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CONCEPTUAL FRAMEWORK OF MANAGEMENT SYSTEM OF FAILURES OF AGRICULTURAL MACHINERY

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Abstract. *One of the main elements of the management system of failures of agricultural machines is the management of risk factors for the occurrence of failures themselves. Risk reduction is possible in various ways (e.g., equipment replacement, staff training, etc.).*

For the effective implementation of components need to develop methods for each management system element failures of agricultural machinery. In existing agricultural companies have already developed the system and have their own developments in this area. The basis of determination of level of risk of failure lies with expert method, and this stage is complex.

It is known that achieving zero risk in functioning systems is impossible. Currently, the concept of absolute reliability is rejected and uses the concept of acceptable (permissible) risk of failure, the essence of which consists in seeking to achieve this level of reliability, which is acceptable in a given time period or lowest feasible level.

Achieving the lowest possible level is determined by the financial resources of the agricultural companies. Allocating resources is one of the most important organizational processes of agricultural companies. The lack of financing of measures on providing of reliability of agricultural machines can have a negative impact on the gross yield of products of rastenievodstva, the excess – will have a negative impact on the financial condition of the company.

Key words: ***probability, loss, exploitation, efficiency, agricultural machine***

Introduction. With the implementation of the management system of failures of agricultural machinery in addition to the insured costs (funded by insurance premiums paid by insurance carriers) that can be recovered, there are also uninsured costs which cannot be recovered and, as a rule, twice or three times exceed insured costs:

- insurance deductions;
- lost time and overtime, cost of hiring and training replacement;
- the loss of productivity of staff;
- the cost of restoring order;

- lost time equipment usage;
- the cost of renting or leasing replacement equipment;
- increased operational costs attributable to the remaining equipment;
- loss of spares or specialized equipment fines and citations;
- payment for legal services provided in connection with the incident, increased insurance premiums;
- payments on obligations in excess of the amounts insured, the reduction in tidal volume of business and damage to reputation, expenses to remedy the situation.

Formulation of problem. Thus, when the control system failures of agricultural machinery it is important to realize a balanced allocation of resources between protection and production, and to determine in space the security of financial the border and border security – the border, the achievement of which indicates that it creates a situation of unbalanced allocation of resources (Fig. 1).

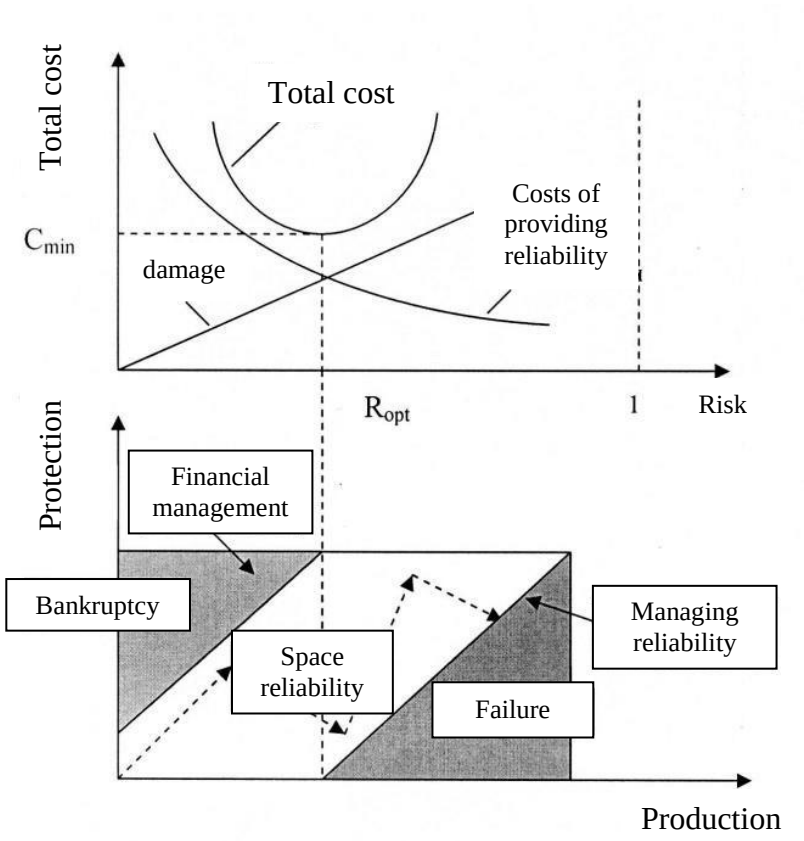

Fig. 1. Boundaries of total cost in management system of failures of agricultural machinery: C_{min} – minimum total cost, R_{opt} – level of risk of accident, the corresponding minimum total costs.

Analysis of recent research results. Immediately eliminate all possible negative factors affecting the occurrence of failure of agricultural machinery is not possible and economically feasible [1]. With this in

mind, the decision to reduce the risk of failure of agricultural machinery will be much more efficient if all the activities to improve first and foremost to choose those that will provide a balance between the costs of ensuring reliability of machinery and the organization of production. In order to make such selection it is necessary to develop a mathematical model of the total cost with the optimization option – the effectiveness of measures to improve the level of reliability of the machines, then find the optimal value of the efficiency of measures on the basis of the criterion of minimum total cost [2–6].

Purpose of research is substantiate the conceptual framework of management system failures agricultural machinery.

Results of research. Mathematical model of the total cost will be incorporated in the basis optimization of the process control factors, the risk of failure of agricultural machinery on the basis of the criterion of minimum total costs in the management system of failures of agricultural machinery agricultural companies. This method will be the solution to the dilemmas arising in the space of reliability.

To date the proposed approach to increase the reliability of agricultural machinery on the basis of the criterion of minimum total cost has not been, and will be of particular interest to enhance the effectiveness of existing control systems, failures of agricultural machinery agricultural companies.

In the management of negative factors, risks of failure of agricultural machinery is important to consider the principle of marginal efficiency of investment, whereby every portion of the additional investments the efficiency of the latter decreases after certain levels of investment.

To determine for agribusiness companies, the optimal level to increase the availability of agricultural machinery in this article the conclusion and analysis of mathematical models of total cost of agricultural companies in the management system of failures of agricultural machinery agricultural companies.

Under the total cost management system of the occurrence of cracks of agricultural machinery agricultural companies refers to expenses aimed at implementation of measures to reduce the risk of failure of agricultural machinery and elimination of consequences of the expected loss from failures. Cases of damage:

- only of the engine, its ancillary units, hoods, its failure, the braking device, not the power elements;
- other elements, if not broken the strength of the structure as a whole;
- bushing steering column;
- ventilation unit, reducer, transmission parts, chassis parts.

In the preparation of proposals to improve reliability of agricultural machinery the article deals with the whole structure of agricultural companies , including engineering staff, fleet, service of service.

Various failures and shortcomings in the work of these subsystems can lead to failures. The main points of the status parameter of the system is the reliability of the machine, which is expressed through the probability of failure. The main factors affecting the reliability of the machine, are the human, technical, non-systemic.

The same type of failures that occur on the same (or different) reasons, and lead to similar consequences, to form a homogeneous flow of events, differing in time of appearance.

However, the possibility of using the Poisson to estimate the probability of failure of agricultural machinery because of their rarity and independence. To confirm the hypothesis about the failure distribution of agricultural machinery Poisson statistics were considered failures with different harvesters: 286 gradual failures, 51 crashes. Identified using the criterion of Pearson (Chi-square) that the failure of agricultural machinery is distributed Poisson with the probability of 0.68 for emergency waivers of 0.71 for gradual. Argument in favor of the proposed hypothesis about the distribution is the proximity of the values of statistical characteristics such as mathematical expectation and variance of the frequency of occurrences of failures of agricultural machinery.

With this in mind, the probability of increase of reliability of agricultural machines that are distributed by the Poisson law is determined by the formula:

$$P(AC) = \lambda_{AC} \cdot T, \qquad (1)$$

where: λ_{AC} – intensity of flow of homogeneous failures, hour^{-1}, T – developments of agricultural machinery.

Stream failure of agricultural machinery is estimated by the parameter stream. For the evaluation of homogeneous events used the intensity of flow events – number of events per unit time and has the dimension [hour^{-1}].

To calculate the magnitude of the individual fluxes (or intensities of flows) the failures of agricultural machinery you can apply three approaches:

1. To determine the value of the parameter flows on the basis of given criterion of probability of emergency failures and statistical correlations of parameters of the flow of failures. One of the approaches of the calculation of the pyramid of risks.

2. λ_{AC} value can be taken equal to the corresponding probabilities of occurrence of particular situations in the expected operating conditions of agricultural machinery established by the norms of validity, provided that the design data requirements have been met and verified by testing at the factory at the beginning of mass production.

3. The parameters for each specific type of failure of agricultural machinery is calculated on the basis of existing classifiers and statistical data of the company.

Any failure of agricultural machinery can be the consequence of several factors (causes).

Each factor has its share in the occurrence of failure. In particular failure and have place their factors, which is complete group of events.

The proportion factor of failures of agricultural machinery represents not that other, as the conditional probability that the failure occurred due to this factor.

Denote the conditional probabilities given in Table 1.

1. Denote the conditional probabilities of occurrence of failure of agricultural vehicles on certain factors.

AC	Factors (causes) failures						
	F_1	F_2	F_3	…	F_a	…	F_g
AC_1	$P(F_1/AC_1)$	$P(F_2/AC_1)$	$P(F_3/AC_1)$	…	$P(F_a/AC_1)$	…	$P(F_g/AC_1)$
AC_2	$P(F_1/AC_2)$	$P(F_2/AC_2)$	$P(F_3/AC_2)$	…	$P(F_a/AC_2)$	…	$P(F_g/AC_2)$
…	…	…	…	…	…	…	…
AC_j	$P(F_1/AC_j)$	$P(F_2/AC_j)$	$P(F_3/AC_j)$	…	$P(F_a/AC_j)$	…	$P(F_g/AC_j)$
…	…	…	…	…	…	…	…
AC_m	$P(F_1/AC_m)$	$P(F_2/AC_m)$	$P(F_3/AC_m)$	…	$P(F_a/AC_m)$	…	$P(F_g/AC_m)$

The probability does not indicate the severity of events. In the assessment of the severity of the possible consequences of uncertainty, the payment of which is the risk matrix.

$$\overline{\sum_{a=1}^{g} P\left(\frac{F_a}{AC_j}\right)} = 1, \forall j,\ j=1,m,\ a=1,g.$$

Every failure, even due to the same cause (or multiple causes) will occur on its own, and will lead to your damage. Therefore, statistical data should be obtained for this factor the average value of the expected loss as the average of the sample or the arithmetic average of simple. These data are summarized in Table 2.

The damage from the failures of agricultural machinery on the same machine will be equal to the average $\overline{C_{AC}}$ and is determined by the formula:

$$Y = \overline{C_{AC}}\ \lambda_{AC} \cdot T, \quad (2)$$

where: $\overline{C_{AC}}$ – the average damage of failure.

Noted that the private costs of agricultural companies in the event of failure of agricultural machinery in two or three times higher insurance payments. Given this, the paper discusses the damages without insurance and level of deductibles (for simplicity and as a first

approximation). The damages associated with the risk. In modern terminology, the concept "risk" has different definition. For example, in the first edition of risk was defined as "combination of the probability of a hazardous event and the severity of potential consequences." In second edition of risk to reliability of agricultural machinery, represents "an assessment of consequences of hazard, expressed in form of predicted probability and severity, while control reference was adopted predvidela the worst situation." In third edition of risk "the predicted probability and seriousness of consequences.".

2. Denote the average of expected losses from failures.

AC	The average damage from the failure on the a-th factor						
	F_1	F_2	F_3	…	F_a	…	F_g
AC_1	$\overline{C_{11}}$	$\overline{C_{12}}$	$\overline{C_{13}}$	⋯	$\overline{C_{1a}}$	⋯	$\overline{C_{1g}}$
AC_2	$\overline{C_{21}}$	$\overline{C_{22}}$	$\overline{C_{23}}$	⋯	$\overline{C_{2a}}$	⋯	$\overline{C_{2g}}$
…	…	…	…	…	…	…	…
AC_j	$\overline{C_{j1}}$	$\overline{C_{j2}}$	$\overline{C_{j3}}$	⋯	$\overline{C_{ja}}$	⋯	$\overline{C_{jg}}$
…	…	…	…	…	…	…	…
AC_m	$\overline{C_{m1}}$	$\overline{C_{m2}}$	$\overline{C_{m3}}$	⋯	$\overline{C_{ma}}$	⋯	$\overline{C_{mg}}$

According to the "Management of risk. Study hazard and operability. Applied management", "Management risk. Risk analysis of technological systems" and "Management risk. Terms and definitions", "risk is the combination of the probability of an event and its consequences." In accordance with the "safety Aspects. Rules inclusion in standards" risk "combination of probability of harm and severity of that harm". The law "On technical regulation" risk "probability of harm to the life or health of citizens, property physical or legal persons, state or municipal property, environment, life or health of animals and plants taking into account the gravity of that harm". Thus, the risk of failure of agricultural machinery agricultural companies on one factor will be determined by the formula:

$$R = \overline{C_{\text{AC}}}\ \lambda_{AC} \cdot T \cdot P\left(\frac{F}{AC}\right), \qquad (3)$$

where: $P\left(\frac{F}{AC}\right)$ – conditional probability that the failure occurred because of specific factor F.

The most important characteristic of random variable is its mathematical expectation is mean value, around which are grouped all its possible values. The expectation in the risk of AC_j will be determined by the expression:

$$R_j = P(AC_j) \cdot P\left(\frac{F_1}{AC_j}\right) \cdot \overline{C_{J1}} + P(AC_j) \cdot P\left(\frac{F_2}{AC_j}\right) \cdot \overline{C_{J2}} + \cdots +$$

$$+P(AC_j)\cdot P\left(\frac{F_g}{AC_j}\right)\cdot\overline{C_{jg}}=P(AC_j)\cdot P\left(\frac{F_a}{AC_j}\right)\cdot\sum_{a=1}^{g}\overline{C_{ja}}=$$

$$=\lambda_j\cdot P\left(\frac{F_a}{AC_j}\right)\cdot T\sum_{a=1}^{g}\overline{C_{ja}}$$

Given that the number of failure modes m, the total risk of m crashes (which are relative to each other for heterogeneous (for example, serious incidents and failures)) will be determined by the expression:

$$R_{AC}=\sum_{j=1}^{m}R_j=\sum_{j=1}^{m}\lambda_j\cdot P\left(\frac{F_a}{AC_j}\right)\cdot T\cdot\sum_{a=1}^{g}\overline{C_{ja}}$$

If the structure of the park of agricultural machinery agricultural companies includes a certain number of machines and if you make q – specific machine type $q=\overline{1,\ v}$, the risk of failure will be determined by the formula:

$$R_{AC}=\sum_{j=1}^{m}R_j=\sum_{j=1}^{m}\lambda_j\cdot P\left(\frac{F_a}{AC_j}\right)\cdot\sum_{a=1}^{v}T\cdot\sum_{a=1}^{g}\overline{C_{ja}}$$

Conclusions. Used, risks are classified by types of events (risks of crashes, failures, incidents), by type of factors (the risk of failures caused by technical, human, non-systemic factors), the degree of acceptability, depending on the magnitude of probability and expected damage, in accordance acceptable, acceptable, unacceptable performance.

References

1. *Rogovskii Ivan*. (2016). Graph-modeling when the response and recovery of agricultural machinery. Motrol: Motorization and power industry in agriculture. Lublin. T. 18. No. 3. 155-164.
2. *Rogovskii I. L.* (2015). Methodologist vikonannya technologicznych operations vbnewline procedatos clinicopathogenetic machines with obojeni resources. Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK. Kiev. Vol. 212. Part 1. 314-322.
3. *Voytyuk V. D., Rogovskii I. L.* (2016). Analitical model of parallel complex system of machinery of planting. Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK. Kiev. Vol. 251. 400-409.
4. *Rogovskii I. L., Melnyk V. I.* (2016). Analyticity of spatial requirements for maintenance of agricultural machinery. Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK. Kiev. Vol. 251. 426-433.
5. *Rogovskii I. L.* (2016). Analysis of model of recovery of agricultural machines and interpretation of results of numerical experiment. Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK. Kiev. Vol. 254. 424-431.
6. *Rogovskii I. L.* (2017). Probability of preventing loss of efficiency of agricultural machinery during exploitation. Scientific Herald of National University of Life and

Enviromental Science of Ukraine. Series: Technique and energy of APK. Kiev. Vol. 258. 399-407.

Список літератури

1. *Rogovskii Ivan*. Граф-моделирование при восстановлении работоспособности сельскохозяйственных машин. Motrol: Motorization and power industry in agriculture. Lublin. 2016. Т. 18. №3. P. 155—164.
2. *Роговський І. Л.* Методологічність виконання технологічних операцій відновлення працездатності сільськогосподарських машин при обмежених ресурсах. Науковий вісник Національного університету біоресурсів і природокористування України. Серія: техніка та енергетика АПК. Київ. 2015. Вип. 212. Ч. 1. С. 314—322.
3. *Voytyuk V. D., Rogovskii I. L.* Analitical model of parallel complex system of machinery of planting. Науковий вісник Національного університету біоресурсів і природокористування України. Серія: техніка та енергетика АПК. Київ. 2016. Вип. 251. С. 400—409.
4. *Rogovskii I. L., Melnyk V. I.* Analyticity of spatial requirements for maintenance of agricultural machinery. Науковий вісник Національного університету біоресурсів і природокористування України. Серія: техніка та енергетика АПК. Київ. 2016. Вип. 251. С. 426—433.
5. *Rogovskii I. L.* Analysis of model of recovery of agricultural machines and interpretation of results of numerical experiment. Науковий вісник Національного університету біоресурсів і природокористування України. Серія: техніка та енергетика АПК. Київ. 2016. Вип. 254. С. 424—431.
6. *Rogovskii I. L.* Probability of preventing loss of efficiency of agricultural machinery during exploitation. Науковий вісник Національного університету біоресурсів і природокористування України. Серія: техніка та енергетика АПК. Київ. 2017. Вип. 258. С. 399—407.

КОНЦЕПТУАЛЬНІ РАМКИ СИСТЕМИ УПРАВЛІННЯ ВИНИКНЕННЯ ВІДМОВ СІЛЬСЬКОГОСПОДАРСЬКИХ МАШИН

І. Л. Роговський

Анотація. *Одним з основних елементів системи управління виникнення відмов сільськогосподарських машин є управління факторами ризику для виникнення самих відмов. Зменшення ризику можливо різними способами (наприклад, заміна обладнання, навчання персоналу та ін).*

Для ефективної реалізації компонентів потрібно розробляти методики для кожного елемента системи управління виникнення відмов сільськогосподарських машин. У діючих аграрних компаніях вже розроблені системи і є свої напрацювання в цій області. В основі прийняття рішення по корекції рівня ризику виникнення відмов лежить експертний метод, і даний етап є складним.

Відомо, що забезпечити нульовий ризик у діючих системах неможливо. В даний час концепція абсолютної безвідмовності відкинута і використовується концепція прийнятного (допустимого) ризику виникнення відмов, суть якої полягає в прагненні до забезпечення такого рівня безвідмовності, який є прийнятним в даний період часу або найменшого практично можливого рівня.

Досягнення найменшого практично можливого рівня визначається фінансовими ресурсами аграрних компаніях. Грамотне розподіл ресурсів є одним з найбільш важливих організаційних процесів аграрних компаніях. Недолік фінансування заходів щодо забезпечення безвідмовності сільськогосподарських машин може негативно позначитися на валовий збір продукції расстениеводства, надлишок – негативно вплине на фінансовий стан компанії.

Ключові слова: ***ймовірність, втрата, експлуатація, працездатність, сільськогосподарська машина***

КОНЦЕПТУАЛЬНЫЕ РАМКИ СИСТЕМЫ УПРАВЛЕНИЯ ВОЗНИКНОВЕНИЯ ОТКАЗОВ СЕЛЬСКОХОЗЯЙСТВЕННЫХ МАШИН

И. Л. Роговский

Аннотация. *Одним из основных элементов системы управления возникновения отказов сельскохозяйственных машин является управление факторами риска для возникновения самих отказов. Уменьшение риска возможно различными способами (например, замена оборудования, обучение персонала и др.).*

Для эффективной реализации компонентов нужно разрабатывать методики для каждого элемента системы управления возникновения отказов сельскохозяйственных машин. В действующих аграрных компаниях уже разработаны системы и имеются свои наработки в этой области. В основе принятия решения по коррекции уровня риска возникновения отказов лежит экспертный метод, и данный этап является сложным.

Известно, что обеспечить нулевой риск в функционирующих системах невозможно. В настоящее время концепция абсолютной безотказности отвергнута и используется концепция приемлемого (допустимого) риска возникновения отказов, суть которой состоит в стремлении к обеспечению такого уровня безотказности, который является приемлемым в данный период времени или наименьшего практически возможного уровня.

Достижение наименьшего практически возможного уровня определяется финансовыми ресурсами аграрных компаниях. Грамотное распределение ресурсов является одним из наиболее важных организационных процессов аграрных компаниях. Недостаток финансирования мероприятий по обеспечению безотказности сельскохозяйственных машин может негативно отразиться на валовом сборе продукции расстениеводства, избыток – негативно повлияет на финансовое состояние компании.

Ключевые слова: ***вероятность, потеря, эксплуатация, работоспособность, сельскохозяйственная машина***