repeatability for the case of maintenance in the mean time k=1, i.e. the controlling and Executive part of practically merge.

The feasibility of using a particular method of maintenance (controlled or not) is determined by the ratio of costs for the elimination and prevention of failures, monitoring and implementing of the operation, variations of random variables and other factors.

The cost of the maintenance:

$$C_n = C_k + kC_u, \quad (2)$$

where: C_k and C_u is the cost of monitoring and implementing parts of the maintenance operations.

In practice, there are the following methods for determining the frequency of maintenance:

– at acceptable level of reliability based on the choice of the value achievements, where the probability of failure of the elements does not exceed a predetermined value,

– at the acceptable value and regularities of change of a parameter of the technical condition based on the choice of the value achievements, where the parameters of the technical condition of agricultural machines with a given level of probability do not reach their allowable values,

– the feasibility method is based on choosing the magnitude of the developments, which will be a minimum total of unit costs for maintenance and repair,

– statistical tests based on the simulation of real and random processes, as a result, the rational method determines the frequency of maintenance,

– economic-the likely method generalizes the previous one and takes into account economic and risk factors, and allows to compare different strategies of maintaining and restoring the health of agricultural machines.

The method of determining the frequency of maintenance on acceptable level of reliability. this method is designed for the selection of the rational frequency, in which the probability of failure F(x) element is not more than a predetermined value and is called the risk.

The probability of failure is determined by:

$$P_Д(x_i \ge l_0) \ge R_Д = \gamma, \quad l_0 = x_\gamma, \quad (3)$$

where: $P_Д$ – allowable probability of failure,

x_i – time to failure,

F=1-γ – risk,

l_0 – periodicity of maintenance,

x_γ – gamma-percent resource.

OBJECTIVE

To summarize the analytical approaches to the justification of norms of technical operation of agricultural machines taking into account the actual production of growing cycles of production of agricultural crops.

THE MAIN RESULTS OF THE RESEARCH

For units and mechanisms, ensuring the safety:

$$R_Д = 0{,}9 \div 0{,}98 \; (90 \div 98\%),$$

for other components and assemblies:

$$R_Д = 0{,}85 \div 0{,}9 \cdot$$

In this case, the frequency is much less than the average MTBF (Fig. 1) and is connected in the following way:

$$l_0 = \beta \bar{l} = \beta \overline{x_1}, \quad (2)$$

where: β – the rational frequency ratio, taking into account the amount and nature of variation of the MTBF and adopted by the permissible probability of failure (Tabl. 1).

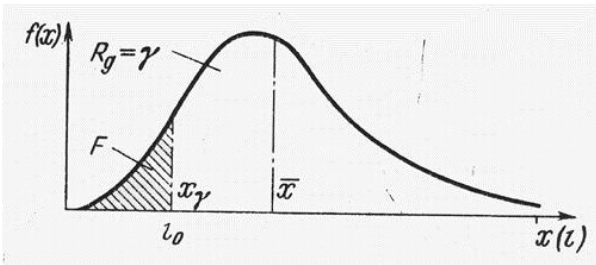


Fig. 1. Determining the frequency of maintenance at the acceptable level of reliability.

Table 1. The coefficients of the rational frequency for different values of RД and ϑ.

№	RД	Coefficients of variation ϑ			
		0,22	0,4	0,6	0,8
1	0,85	0,80	0,55	0,40	0,25
2	0,95	0,67	0,37	0,20	0,10

Table 1 shows the variation of the random variable, the greater the duration between maintenance operations under other equal conditions may be imposed. The tougher security requirements, the less rational the frequency of maintenance.

For example, the frequency of the control and recovery of pre-torquing fasteners $\beta \cong 0{,}4 \div 0{,}6$.

The method of determining the frequency of maintenance at the acceptable value and regularities of change of a parameter of the technical condition. To modify a particular parameter of the technical condition for each of the groups of agricultural machines are different. However, the average for the group of agricultural machinery trend of each parameter is characterized by a curve on which, and the allowable value of the parameter "**У**Д" determine the average operating time $x_ч = \bar{l}$, then, average the whole set of products reaches the valid values for the parameter of the technical condition (Fig. 2).

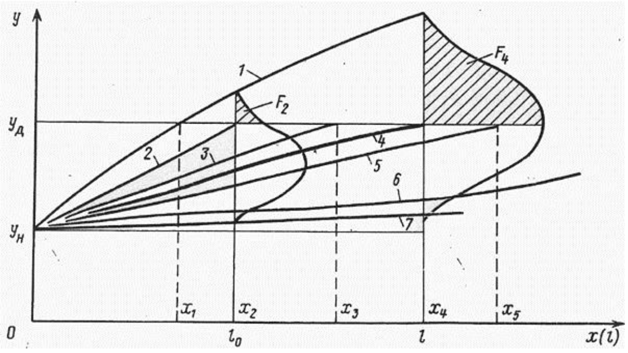


Fig. 2. Determining the frequency of maintenance at the acceptable value and regularities of change of a parameter of the technical condition

The average operating time corresponds to the average intensity change of the parameter $\bar{a}$: the products in which the intensity change of the parameter is above average, i.e. $a_i > \bar{a}$ reach the limit state much earlier (in less time). Consequently, when the assigned frequency $\bar{l}$ с вероятностью $F_ч \approx 0{,}5$ will be recorded a failure. Therefore choose a frequency $l_0 < \bar{l}$, in which the failure probability does not exceed a predetermined risk value F, for example ($F=F_2$). In this case, the degree of intensity change of the parameter of the technical condition of the product is higher than the average. The maximum intensity changes of the parameter of the technical condition:

$$a_0 = \mu \cdot \bar{a},$$

where: μ – the ratio of the maximum intensity changes of the parameter of the technical condition, this should respect the condition:

$$P_Д(a_i \le a_Д) = 1 - F = R_Д. \quad (3)$$

The coefficient μ is affected by the degree of risk variation V and the form of the distribution of a random variable.

For the normal distribution:

$$\mu = 1 + z\vartheta, \quad (4)$$

where: $z = \frac{(x - \bar{x})}{\sigma}$ – the normalized deflection corresponding to a confidence level of probability.

For the law of Weibull-Gnedenko ratio of maximum intensity change of the parameter:

$$\mu = \frac{\sqrt[-m]{-\ln(1-P_Д)}}{\Gamma(1+1/m)}, \quad (5)$$

where: Γ – gamma function,

m – parameter of the distribution.

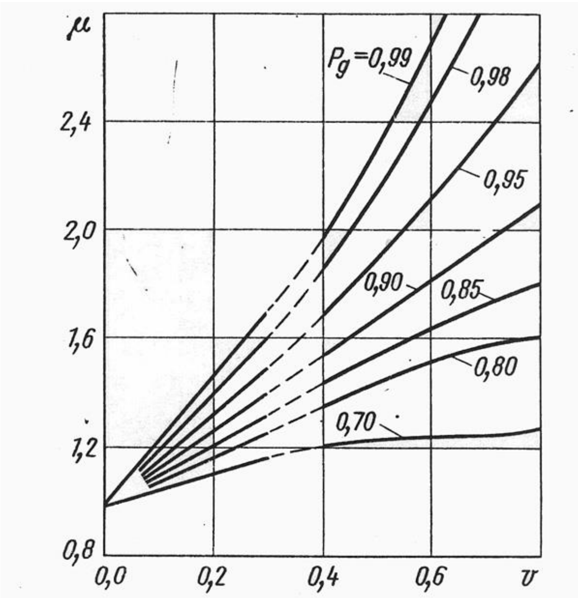


Fig. 3. The influence of the coefficient of variation ϑ for the ratio of the maximum intensity μ

From the graph Fig. 3 shows that the more ϑ or $P_Д$, the more μ (less than optimal maintenance intervals). This method can be used for nodes with fixed parameter change of the technical condition. These include most of the wear components, mechanisms and connections, the technical condition is maintained by adjusting (valve and brake mechanisms, etc.). For adjusting work is characterized $\vartheta = 0{,}5 \div 0{,}8$, in which $\mu = 1{,}6 \div 2{,}1$, i.e., good maintenance intervals will be $1{,}6 \div 2{,}1$ times below the average.

Techno-economic method. He is associated with Oprah-dividing the total specific costs for technical services and repair and their subsequent minimization. The minimum cost corresponds to the optimal frequency of maintenance – l_0.

Unit costs for maintenance:

$$C_1 = \frac{d}{l}, \quad (6)$$

where: l – the frequency of maintenance,

d – the cost of operation maintenance.

With increasing frequency the cost of operation maintenance remain constant or slightly increase, and unit costs are significantly reduced.

Increase the frequency of maintenance leads to a reduction in resource parts, units, assemblies, mechanisms and machines in general, and the growth of repair costs:

$$C_{II} = \frac{C}{L},$$

where: C – repair costs, L – the resource to repair.

The expression $C_I = C_I + C_{II}$ is the objective function, extreme value, which corresponds to the optimum value, i.e. in this case a low unit cost.

The optimal value of periodicity of maintenance or minimum of the objective function is defined graphically (Fig. 4) or analytically for dependencies $C_I = f(l)$ *and* $C_{II} = \psi(l)\cdot$

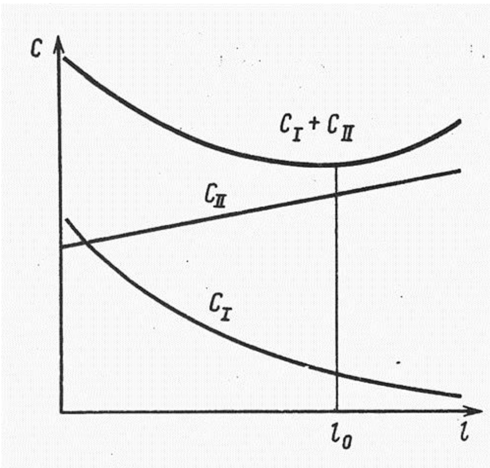


Fig. 4. The scheme for determining the frequency of maintenance of the techno-economic method

Techno-economic method is applied to determine the optimal frequency of work affecting the safety, if you assign the level of risk to take into account the losses associated with accidents.

Economic-probabilistic method – probabilistic and takes into account economic factors, and allows to compare different strategies of maintaining and restoring the health of agricultural machines.

The first strategy is the elimination of failures and malfunctions as they arise, i.e. according to needs (Fig. 5,a).

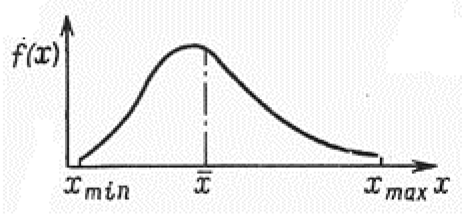
Unit costs:

$$C_{II} = \frac{C}{\overline{x}} = \frac{C}{\int\limits_{x\,\min}^{x\,\max} x \cdot f(x)dx}, \qquad (7)$$

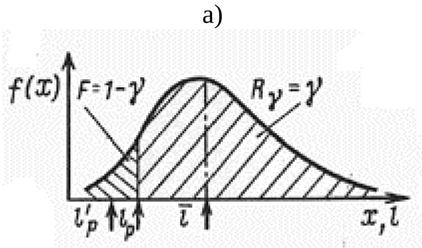
where: $\overline{x}, x_{\min}, x_{\max}$ – average, minimum and maximum time to failure,

C – cost of repair.

The advantage of this strategy is simplicity. The main disadvantages – uncertainty of the status of agricultural machinery in which the failure can occur at any time, hampered the planning and organization of maintenance and repair.



a)



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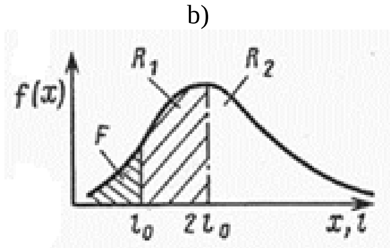

c)

Fig. 5. Methods of performing maintenance and repairs: a) repair needs, b) maintenance by operating time, c) maintenance of technical conditions

The second strategy involves the prevention of failures, restore the original or close to it condition of agricultural machinery and his components, assemblies and systems. However, theoretically, the failure and malfunction can occur with a frequency as many small (Fig. 5,b). The second strategy cannot be executed in pure form, i.e. the elimination of failures and malfunctions is carried out in the period of periodic control and recovery operations.

Thus, we can speak about mixed strategy, which is diagnostic and maintenance according to the preventive maintenance system and repair and elimination of failures and malfunctions as they arise. In this case, you specify the acceptable probability of failure or the required probability of failure.

Mean time, which will be eliminated waivers:

$$l'_p = \frac{\int\limits_{x\,\min}^{x\,\max} l \cdot f(l)dl}{\int\limits_{x\,\min}^{l_p} f(l)dl}, \qquad (8)$$

where: b_p – the frequency of preventative maintenance.

Failures that occurred before held $l_p\ (x_i < l_p)$, eliminate at least the appearance. The cost to remediate these failures in any strategy is equal to C, i.e., have a value of fault that occur with certainty x_i, equal C.

The rest of the work is carried out with a frequency of b_p, cost d and the probability of this event $R = P_Д$.

The advantages of the second strategy:

– guaranteed a certain level of reliability of agricultural machines,

– expenses for maintenance of the healthy state is lower than in case of refusal (*d* < *C*), because Trouble-shooting is accompanied by additional losses associated with aid on the line,

– the possibility of preventive maintenance determines rational ways of improving the maintenance system.

The main drawback – the underutilization of the resource of the separate units, aggregates and systems of agricultural machinery, because the average periodicity of maintenance and repair less MTBF $(l_p < \bar{x})$.

Unit costs are determined by the ratio of the weighted average cost of one operation To the weighted average resource:

$$C_{1-1} = \frac{c \cdot F + d \cdot R}{l_p \cdot R + l'_p \cdot F}. \quad (9)$$

Then, differentiating the expression for *l* and equating the derivative to zero, and determine the frequency corresponding to b_0 $C_{1\text{-}1}$. When comparing unit costs according to the formulas (7) and (9) in the case $C_{1\text{-}1\,min} < C_{II}$ first is the preferred method of preventive strategies, i.e. maintenance.

In Economics and probabilistic method in the same way as when determining the optimal frequency for reliability uses the concept of ratio is the optimal frequency:

$$\beta \leq \frac{l_0}{x} = \left[\frac{2k_{\Pi} \cdot \vartheta_x}{(1+\vartheta_x^2)(1-\vartheta_x^2)}\right]^{\vartheta_x}. \quad (10)$$

where: $k_{\Pi} = \frac{d}{c}$ – the coefficient indicating the ratio of the cost of maintenance to the cost to eliminate failure,

ϑ_x – the coefficient of variation of the MTBF the first strategy (ϑ_x < 1).

If there are limitations in the reliability of the rational frequency ratio is determined:

$$\beta'_0 \leq \left[\frac{k_\omega}{0{,}5 \cdot (\vartheta_1^2 + 1)}\right]^{\frac{\vartheta_x}{1-\vartheta_x}}, \text{ in } \vartheta_x < 1, \quad (11)$$

where: $k_\omega = \frac{\omega_I}{\omega_{II}}$ – the reduction ratio parameter of stream of refusals,

ω_I – the parameter of stream of refusals in the use of preventive strategies,

ω_{II} – parameter flow of failures at the fault on demand.

It should be noted that the adoption of the additional requirements on reliability, reduces rational intervals compared to using only the economic-probabilistic criteria.

To a first approximation, without resorting to calculations on the theoretical dependency ratio rational maintenance intervals can also be found graphically (Fig. 6).

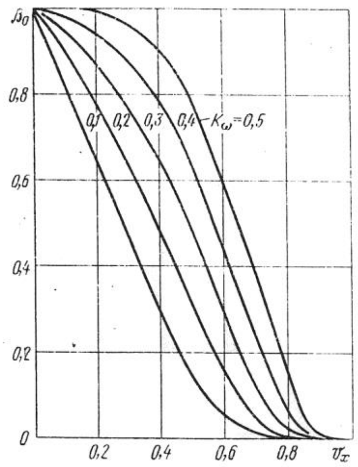

Fig. 6. Optimal maintenance intervals for a given level of reliability

Economic-probabilistic method allows us to find rational ways for improvement of the maintenance organization. Indeed, if the frequency l_0, preventative effects require the products (first group), potential failure which can occur with some probability R_1 (Fig. 5,c) in the mean time $l_0 < x_i < 2l_0$. Products of the second group with potential MTBF $x_i > 2l_0$ enjoy in this, and subsequent services. The probability of this event is $R_2 = R - R_1$, so with this method of implementation of preventive strategies requires the division of products, which is carried out using a diagnosis that requires additional costs.

In this case, the optimal periodicity l_0 controlled all not failed up to this point products. The cost of this control is d_k, and the work to bring the technical condition to normal, with a cost of d_u, carried out only for the first group of products.

The development of preventive strategies using diagnosis would be appropriate if the additional cost of control will be offset by the reduction of the cost of preventive maintenance and damage from failures.

For the case of allowing only two consecutive maintenance unit costs in the prevention with advanced control will:

$$C_{1-2} = \frac{C \cdot F \cdot d_u \cdot R_1 + d_k \cdot R}{F' \cdot l'_p + l_p \cdot R} = \frac{C\frac{F}{R} + d_{\Pi}}{l'_p \frac{F}{R} + l_p}. \quad (12)$$

where: $d_{\Pi} = d_k + kd_u$ – the cost of maintenance with advanced monitoring,

C – repair costs,

F – the probability of failure over a certain range developments,

d_u – the cost of repair,

R_1 – the likelihood of recovery,

d_k – cost control-diagnostic works (CDW),
l_p – the periodicity of maintenance operations,
l'_p – mean time, which will be eliminated waivers,
R – the probability that the CDW,
$k = \frac{R_1}{R_1 + R_2}$ – the coefficient of repeatability, which determines the proportion of products that will require, together with the monitoring and rectify deviations of the parameters of the technical condition of the normal values.

It is obvious that pre-control is appropriate when $(C'_{1-2})_{\min} < (C_{1-1})_{\min}$.

One of the methods of conducting examinations is diagnosis, which is used to determine the technical condition of agricultural machines, units and assemblies without dismantling and is a maintenance item and repair.

The method of statistical tests based on the simulation (imitation) of real random processes maintenance, which allows to exclude influence of adverse factors, to drastically reduce the cost of experiments and accelerated testing.

Modeling can be done manually or on a computer. The initial data for the simulation are applied as actual data observations and the laws of distribution of random variables. When determining optimal maintenance intervals proceed as follows:

– pre-assign one or more values of periodicity of maintenance service $(\overline{l}_1, \overline{l}_2, \overline{l}_3, \ldots)$ and coefficients of variation ϑ_l,

create two arrays of data: time between periodicity of maintenance service [X] maintenance intervals – [l],

– choose from the first array the value of Nara-processing to failure x_i,

– choose from the second array service interval value l_i is determined by taking into account the average frequency $\bar{l}$ and its variations ϑ.

A pair of numbers x_i and l_j is called the implementation. If it is identified $x_i < l_j$, as the failure, while the fixed is performing maintenance operations. If the probability of failure in the simulation more than the specified, then reduce the source data periodicity and repeat the simulation.

From Fig. 7 shows that increasing the frequency of maintenance is reduced the probability of carrying out operations of diagnostics, and increases the likelihood of failures between maintenance. The value of the probability of carrying out maintenance operations on the control results and the coefficient of the frequency of occurrence initially increases up to a certain limit and then decreases.

Thus, if optimum performance of the contents of the maintenance operations will be the most complete, and the ratio between the controlling and performing operations of rational.

The introduction of additional quantities (the cost or complexity of performing preventive or repair operations) will allow in each individual case to determine the total unit cost of maintenance and repair and to compare different maintenance intervals, according to the economic criterion.

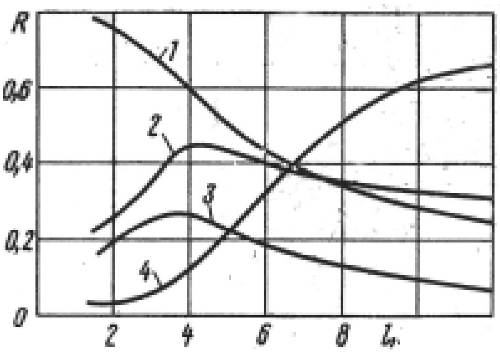

Fig. 7. Influence of maintenance intervals on the condition of the brake system: 1 – probability of executing only the control part of the operation, 2 – coefficient of repeatability, 3 – probability of completing the performing of the operation according to inspection results, 4 – probability of failure between maintenance.

The mapping of all possible strategies, means of implementation and the costs involved can be carried out using the card preventive operation (Fig. 8), which shows:

– the boundary unit cost (1) corresponding to elimination of failure on demand (C_{II}),

– unit costs (2) while holding the parameter of the technical condition, i.e., advanced control (C_{1-2}),

– unit costs (3) during the operating time (C_{1-1}),

– changing the tolerance parameter of the technical condition (4) when performing maintenance on (C_{1-2}).

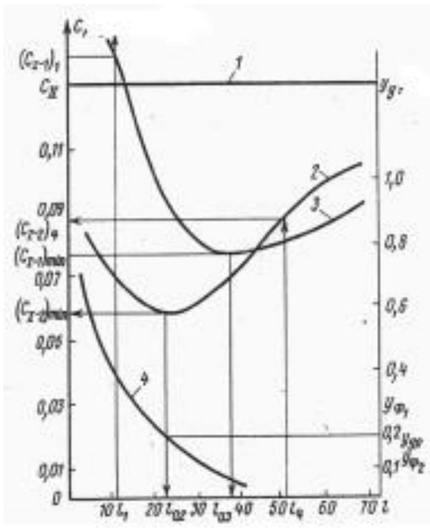

Fig. 8. Card of preventive maintenance operations

Map for the particular unit or host allow:

– to compare the different techniques and strategies,

– to determine for various methods of optimal frequency and the corresponding specific over-spending,

– assign the valid values for the parameters of the technical condition of the maintenance in conducting the parameters of the technical condition.

If, for example, the results of control when the periodicity $l_{0,2}$ (C_{1-2}) the actual value of a parameter of the technical condition $У_{ф,2} > У_д$, in addition to diagnostics it is necessary to conduct Executive work, i.e. finishing of the parameter of the technical condition to the rated value. When $У_{ф.2} < У_Д$ the executive part of the operation when the maintenance is not carried out. It follows from the foregoing that, first, the use of diagnosis contributes to the development of preventive maintenance strategies, and secondly, whether and how the precautionary strategy (diagnosis or not) are determined by technical and economic calculations, thirdly, depending on the taken for the operation frequency is acceptable may be any of the described strategies (compare the frequency $l_1, l_{0.2}, l_{0.3}, l_4$).

Consider in General a few examples of determining the frequency of maintenance (l_0):

A) At the acceptable level of reliability. You must select a rational frequency, in which the probability of failure F(x) does not exceed a given degree of risk.

For all mechanisms and units, ensuring the safety taken $R_Д$ =0,9 and get a frequency significantly less than the average MTBF $\bar{x}(\bar{l})$:

$$l_0 = \beta \cdot \bar{l} = \beta \cdot \bar{x}.$$

The rational frequency ratio β takes into account the coefficient of variation ϑ of the MTBF and adopted by the permissible probability of failure $R_Д$ =0,9.

For the normal distribution take, for example, ϑ =0.2 and in Tabl. 1 find β =0,75.

In the end, we find about the periodicity of technical service of agricultural machines

$$l_0 = \beta \cdot \bar{l} = 0{,}75 \cdot \bar{l} = 0{,}75 \cdot \bar{x}.$$

B) At the acceptable value and regularities of changes in parameters of the technical condition.

We had already discussed the patterns of change in the technical state of the nodes of agricultural machinery for the development described power functions (1) or linear relationships (3).

Positioning the values of the parameters of the technical condition of several units or mechanisms, to the moment developments *l*, they are valid *УД* and the initial *Ун* values, it is easy to calculate the time until each reaches $l_Д$.

Have

$$y_i = a_0 + a_{1i} l^b, \quad Ун = a_0,$$

where: y_i – the value of the parameter of the technical condition of each agricultural machines.

The valid time of each of the agricultural machines to achieve the parameter *УД* is

$$l_Д = \left(\frac{У_Д - a_0}{a_{1i}} \right)^{1/b}.$$

Determine the average value of achievements

$$\bar{l}_Д = \sum_{i=1}^{n} \frac{\bar{l}_{Дi}}{n}.$$

The standard deviation

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (l_{Дi} - \bar{l}_Д)^2}{n-1}}.$$

The coefficient of variation

$$\vartheta = \sigma / \bar{l}_Д.$$

It is necessary to consider the ratio of the maximum intensity changes of the parameter of the technical condition μ, provided the condition

$$P_Д(l_i \le l_{Дi}) = 1 - F = R_Д.$$

The ratio μ is affected by the coefficient of variation ϑ and the form of the distribution.

For the normal distribution

$$\mu = 1 + z\vartheta,$$

where: $z = \frac{\left(l_{Дi} - \bar{l}_Д\right)}{\sigma}$.

If $\vartheta = 0{,}4 \div 0{,}6$, the ratio of the maximum intensity μ for the law of distribution of Weibull–Gnedenko find out of based on

$$\mu = \frac{\sqrt[-m]{-\ln(1 - P_Д)}}{\Gamma(1 + 1/m)},$$

where: Γ – gamma function, m – parameter of the distribution.

Having the value of the function of the standard normal distribution

$$\Phi(z) = 1 - F,$$

it is easy to determine the value of its argument Z and calculate the value for the service interval (l_0):

$$l_0 = \bar{l}_Д / \mu.$$

If you take accepted above the allowed probability of failure $R_Д$ = 0,9 and ϑ = 0,2, then find $z \approx 1{,}25$.

Hence the frequency when $\mu = 1 + 1{,}25 \cdot 0{,}2 = 1{,}25$ will

$$l_0 = \bar{l}_Д / \mu = \frac{\bar{l}_Д}{1 + 1{,}25 \cdot 0{,}2} = 0{,}8 \cdot \bar{l}_Д .$$

Values $P_Д$ and ϑ from the graph in Fig. 4 find $\mu \approx 1{,}25$ and get

$$l_0 = \bar{l}_Д / \mu = \frac{\bar{l}_Д}{1{,}25} = 0{,}8 \cdot \bar{l}_Д .$$

C) Economic-probabilistic method, as well as in the frequency of reliability uses the concept of rational frequency ratio β:

$$\beta_0 \le \frac{l_0}{l_Д} = \left[\frac{2 \cdot k_П \cdot \vartheta}{(1+\vartheta^2)\cdot(1-\vartheta^2)} \right]^{\vartheta}$$

where: $k_П = d / c$ – the ratio of cost of maintenance to repair,

ϑ – the coefficient of variation.

If the unit or the unit has indicators $k_П = 0{,}8$, ϑ =0,2, get

$$\beta_0 \le \frac{l_0}{l_Д} = \left[\frac{2 \cdot 0{,}8 \cdot 0{,}2}{(1+0{,}04)\cdot(1-0{,}04)} \right]^{0,2} = 0{,}81 .$$

If you want to reduce the parameter of stream of refusals in the use of preventive strategies in four times, i.e.

$$k_\omega = \frac{\omega_I}{\omega_П} = 0{,}25 ,$$

where: ω_I – parameter flow of failures of preventive strategies,

$\omega_П$ – the same, while eliminating failure demand, the coefficient of rational frequency will be determined by the formula

$$\beta_0 \le \frac{l_0}{l_Д} = \left[\frac{k_\omega}{0{,}5 \cdot (\vartheta^2 + 1)} \right]^{\frac{\vartheta}{1-\vartheta}} = \left(\frac{0{,}25}{0{,}5 \cdot 1{,}04} \right)^{0,25} \approx 0{,}83 .$$

For these values k_ω= 0,25 and ϑ= 0,2 from the graph in Fig. 6 we find that $\beta'_0 \approx 0{,}88$.

The calculation of the coefficients of the rational frequency shows that with decreasing values of K-factor of the variation between failure ϑ and increases maintenance intervals, i.e., here based on the first strategy of cost C_I diagnostic work is reduced, and the cost C_{II} to repair under the second strategy rise or in the General case $l_0 \to \bar{l}_Д$.

Additionally it is necessary to analyze the feasibility of the method and statistical tests.

CONCLUSIONS

1. Additional requirements for reliability, reduce rational intervals compared to using only the economic-probabilistic criteria.
2. At optimum performance contents maintenance operations will be the most complete, and the ratio between the controlling and performing operations of rational. The introduction of additional quantities (the cost or complexity of performing preventive or repair operations) will allow in each individual case to determine the total unit cost of maintenance and repair and to compare different maintenance intervals, according to the economic criterion.
3. The calculation of the coefficients of the rational frequency shows that with decreasing values of the coefficient of variation of the MTBF is increased maintenance intervals, i.e., here based on the first strategy, the cost of diagnostic work is reduced and repair costs for the second increase.
4. Additionally it is necessary to analyze the feasibility of the method and statistical tests.

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НОРМАТИВЫ ТЕХНИЧЕСКОЙ ЭКСПЛУАТАЦИИ СЕЛЬСКОХОЗЯЙСТВЕННЫХ МАШИН

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Аннотация. Для каждого типа сельскохозяйственных машин и условий их эксплуатации определены объем и периодичность технического обслуживания. Нарушение нормативов обслуживания приводит к ухудшению технического состояния узлов и агрегатов машин, влияющих на его технологичность. токсические и экономические показатели.

При назначении технических условий на предельные состояния выходных параметров механизмов выбираются лишь те, изменение которых возможно в процессе эксплуатации. Если опыт эксплуатации свидетельствуют, что данный выходной параметр не претерпевает изменений или эти изменения не регламентированы требованиями к работоспособности механизмов, то технические нормативы не устанавливают и его предельных значений. Следует отметить, что сложность процессов функционирования и потери

механизмом работоспособности часто приводят к необоснованным назначениям нормативов на предельные состояния или к их отсутствию для ряда характеристик. Кроме того, численные значения допусков на выходные параметры часто устанавливаются для новых механизмов и не оговариваются допустимые пределы их изменения. Поэтому весьма актуальной является задача по обоснованию и установлению запасов надежности по выходным параметрам механизмов. При этом для современных сельскохозяйственных машин часто целесообразно устанавливать нормативы не только на предельные состояния по выходным параметрам, но и по степени повреждения отдельных элементов машины, определяющих изменение ее характеристик. Так лимитируются предельные состояния по износу, по степени деформации, по величине возникающих трещин и другим повреждениям. Существуют нормативы на предельные состояния агрегатов и узлов сельскохозяйственной техники, где указываются критерии и величины наибольших повреждений, при достижении которых узел и машина требуют ремонта.

Качество документации на эксплуатацию машин характеризуют не только ошибки в чертежах, технической документации или отклонения от стандартов и нормативов, но и такие показатели, как уровень стандартизации и унификации, продуманность и прогрессивность технических решений, технологичность, ремонтопригодность конструкции и ее металлоемкость, простота конструктивных форм, обоснованность технических условий на элементы машин и на выходные параметры и другие показатели совершенства самой конструкции сельскохозяйственной машины.

Требования к организации эксплуатации сельскохозяйственной машины включают нормативы на проведение технического обслуживания и ремонтов, инструкции персоналу о мерах по предотвращению аварий и ликвидации их последствий, по распределению ресурсов в пиковых нагруженных состояниях.

Ключевые слова: норматив, вероятность, эксплуатация, ресурс, сельскохозяйственная машина.