UDC 629.114.2

ADJUSTMENT OF TRACTORS TO ADJUSTMENT OF DISCLAIMERS AND DISABILITIES IN FIELD CONDITIONS

S.M. Uminsky, V. I. Makarchuk
Odessa State Agrarian University

The questions of influence of conditions of operation on adaptation of tractors to elimination of failures in field conditions are considered. In this case, it is useful to perform the analysis using the availability factor. When analyzing the adaptability of tractors to eliminate failures and malfunctions, it is preferable to use interval estimates that allow them with a given probability to determine their accuracy.

Key words: tractor, engine, operation, laboriousness, repair, distribution, resource, failure, readiness factor, coefficient of technical use.

Introduction. In real conditions of operation, the second state of a violation of the normal operation of tractors - the most frequent. Therefore, timely detection of a failure or tractor failure and correct classification of the tractor can detect and eliminate the failure and prevent the possibility of an emergency condition of the tractor. To quickly determine the reasons for the violation of the tractor allows the application of a systematic approach to the detection of failures. The basis is the principle of logical search for an integral part or assembly unit, in which the most likely possibility of occurrence of failure, which determines the characteristic that is characterized. This approach avoids unnecessary disassembly of the tractor, thus reducing the complexity of eliminating the consequences of failures, identifying directions for improving the operational efficiency of tractors and improving reliability [1,2].

Problem. The failures of a constructive and technological character, as well as the appearance of cracks, various kinds of breakage, destruction, deformation and rupture of products, which account for up to 63%, due mainly to structural defects, violation of the technology of manufacturing and assembly, low quality welding and other technological processes production. The elimination of emerging failures is mainly due to the replacement of MS, IT and parts (68%), recovery of products (20%), and only 4% of failures are eliminated by regulation, tightening, cleaning, flushing and other similar techniques. At the same time, a certain number of failures in the conditions of operation is practically not eliminated (up to 8%). Tractors often work with leaking water, fuel I grease, faulty light and sound signaling. The main technical base for eliminating the simple failure is the tractor brigade, which eliminates up to 76% of the consequences of the failures of the I and II difficulty groups. About 18% of failures are eliminated in the central workshops of farms (the failure of the III group of complexity), and only a small part of the failures (up to 3%) associated with the dismemberment or replacement of MS, is eliminated in repair factories, Directly in the field eliminated up to 3% of failures and malfunctions . Thus, the high proportion of failures that are eliminated in the brigade of the farm and by the tractorists themselves indicates the need to improve the adaptability of tractors to the conditions of operation, in particular, to improve the technological efficiency of their structures when eliminating the consequences of failures and malfunctions. The most common manifestations of failure (up to 20%) are expressed in the destruction, melting, breaking of parts from non-metallic materials (eg water pump seals, filter cases, etc.), breakage (rings, springs, shafts) - 10%, the appearance of cracks (body parts, covers, lubricants and fuel lines) - 9%, burning (gaskets) - 6% destruction (bearings, bushings) - 5%, mechanical damage (tires, gaskets) - 5%, freezing, rotation, deformation, bending parts - 28%, breakage of metal products (bolts, studs) - 3%, cut (carving, rivets, keys) - 3%, break (according to vartsi) - 4% circuit (wiring, winding) - 3%. Refusals for refracting do not exceed 3%, in particular, by nozzles and clutch coupling [2,3,4,8].

The purpose of research. Depending on the deviation in the design documentation, the technology of production and operating conditions there are failures, but without disassembly (the failure of the I and II difficulty groups), and only to eliminate 6.4% of failures (failure of the III group of complexity) disassembly or dismemberment of tractors and their MS . To identify the most convenient and time-consuming places for the design of the tractor when eliminating the failures, it is necessary to know the distribution of the value of the complexity of their elimination on the CM and systems.

Research results. Figure 1 shows a diagram of the relative (in%) operational complexity and the coefficient of availability of elimination of failures (for the tractor KhTZ-221). The diagram shows that the smallest fraction of the complexity of the elimination of failures in relation to the complexity of the whole tractor falls on the chassis, electrical equipment , devices, cab and plumage, auxiliary units of the engine and units of the hinged system (while improving the accessibility of these MFs and systems). However, the complexity of eliminating the consequences of failures on the engine and transmission is high and requires further reduction. The most effective way to reduce the complexity of eliminating failures is usually to eliminate the causes of potential failures (mainly due to increased resource details). At the same time, technical and economic constraints often hinder this, and if the probability of failure is significant, the loss of time and labor to eliminate it can be significantly reduced by increasing accessibility to MS and systems when eliminating failures. In this case, it is useful to perform the analysis using the coefficient of availability (Fig. 1). When eliminating bursts a certain proportion of labor costs (in some cases, it reaches a large value) has to be auxiliary operations, that is, those types of work, without which it is impossible to carry out basic work in accordance with the rules of the TOE. One of the possible options for reducing these labor costs may be of a corresponding origin (constructive, technological or operational). Analysis of the causes of these refusals allows timely measures that ensure a reduction in their number [3,4,5,8].

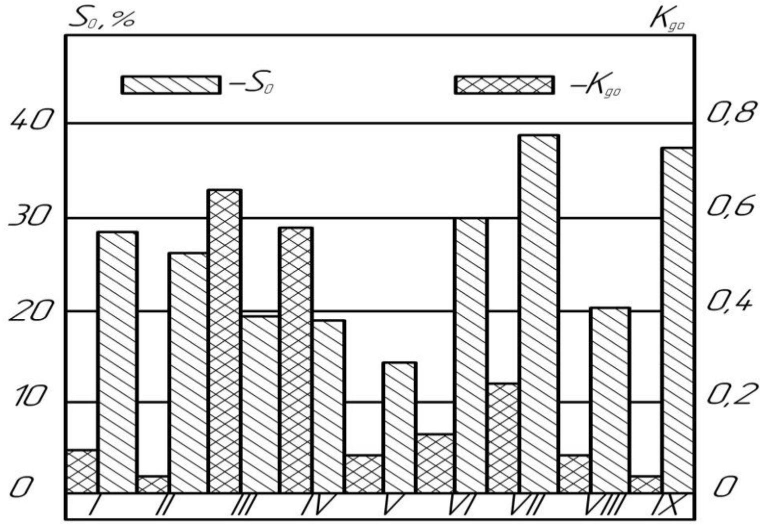

Fig.1. The diagram of the relative complexity S_0 and the coefficient of availability $K_{\partial o}$ of elimination of failures: I -equipment. II - devices, III - engine, IV - transmissions, V - running system, VI - hydrodynamic system, VII - steering, VIII - auxiliary units of the engine, IX - cabin and plumbing.

Considerable, the loss of time and labor to eliminate it can be greatly reduced by increasing accessibility to MS and systems when eliminating failures. In this case, it is useful to perform the analysis using the availability coefficient $K_{\partial o}$ (Figure 1). When eliminating bursts, a certain proportion of labor costs (in some cases, it reaches a large value) has to be auxiliary operations, that is, those types of work, without which it is impossible to carry out basic work in accordance with the rules of the TOE. One of the possible options for reducing these labor costs may be of a corresponding origin (constructive, technological or operational). Analysis of the causes of these refusals allows timely measures to reduce their number [2,7,5,8]. There are different schemes for the classification of failures on single features (the way of elimination, cause of occurrence, external appearance, etc.). For tractors, a relatively complete classification of structural and technological failures. Existing classifications reflect different properties of failure, but they do not fully cover all aspects of the assessment of the technolo gism of eliminating the consequences of failures in the field, in particular, the reasons for the occurrence of operational failures, conditions for their occurrence (types of performed works), the ability to identify and prevent failures built-in means of control and protection, place of elimination of failures and malfunctions (in the field, the farm, etc.). It is important to separate the refusals of the possibility of their detection, that is, to identify controlled or uncontrolled failures directly in the process of work of tractors. The study of the influence of operating conditions on the trouble-free operation of tractors allowed to present a classification of failures and malfunctions in a generalized form and to take it as a basis for qualitative evaluation. As a result of observations, it was found that for operational reasons 37% of failures arise, of which 13% - due to violations of the rules of the maintenance, the majority of failures (93.6%) is eliminated without disclosing the internal cavities of MS and systems, or with partial improvement of accessibility. The most accessible at elimination of consequences of failures is a cab and a feather, a steering, an electrical equipment and devices. Improved availability is achieved by the rational arrangement of pipelines, traction control, wiring tracks, connecting elements, etc. In the future, access to the engine, transmission system and transmission elements should be facilitated, primarily by reducing the volume of auxiliary operations that provide access to the replacement element, as well as improving the quality of assembly, regulation and other measures that increase the reliability of the work. Of course, not all refusals deserve the same assessment. First of all, measures should be developed to reduce the number of such refusals, the elimination of which consequences are labor-intensive and associated with prolonged downtime. The qualitative analysis of elimination of failures and malfunctions allows to reveal the causality of their occurrence, to give them an assessment according to the groups of complexity, the nature of manifestation, etc. However, for a detailed analysis of the adaptability of tractors to eliminate abandonments, a quantitative estimate is required [2,6,8]. Quantitatively, the evaluation of the trouble-free operation of tractors, including the adaptability of their designs to the current repair (to eliminate the consequences of failures and malfunctions) is currently carried out on many indicators. The main ones include: readiness factor, coefficient of technical use, average and specific total operational complexity of current repairs, and others. In this case, as a rule, apply point estimates. But it is very important to determine interval estimates of indicators, since they can help establish the reliability of point estimates. If the point estimates coincide, different confidence intervals (at a given probability) give additional information. In addition, uncertainty often occurs when, in the aftermath of the research of several tractors, a comparative analysis is required on the feasibility of eliminating the failure of a set of indicators. This is comparable comparison is performed separately according to the point or interval estimates of refusal, average recovery time or average total operational complexity of recovery, which is not always reliable, since the conclusions from these estimates are in many cases contradictory. Two approaches to the decision of a given task are worthwhile. As the first one, let's consider a comparative assessment of the adaptability of tractors to eliminate failures using the classical probability theory. The True Tractor begins to operate at the time $T = 0$ and, after working out the accidental time x_1 stops to eliminate the failure or malfunction y_1. The repair requires a random time. The result of the calculation will be a set of data $\{x_i\}_{i=1...n}$ and $\{y_j\}_{j=1...m}$. At the same time, we operate not with $\{x_i\}$ an array and with an array $\{\Delta_i = x_{i+1} - x_i\}_{i=1...k}$, with sequences of time between failures and time to eliminate failures, leaving the designation of the former. We assume that x_i - independent random variables with a distribution density a $f_i(x)$ and $y_j \neq 0$ distributed with density, $g_i(y)$ and $f_i(x)$ $g_i(y)$ - arbitrary two-parameter distributions given in the interval $(0,\infty)$. Since samples $\{x_i\}$ $\{y_j\}$

should be significant for reliable data, they are simultaneously exploring several types of tractors of the same type, and then data is combined into one set. Before this, individual implementations are checked for the absence of significant differences (according to Student's criterion). This test gives grounds to speak about stationarity (in the broad sense) of the general collections $\{x_i\}$ and $\{y_j\}$. Consequently, the process of eliminating the consequences of failures and malfunctions can be considered as a random stationary process with the final time of their recovery. The main indicator of evaluation is the readiness factor

$$K_r = \frac{1}{1+\frac{T_в}{T_o}} = \frac{1}{1+\eta} \qquad (1)$$

where T_o - failure rate; $T_в$ - average recovery time after failure.

From formula (1) it is clear that the lower the value of the η indicator, the higher the level of adaptability of the tractor to eliminate the failures. However, in determining η the use of point estimates and not always able, because the likelihood of the existence of these estimates may vary significantly. This is scientifically confirmed by the dependencies presented in Fig. 2. The sought-in evaluation η should be determined within an interval whose boundaries depend on the degree of probability evaluated η. Since we usually operate only by point estimates, and we will need estimates and intervals, T_o then $T_в$ respectively, we find:

$$T_o = \int_0^\infty xd\left(f(x)\right), \qquad (2)$$

$$T_в = \int_0^\infty yd\left(g(y)\right). \qquad (3)$$

In this case, T_o we define as a mathematical expectation of the time between failures. This allows you to get interval estimates with confidence limits.

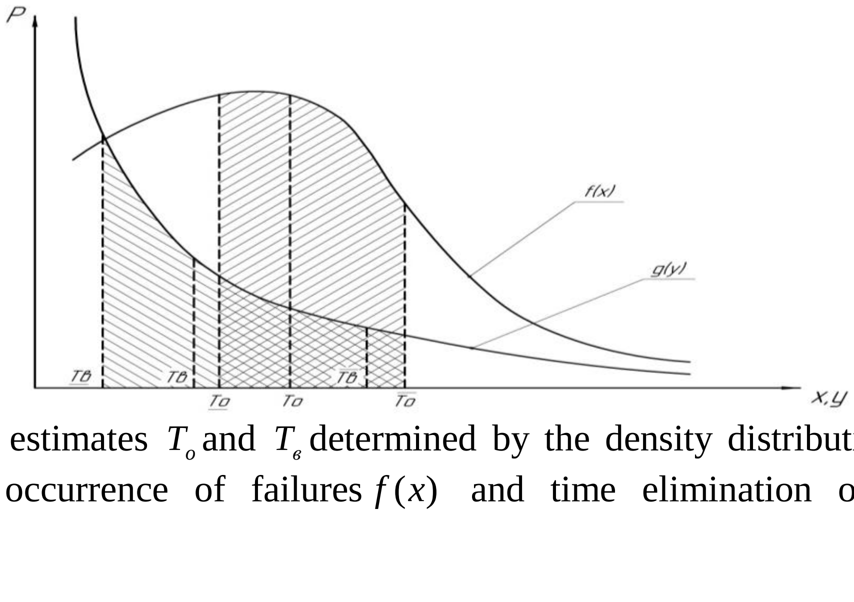

Fig. 2. Interval estimates T_o and $T_в$ determined by the density distribution of the probability of occurrence of failures $f(x)$ and time elimination of failures and $g(y)$.

It is known that for large volumes of sample data $\{x\}$ and $\{y\}$ (more than 50) sufficiently accurate values of confidence limits can be obtained by an approximate method based on the definition of the lower and upper confidence limits $\underline{T}_o$ $\underline{T}_в$ $\overline{T}_o$ $\overline{T}_в$ and separately for the values T_o and $T_в$. Bilateral confidence limits for η probability $\alpha = \alpha_o^2 = \alpha_в^2$ are defined as:

$$\alpha = p\left(\frac{\underline{T}_в}{\overline{T}_o} \le \frac{T_в}{T_o} \le \frac{\overline{T}_в}{\underline{T}_o}\right) \qquad (4)$$

Substituting the boundaries of the interval estimation η into formula (4), we obtain an integral estimation of the readiness factor K_r. The disadvantages of this indicator should be the presence of some restrictions. In order to eliminate these restrictions, we will conduct a comparative analysis of the technological efficiency of eliminating tractor failure using the indicator, taking into account the average complexity of recovery. Let's assume that the time of finding a tractor in its proper condition T_i is distributed according to the law $f(t)$, and the complexity Z_i - in accordance with the law $g(z)$, $f(t)$ and $g(z)$ - arbitrary two-parameter differential functions of the distribution given in the interval $(0,\infty)$. In the same way as in the first case, the randomness $\{T_i\}$ and $\{Z_i\}$ stationary of the samples and. We introduce the stationary value of the indicator of the specific total operational complexity of eliminating failures:

$$H = \frac{Z}{T} \qquad (5)$$

where $Z = \int_0^\infty zd\left(g(z)\right)$ and $T = \int_0^\infty td\left(f(x)\right)$ - mean values $\{T_i\}$ and $\{Z_i\}$ respectively.

The use of point H estimates is very rough, since the likelihood of these estimates generally varies significantly. Therefore, for the analysis of the properties of the technology of elimination of failures, it is proposed to use an integral estimate H_α. By analogy with formula (5) we have:

$$\underline{H}_\alpha \le H_\alpha \le \overline{H}_\alpha \qquad (6)$$

where $\underline{H}_\alpha = \underline{Z}_{\alpha_1} / \overline{T}_{\alpha_2}$ and $\overline{H}_\alpha = \overline{Z}_{\alpha_1} / \underline{T}_{\alpha_2}$ - lower and upper limits $\alpha = \alpha_1 \alpha_2$ - confidence probability unilateral limits.

The same form has formulas for bilateral trust limits, corresponding to the trust probability $\alpha = \alpha^2{}_1 = \alpha^2{}_2$. We will analyze the adaptability of tractors to eliminate failures and malfunctions using interval estimates of the indicator H_α. For calculations we will take the results of observations on tractors KhTZ-5020, YUMZ-8240 and YUMZ-8070 under conditions of their operation. Data on failures and results of calculations are given in Table 1, namely: $T_э, Z_э, \sigma_э$ and T_T, Z_T, σ_T - respectively, the estimation of mean and root mean square deviations, obtained experimentally and in theoretical distributions; K and β - parameters of the theoretical Weibull distributions, taken at the level of significance α; $H_э \cdot 10^2$ and $H_T \cdot 10^2$ - point estimates of the specific total operational complexity of elimination of failures, calculated on the basis of experimental and theoretical data, respectively. In the last graphs, the upper and lower boundaries of the interval estimation, the average of which are equal $H_T \cdot 10^2$. The theoretical functions of time distributions between failures and time to eliminate their consequences were described by Weibull's law:

$$f(t) = \frac{K}{\beta} T^{K-1} \cdot \exp\left(-\frac{t^K}{\beta}\right), \qquad (7)$$

The hypothesis was taken with the level of significance:

$$p\left(\chi^2 \leq \Delta\sigma\right) = 0{,}1 \qquad (8)$$

The difference between the estimates of the mean and the mean square deviation obtained from the experimental data (presented in a grouped form) and the theoretical distribution, due to the fact that the selection of distribution parameters is carried out not by the method of moments, but by the minimum criterion χ^2. However, in further calculations it is recommended to use the estimates of the theoretical distribution as the most common. On Fig. 3. graphs of differential functions of distribution of probability density of the time between the failures and the complexity of eliminating failures are depicted. From Fig. 3 it is evident that the schedules of the abandonment of tractors YUMZ-8240 and YUMZ-8070 almost coincide. However, the statistical characteristics of the complexity of eliminating the consequences of failures are different. The average time spent on the failure of the tractor KhTZ-5020 is lower than that of the tractors YUMZ-8240 and YUMZ-8070, and the average complexity of elimination, failure is less than they (Table 1). Therefore, it is difficult to make an unambiguous decision on comparable objects only in terms of the reliability of T and the adaptability to eliminating Z failures, and there will be a useful indicator H_α here. With a confidence probability = 0.81, the indicator H_α is equal to the specific operational complexity of the fault elimination (based on 100 g of fail-safe operation), respectively, for tractors:

KhTZ-5020 - (0,55 0,73 0,98);

YUMZ-8070 - (0,41 0,64 0,97);

YUMZ-8240 - (0.56 0.77 1.07).

From the definition of the indicator it follows that the smaller it is, the higher the level of adaptability of tractors to eliminate failures and malfunctions in the field. Consequently, the data of tractors in the estimation of the indicator are in order to increase the level of technological efficiency of their structures when eliminating the failures in the following way: YUMZ-8240, KhTZ-5020 and YUMZ-8070. This means that tractors MTZ-80L are much better adapted to maintenance work than ХТЗ-5020 and YUMZ-6L. Thus, in the analysis of the adaptability of tractors to eliminate failures and malfunctions, it is preferable to use interval estimates that allow them with a given probability to determine their accuracy.

Using for this purpose an indicator characterizing the specific total operational complexity of the elimination of failures makes it possible together with the failure to take into account the labor costs of recovery [2,8].

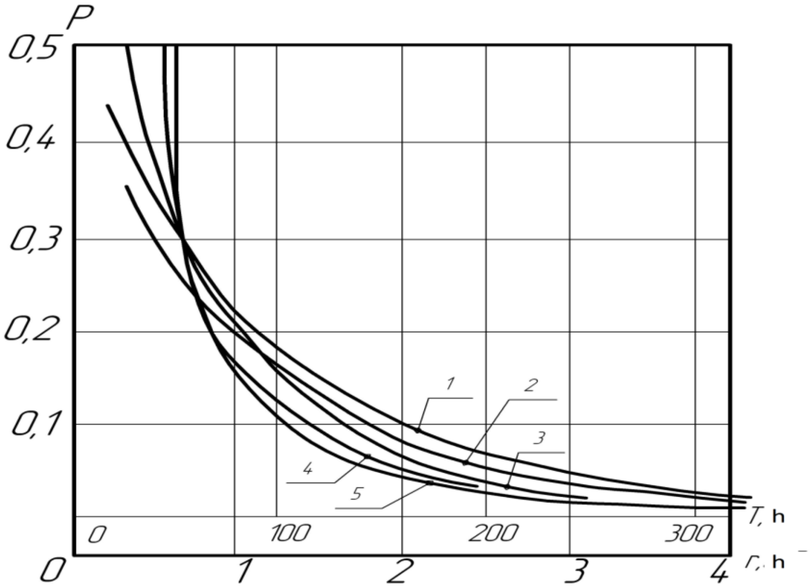

Fig. 3. Statistical characteristics of the fail-safe operation of tractors: the complexity of tractors for YUMZ-8070 and YUMZ-8240 (1) and KhTZ-5020 (2) and working hours for tractors KhTZ-5020, YUMZ-8070 (4), YUMZ-8240 (5) .

Conclusions. The most effective way to reduce the complexity of eliminating failures is usually to eliminate the causes of potential failures (mainly due to increased resource details). At the same time, technical and economic constraints often hinder this, and if the probability of failure is significant, the loss of time and labor to eliminate it can be significantly reduced by increasing accessibility to MS and systems when eliminating failures. In this case, it is useful to perform the analysis using the availability factor. When eliminating bursts, a certain proportion of labor costs (in some cases, it reaches a large value) has to be auxiliary operations, that is, those types of work, without which it is impossible to carry out basic work in accordance with the rules of the TOE. The study of the influence of operating conditions on the trouble-free operation of tractors allowed to present a classification of failures and malfunctions in a generalized form and to take it as a basis for qualitative evaluation. As a result of observations, it was found that for operational reasons 37% of failures arise, of which 13% - due to violations of the rules of the maintenance, the majority of failures (93.6%) is eliminated without disclosing the internal cavities of MS and systems, or with partial improvement of accessibility. When analyzing the adaptability of tractors to eliminate failures and malfunctions, it is preferable to use interval estimates that allow them with a given probability to determine their accuracy. Using for this purpose the indicator characterizing the reliability of the specific total operational complexity of the elimination of failures, makes it possible, together with the failure to take into account and labor costs for recovery.

Table 1. **Results of interval estimation of indicators of adaptation of tractors to eliminate failures and malfunctions**.

Mark of tractor	Output	Sample volume	Estimates by grouped data		Weibull Law Distribution Parameters		Level of Significance	Estimation of Theoretical Distribution		Point Estimation, H		Bilateral Limits			
												T,Z		*H2*	
			Te, Ze	*δe*	*K*	*β*	*λ*	*Tт, Zт*	*δт*	$He*10^2$	$Hт*10^2$	Upper	Lower	Upper	Lower
KhTZ-5020	*Ti*	122	19,50	91,30	1,000	100,00	0,1	100,00	100,00			113	89,00		
										0,805	0,73			0,08	0,55
	Zj	125	0,80	0,71	0,700	1,47	0,1	1,06				0,87	0,62		
UMZ-8240	*Ti*	99	103,10	94,97	0,920	82,00	0,1	125,10	136,10			144	133,00		
										0,806	0,64			0,97	0,41
	Zj	100	0,88	0,88	0,420	0,57	0,1	0,80	2,30			1,10	0,59		
UMZ-8070	*Ti*	139	102,40	94,70	0,93	77,80	0,1	115,40	125,20			130	102,50		
										1,050	0,77			1,07	0,56
	Zj	149	1,08	1,10	0,583	0,69	0,1	0,89	1,82			1,10	0,73		

REFERENCES

1.Lyshko G.P., Topilin G.E. Maintenance, diagnostics and storage of tractors. - Chisinau: Moldovan Map, 1981, - 16.2 p.
2.Topilin GE, Uminsky S.M., Chuchuy V.P. Operational traction of tractors. Simeksprint Printing and Publishing House. ISBN 978-966-2771-35-0. 2014, 593 p.
3.Uminsky S.M., Chuchuy V.P., Inyutin S.V. Technical service in the agro-industrial complex. TES publishing house and printing house., ISBN 978-617-7054-07-7, 2013, 196 p.
4.Topilin GE, Uminsky S.M. Generalized estimation of conditions of technical exploitation of tractors on the set of features. - AGRICULTURAL BULLETIN PRIORNORMORY. Technical sciences.Whip 45. Odessa, 2008- 196 p. P.76-90.
5.Uminsky S.M., Chuchuy V.P., Inyutin S.V. Technical exploitation of mobile agricultural machinery. TES publishing house and printing house., ISBN 978-617-733754-06-4, 2015, 224p.
6.Umnsky S.M., Makarchuk V.I. Determination of indicators of adaptation of tractors to maintenance during storage. - AGRICULTURAL BULLETIN PRIORNORMORY. Technical sciences. 2014- 186 s. P.89-96.
7.Uminsky S.M., Chuchuy V.P., Inuitin SV Organization of technical service in agricultural production. TES publishing house and printing house, ISBN 978-617-7054-32-9, 2014, p. 225p.
8. Uminsky S.M., Inyutin S.V. Operational reliability of tractor components. TES publishing house and printing house., ISBN 978-966-2389-88-3, 2013.190 p.

ПРИСПОСОБЛЕННОСТЬ ТРАКТОРОВ К УСТРАНЕНИЮ ОТКАЗОВ И НЕИСПРАВНОСТЕЙ В ПОЛЕВЫХ УСЛОВИЯХ

Уминский С.М., Макарчук В. И.

Ключевые слова: трактор, двигатель, трудоемкость, эксплуатация, ремонт, распределение, ресурс, отказ, коэффициент готовности, коэффициент технического использования.

Резюме

Рассмотрены вопросы влияния условий эксплуатации на приспособленность тракторов к устранению отказов в полевых условиях. В этом случае полезно применять анализ с использованием коэффициента доступности. При анализе приспособленности тракторов к устранению отказов и неисправностей не обходимо использовать интервальные оценки, что позволяет с заданной вероятностью определить их точность.

ADJUSTMENT OF TRACTORS TO ADJUSTMENT OF DISCLAIMERS AND DISABILITIES IN FIELD CONDITIONS

Uminskij S.M., Makarchuk V.I.

Key words: tractor, engine, operation, laboriousness, repair, distribution, resource, failure, readiness factor, coefficient of technical use.

Summary

The questions of influence of conditions of operation on adaptation of tractors to elimination of failures in field conditions are considered. In this case, it is useful to perform the analysis using the availability factor. When analyzing the adaptability of tractors to eliminate failures and malfunctions, it is preferable to use interval estimates that allow them with a given probability to determine their accuracy.