Justification of the methods of material and technical maintenance and repair of agricultural machines

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Abstract. This work substantiates the rational structure of the repair and maintenance base of agricultural machinery, methods for determining the needs for material and technical means, taking into account the appropriate proportions between the links of the repair network. The maintenance and restoration of the operability of tractors and other agricultural machines in sufficient limits is ensured, as is known, with the help of a system of maintenance and repair, which provides for the implementation of preventive maintenance operations and the conduct of routine and major repairs of machines in a planned manner. The established system of maintenance and repair, the creation of a material and technical basis for its implementation, as well as a continuous process of improving the qualifications of machine operators and repair personnel, contribute to the effective use of equipment in agriculture. At the same time, there are significant disadvantages in the use of tractors and agricultural machines. The analysis of the results of numerous studies of VIMa, ChIMESXa and other organizations made it possible to identify and systematize the loss of time due to machine downtime. In particular, machine downtime for regulated maintenance is 10-15% of the shift time, for technical malfunctions - from 5-8% for plowing, up to 30% for harvesting crops. The volume of work on the repair of cars in the country as a whole is more than 2 times higher than the standard. The efficiency of maintenance and repair of machines largely depends on the level of the material and technical base of these works - the availability of modern equipment and tooling, industrial buildings, warehouses, and other structures, inventories, means of transport and communications.

1. Introduction

Modern views on the system and methods of organizing maintenance and repair of machines are based on long and numerous studies. The scientific foundations and the general theory of the loss and restoration of the working capacity of tractors and agricultural machines were developed in the works of V.I. Kazartsev, A.I. Selivanov, I.S. Levitsky, I.E. Ulman, M.M. Severiev, D.G. Vadnvasov, and on cars, in the works of V.V. Efremov, K.G. Koshkin, L.V. Dekhterinsky. The study of published works, analysis of the shortcomings of the existing system, and generalization of advanced domestic and foreign experience made it possible to define in a new way the ways and main directions of improvement in maintenance and repair.

To study the patterns of changes in the main technical and economic indicators of the use of machines, the data of the Tselinny branch of GOSNITI, obtained as a result of eight years of

monitoring the work of a large group of tracked tractors of the 3rd class, were analyzed. These data indicate a constant decrease in their post-repair resources as the operating time increases and the number of bulkheads increases. Despite the increase in the number of repairs, the average shift operating time of these tractors by their average service life (4 years) decreases by 10% in comparison with the operating time in the first years of operation. The number of shifts worked by tractors after 4 years is reduced by 20%, the annual operating time by 27% [1, 2, 3, 4]. By the amortization service life of tractors (8 years), such indicators change and the rate of deterioration is almost twofold. The consumption of spare parts by the average service life of tractors increases 2-3 times for transmission parts, 4-5 times for road wheels, and 8-10 times for cylinder-piston group parts.

Along with a decrease in the productivity of tractors, it was noted that the consumption of funds and the labor intensity of repair work on tractors change linearly as they age, increasing at the end of the depreciation period by about 2.5 times compared with the indicators of the second year of operation [5]. Similar indicators were noted when observing the operation of combine harvesters and other machines. Consequently, the applied system and methods of maintenance and repair of machines and the performed repair actions do not ensure the maintenance and restoration of their normal performance.

This happens in many cases because the existing system is based on a simple relationship between the operating time of machines and their need for repair effects. The system does not sufficiently reflect the structural and technological properties of various machines and the patterns of their wear, does not take into account the whole variety of conditions of their operation and the influence of random factors on the change in the state of machines [5, 6]. Such a system does not contain justified methods for determining the time points for performing the required maintenance and repair operations, which is one of the sources of violation of the regulations and the content of repair actions [7, 8, 9]. The production conditions of maintenance and repair also often do not correspond to the actual needs of the machines.

Thus, the improvement of the existing system and methods of maintenance and repair of machines is an important national economic problem. This became especially evident in connection with the broad statement in the research of a more modern, probabilistic approach in the study of the phenomena of wear and identification of the needs of machines for repair effects.

2. Materials and methods

The object of the study was certain constructive and technological properties of machines, wear characteristics and indicators of the durability of their elements, and mainly the DT-75 and MTZ-50 tractors, which are the most complex in a constructive sense, in connection with which their proper organization, maintenance and repair present the greatest difficulties [10,11].

In accordance with the set goal and the main content of the study, its specific tasks are determined:

-to substantiate methods for improving the management of the operability of machines, and to develop the main directions for organizing actions to improve their maintenance and repair.

-to investigate the main causes and nature of the wear of machine elements, to determine the structure of repair and maintenance work, and to find ways to restore their performance.

-to determine the methodology for the development of the main repair standards characterizing the modes of partial reimbursement of the machine's suitability: the frequency and structure of the repair cycle, the assessment of the complexity of the repair, etc.

-to substantiate the most rational methods of organizing maintenance of machines as probabilistic systems that provide partial compensation for their suitability.

-to determine the expedient structure of the repair and maintenance base of agriculture, and to develop methods of material and technical support for the maintenance and repair of machines.

-to substantiate the control system for the reliability of machines: methods of control, methods of standardization, and control of reliability.

3. Results and Discussions

The multifaceted nature of the work predetermines the variety of methods for studying particular issues. At the same time, they are based on some general principles that allow finding a unified approach and establishing the relationship between various aspects of the problem.

$$y = 4019 - 953x + 72x^2 \quad (1)$$

where, x - the number of repairs.

Establishing the pattern of reducing the MTBF made it possible to formulate a hypothesis about the occurrence in the mechanisms of machines with an increase in the duration of operation and as a result of bulkheads during the repair of unfavorable operating conditions of parts that affect their durability.

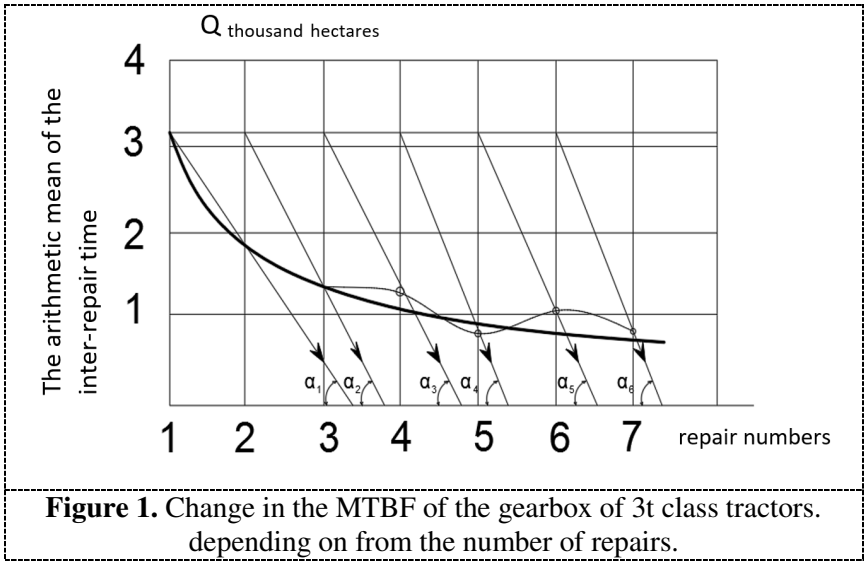

Figure 1. Change in the MTBF of the gearbox of 3t class tractors. depending on from the number of repairs.

Taking into account that the basis of the repair and maintenance base is made up of equipment and tooling, classified by us in terms of cost, productivity and complexity of work, the following conclusions were drawn:

- the operations of successive reimbursement of the suitability of machines with an indicator of C_{mex} <1.7, which do not require complex and expensive equipment, are carried out directly on the farms (detailed);
- operations of successive reimbursement of the suitability of machines with an index of C_{mex}> 1.7, performed with the help of expensive and high-performance equipment, are subject to a certain centralization within economically justified limits;
- the processes of one-time reimbursement of the suitability of machines and assemblies, the restoration of parts, requiring a high level of production equipment, must be carried out centrally at special enterprises. Thus, the repair base seems to consist of three main structural links: the repair and maintenance base of the economy, the production and technical base of the district level and a network of specialized repair enterprises.

Optimal solutions for the centralization of service are made by minimizing the reduced costs, characterized by a decrease in the amortization of production assets and losses from downtime during service with an increase in the number of machines serviced in one place and an increase in the cost of transporting machines to places of service and losses from downtime during transportation, which is shown in figure 2 [12, 13].

The need for production capacities of various links of the repair and maintenance base was determined by analyzing the technological content of repair and maintenance work, a model of their distribution among the links of the repair network was created A model of the need for repair and maintenance work was calculated to assess the availability of production capacities in comparison

with the required ones. The model of the distribution of work on the maintenance of machines between the links of the repair network was obtained in two conditional versions [12]:

- in the first - it is envisaged to perform all operations of periodic maintenance and more than two-thirds of the volume of work of current repairs by the forces of farms;
- in the second - complex maintenance of tractors (TO-3), cars (TO-2) and their current repairs by specialized repair services. Depending on local conditions, other options for the distribution of work may be accepted, however, they will all be within the intervals established by us.

According to the annual reports of the enterprise, labor costs for maintenance and repairs by types of machines and the resulting models of the distribution of work between the links of the repair network, the following distribution is determined, given in table. 1, [14].

According to the most promising second variant of the distribution of work, in which, for example, in 70 farms in the Rostov region, the average annual unit cost of repair and maintenance of machines has a minimum value (0.76 rubles / ha c.p.), it was concluded that farms should

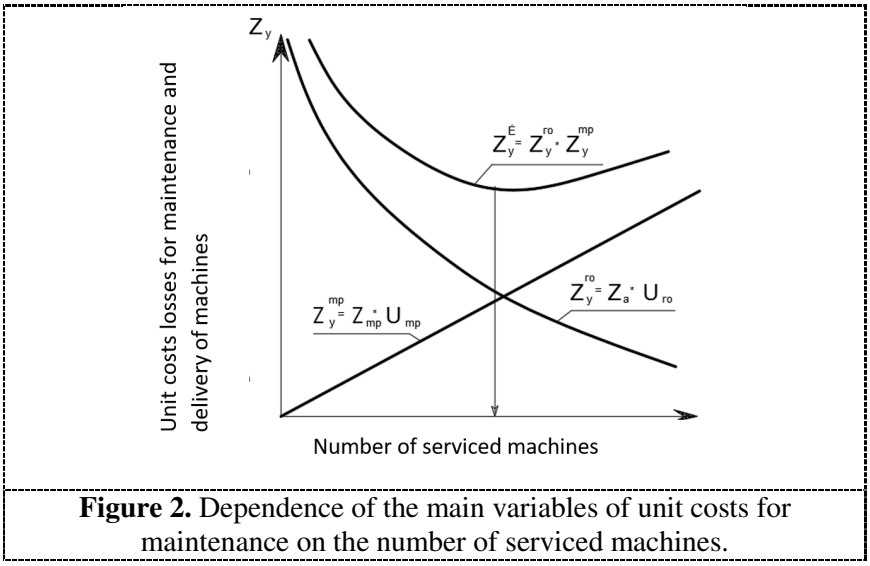

Figure 2. Dependence of the main variables of unit costs for maintenance on the number of serviced machines.

Z_y^{TO} - unit costs and losses in the maintenance of machines; Z_a is the amount of depreciation of production assets; U_{TO} - losses from downtime during machine maintenance; Z_y^{TO} - unit costs and losses for transportation of machines; Z_{mp} - the cost of transporting machines; U_{mp} - losses from downtime during transportation of machines; Z^{Σ}- total unit costs of losses for maintenance and delivery of machines.

Table 1. Job distribution options

Variants distribution of work	General volume works	Performed in%		
		farms	my district link	Spetsializirovannymi predpriyatiyami
I - option	100,0	61,6	10,0	28,4
II- option	100,0	46,4	22,2	31,4

To carry out simple operations in terms of the labor intensity of about half of the total volume of repair and maintenance work. The share of specialized enterprises is about 30%. and district services -20% of the volume of work, and the most complex. It means that the district services should specialize in performing complex periodic maintenance and current repairs of machines [15].

Calculations show that the capacity of specialized enterprises to carry out work on the repair of units and machines currently reaches only 48% of the required capacity, maintenance points - about 25%, mobile repair shops - 38%, mobile maintenance vehicles - 56%. The basis of the material base

of the service is made up of stationary facilities, in combination with which mobile ones operate, reducing the downtime of machines [16]. The paper gives a schematic diagram of the interaction of maintenance and repair facilities.

The calculation of the need for service facilities is carried out using the accepted methods in terms of their performance and duration of service. The total duration of service $\mathrm{P_C^O}$ is determined by the expression:

$$\mathrm{P_C^O} = \sum_{i=1}^{n} \cdot \sum_{j=1}^{m} \cdot \mathrm{P}_{ij}^{o} \cdot k_{ij} \quad (2)$$

where P_{ij}^{O} - duration of one service (repair), h:

k_{ij} - the number of serviced cars; n and m - the number of services and their types.

The tenological fund of the time of operation of the means of maintenance and repair F_m is equal to the difference between the operating fund of time F_p and the time of downtime of the means of service in the repair $\mathrm{T_{REM}}$ as well as the time spent on moving $\mathrm{T_{PER}}$.

$$\mathrm{F}_m - \mathrm{F}_p - (\mathrm{T_{REM}} + \mathrm{T_{PER}}). \quad (3)$$

The need for one or another type of service facilities $\mathrm{R_{CP}}$ is divided by the ratio of the operational duration of service $\mathrm{P^O}$ to the technological annual fund of time from the expression:

$$\mathrm{P_{CP}} = \frac{\mathrm{P^O}}{\mathrm{F_T} \cdot \mathrm{K_B}} \quad (4)$$

where K_B - coefficient taking into account intra-shift loss of time,

K_B = 0,85 - 0,95.

The effectiveness of the use of one or another set of maintenance and repair tools is determined by the well-known methods of minimizing losses U_{TOR} from a decrease in the productivity of machines and, therefore, a shortage of products or a decrease in prices with a deterioration in its quality, the reduced costs of maintenance and repair tools and wages for repair workers [16]

$$U_{\mathrm{TOR}} = S \sum_{k=1}^{m} \cdot C_k \; U_k \; P_k + \sum_{i=1}^{n} \cdot B_i \; E_i \; n_i^{!} \; \frac{\mathrm{T}_{ik}^{!}}{T_{ik}^{i} + \sum_{j=1}^{p} T_{ij}} + \sum_{i=1}^{q} T_{tk}^{!} \; K_{3i} \rightarrow min \quad (5)$$

where S - the area on which the serviced machines operate, hectares;

C_k - cost of 1 centner of the k-th product, rubles;

U_k - yield of the k-th product, c / ha;

P_k - the coefficient of yield losses of the k-th product from downtime and reduction of the chain from deterioration in quality;

B_i - the book value of the i-th means of maintenance and repair, rubles;

E_i - standard coefficient of efficiency of capital investments;

n_i - the number of funds of the same name;

T_{ik} - the time spent by the i-th maintenance and repair facilities for the production of the ki-th product, h;

T_{ij} - the time spent by the i-th maintenance and repair facilities on other j-th work performed during the hearth, h;

K_{3i} - the cost of an hour of work of workers during maintenance and repair, rubles.

Modern machines have a large number of series-connected parts, which inevitably degrades their reliability indicators. Therefore, in order to improve the reliability indicators based on the works of D. Neumann, it is concluded that it is necessary to create an unloaded reserve of spare parts for machines, which are concentrated, depending on their cost and scarcity, directly on machines, on mobile or stationary service facilities, or in regional and regional technical exchange points. At the same time, the reduced losses of farms from failures should be greater than the cost of the reserve elements, therefore the total present value of the unloaded reserve is controlled on the basis of the following criterion:

$$\sum_{i=1}^{n} G_i^P \leq U_t \cdot \sum_{i=1}^{n} \Delta_i \cdot P \quad (6)$$

where G_i^p - cost of reserve i-elements, rubles;

U_t - losses of farms from machine failures, rubles;

$\Delta_i P$ - the magnitude of the increase in the reliability of the i-th element.

4. Conclusion

The calculation results show the expediency of the direction of development of production and technical bases for high-quality maintenance and repairs of agricultural machines. The costs of labor and funds for the maintenance and repair of machines for the amortization period significantly exceed the same costs for their manufacture. For tractors, for example, these pile costs are 6-10 times higher than the labor costs for manufacturing and, accordingly, the cost of money is 3-6 times. Increasing the efficiency of using a particular set of maintenance and repair tools is determined by the known methods of minimizing Uter losses from a decrease in the productivity of machines and, therefore, a shortage of products or a decrease in prices with deterioration in its quality. The need has ripened to attract investments in the field of reconstruction and construction of new production and technical bases with more modern equipment and tools that meet the requirements of machines produced for agriculture.

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