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Original article

OPTIMIZATION OF THE STRUCTURE OF THE AGRICULTURAL MACHINERY REPAIR CYCLE IS CORRECT

E.A. Shapiro

Abstract

Background. This article provides a justification for the structure of the repair cycle of agricultural machinery. It is considered how this technique with disparate service life of parts has a very low repair adaptability and does not meet the basic requirements of scientific planning of current and major repairs. The drawings presented in the work illustrate a scheme for maintaining the permissible gap in the joint by carrying out periodic repairs, a scheme for wearing parts with different wear rates and different service lives, a scheme for creating a rational structure of the repair cycle of machines, etc. This article is prepared for specialists of the agro-industrial complex, researchers, teachers, postgraduates, undergraduates and students of agricultural universities in the field of training "Agroengineering".

Purpose. The purpose of the study is to optimize the structure of the repair cycle of agricultural machinery

Materials and methods. To substantiate the structure of the repair cycle, this article uses a detailed analysis of the wear patterns of machine parts and their service life.

Results. One of the most important directions for improving the planning of scientific, technical and production activities of agricultural enterprises of the Krasnodar Territory is to strengthen a systematic, integrated approach to the technical service of agricultural machinery. Another direction is related to the need to significantly improve the technical level and quality of agricultural machinery while simultaneously increasing its output and reducing production costs.

In order to determine specific measures to improve the effectiveness of scientific research and development (R&D) in agricultural engineering, it is necessary to thoroughly and in detail analyze the existing state of work on the creation of new equipment, trends and prospects for the development of technologies and the material and technical base of agricultural production.

When analyzing the directions of development of agricultural machinery, first of all, there is a steady growth trend in the unit capacity of tractors, working machines and vehicles intended for agriculture.

This direction has so far been associated with the solution of one of the main tasks of the development of agricultural production - optimization of the structure of the repair cycle of machines.

Conclusion. Thus, it can be concluded that using the expressions obtained, it is possible to optimize the repair cycle of a tractor, combine harvester, car, or other agricultural machine.

Keywords: repair cycle; frequency; justification; gaps; repair; service life; labor intensity; MTZ-82 tractor; inter-repair period

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Научная статья

ОПТИМИЗАЦИЯ СТРУКТУРЫ ЦИКЛА РЕМОНТА СЕЛЬСКОХОЗЯЙСТВЕННОЙ ТЕХНИКИ

Е.А. Шапиро

Аннотация

Обоснование. В статье дано обоснование структуры ремонтного цикла сельскохозяйственной техники. Рассмотрено, как эта техника с разрозненными сроками службы деталей имеет очень низкую ремонтопригодность и не отвечает основным требованиям научного планирования текущих и капитальных ремонтов. Приведенные в работе рисунки иллюстрируют схему поддержания допустимого зазора в соединении путем проведения периодических ремонтов, схему изнашивания деталей с различной интенсивностью изнашивания и различными сроками службы, схему создания рациональной структуры ремонтного цикла машин и др. Статья подготовлена для специалистов агропромышленного комплекса, научных работников, преподавателей, аспирантов, магистрантов и студентов сельскохозяйственных вузов по направлению подготовки «Агроинженерия».

Цель. Целью исследования является оптимизация структуры цикла ремонта сельскохозяйственной техники

Материалы и методы. Для обоснования структуры ремонтного цикла в данной статье использован детальный анализ закономерностей изнашивания деталей машин и сроков их службы.

Результаты. Одним из важнейших направлений совершенствования планирования научно-технической и производственной деятельности сельскохозяйственных предприятий Краснодарского края является усиление системного, комплексного подхода к техническому сервису сельскохозяйственной техники. Другое направление связано с необходимостью существенного повышения технического уровня и качества сельскохозяйственной техники при одновременном увеличении ее выпуска и снижении себестоимости.

Для того чтобы определить конкретные меры по повышению эффективности научно-исследовательских и опытно-конструкторских работ (НИОКР) в сельскохозяйственном машиностроении, необходимо тщательно и детально проанализировать существующее состояние работ по созданию новой техники, тенденции и перспективы развития технологий и материально-технической базы сельскохозяйственного производства.

Анализируя направления развития сельскохозяйственной техники, прежде всего, следует отметить устойчивую тенденцию роста единичной мощности тракторов, рабочих машин и автомобилей, предназначенных для сельского хозяйства.

Это направление до сих пор было связано с решением одной из основных задач развития сельскохозяйственного производства - оптимизацией структуры ремонтного цикла машин.

Заключение. Можно сделать вывод, что, используя полученные выражения, можно оптимизировать ремонтный цикл трактора, комбайна, автомобиля или другой сельскохозяйственной машины.

Ключевые слова: ремонтный цикл; периодичность; обоснование; зазоры; ремонт; срок службы; трудоемкость; трактор МТЗ-82; межремонтный период

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Introduction

With the introduction of sophisticated agricultural machinery in the agricultural farms of the Krasnodar Territory, special requirements are imposed for the justification of scientifically based repair cycles of machines. Coverage of the basic theoretical principles of technical service, description of devices and equipment for maintenance and repair are available in a number of scientific and technical books.

Therefore, there is no need to dwell on general issues here. Let's consider only the description of some of the most widely used schemes for forming the structure of the repair cycle. Machine repair systems and structures of their repair cycles must meet the following basic requirements [1, 2, 3]:

– there should be no emergency forms of wear of parts in friction units;

– when repairing machines, there should be no rejection of parts with unused working capacity resources;

– the frequency and structure of repairs should meet the minimum total cost of repairs and coverage of damage caused by machine downtime due to malfunction.

Considering the issue related to the justification of the structure of the belt cycle of machines, it is necessary to briefly focus on the main types and methods of repair. Firstly, it should be noted that the repair of machines is a set of works that ensures the restoration of the main operational parameters of machines.

At the same time, the technical condition of the machines is revealed both by external signs (visually, by touch, by ear) and with the help of devices, devices and tools.

Emergency, routine and major repairs can often be found in the regulatory and technical documentation. In case of emergency repairs, a complete machine must be cleaned, disassembled, carbon deposits and scale removed from worn structural elements, then the repaired machine must be tested at idle, and if necessary, under load.

During major repairs, the machine is completely disassembled, all parts are washed, parts and assembly units are defective, repaired, assembled, adjusted and tested by aggregates and the machine as a whole. Secondly, it should be noted that the repair method is a method and organization of repair production with the dismemberment and specialization of repair work on individual units, assembly units and parts.

A fairly simple nodal method is also possible, in which the entire complex of works is divided into separate parts, each of which represents a completely completed repair process of the assembly unit.

In this repair method, there is specialization and division of labor. Each worker, doing the same job all the time, improves his skills, as a result of which the quality of machine repair is significantly improved, labor productivity increases, equipment, fixtures, tools and the area of repair shops are better used.

The flow-node method is a form of machine repair organization in which the entire range of work is divided into separate operations, representing a complete repair process, and the assembly of machines is carried out on mobile stands.

Assembly units are repaired and assembled at specialized workplaces and installed on a machine that moves from one workplace to another in accordance with the technological process.

With the aggregate repair method, defective units are replaced with repaired ones from the exchange fund or new ones, and defective units are sent to repair and technical enterprises.

This method not only reduces the downtime of machines due to technical malfunctions, but also improves the quality of repairs, reduces the cost of its cost. The method of periodic replacement of repair complexes (MANPADS) is a form of organization of repair of agricultural machinery, when individual units, assembly units and parts with approximately the same service life during disassembly are grouped, taking into account this methodology for optimizing the structure of the repair cycle, into separate kits and sent to mechanical repair plants.

In the workshops of agricultural enterprises, repaired kits are installed on machines.

This method allows you to restore the performance of machines by replacing worn-out sets with repaired ones, which significantly increases the utilization rate of agricultural machinery.

The flow method is used in repair and technical enterprises (factories, workshops). This is the most advanced form of production organization in enterprises with a sufficiently large volume of production program, where similar machines are repaired with uniform loading throughout the year.

Taking into account the present methodology developed by us to substantiate the structure of the repair cycle, in line production, the time for each operation is equal to or a multiple of the production cycle.

Materials and methods

To substantiate the structure of the repair cycle, this article uses a detailed analysis of the wear patterns of machine parts and their service life. In order to comply with the basic principles of scientific research, a systematic approach was applied, methods of induction and deduction, abstraction and concretization, etc. were used.

The integrated approach used in this article includes a number of particular methodological approaches, including such as [4, 5, 6]: – functional approach; – methodological approach related to logical analysis and synthesis; – an approach involving consideration of the life cycle of machines.

With the modern organization of maintenance and repair of agricultural machinery, cars and other machines, when parts and assemblies are discolored during major repairs, machines lose their components, it is possible to determine the degree of deterioration of their performance with operating time only for specific use cases.

Therefore, in this work, such a method is also used as an assessment of the technical condition of machines, taking into account resource conservation.

Results of the research

During the operation of machines, their parts wear out or get damaged. At the same time, their sizes change, the geometric shapes of the working surfaces are violated, bends, twisting, etc. are obtained.

The modern level of modern agricultural machinery allows you to restore a significant part of worn and damaged parts. Repair of worn parts is of great technical and economic importance, therefore it is necessary to systematically expand the range of repaired parts and improve the technology of their repair.

At the same time, the cost of repaired parts is lower than the cost of new parts. Repair of parts will have a great economic effect by saving metal, freeing up labor and equipment engaged in the manufacture of new parts, as well as by justifying the structure of the repair cycle of machines, taking into account the methodology presented in this article.

Currently, the following methods of quality management of car maintenance and repair have been applied in the practice of repair enterprises. The principles of construction of KSUK TOR cars play a special role.

They define the starting points that employees at all levels should follow when developing and operating the system. These principles are interrelated and work simultaneously. Improving the quality of maintenance and repair of cars largely depends on the correctness and completeness of their use at all stages of the creation of KSUK.

Currently, the issues of forming the principles of organizing the development, construction, implementation and operation of product quality management systems in agricultural enterprises and in associations, industries, as well as at the level of the national economy as a whole, are widely covered in the literature [5, 7, 8, 9] and especially fully in the work [5].

From the perspective of the problem under consideration, it seems correct to divide these principles of building and organizing quality management systems into two groups:

– general principles of building all management systems in agricultural production;

– specific principles of building product quality management systems.

The principles of the first group are widely described in the technical literature. Therefore, we will consider the basic principles of only the second group.

The principle of an individual approach. When creating a KSUK TO and R in each association (enterprise), its application involves the creation and organization of the functioning of the system, taking into account the specifics of production and economic activities (transportation process, traffic volumes, number of branches, type of rolling stock, etc.), while ensuring its sufficiently high efficiency.

At the same time, the requirement of maximum use of standard solutions in the system should be taken into account.

The principle of complex problem solving. According to this principle, the system should be focused on the development of integrated programs (impacts) in the management of maintenance and repair quality.

It is necessary to focus on improving the quality of the technical condition of cars while ensuring that all necessary private tasks of the system are solved in terms of time and resources.

The principle of continuous development of the system. It assumes that the KSUK TOR is being developed as an open system to be expanded as agricultural production and management systems develop. Considering the issue related to the optimization of the structure of the repair cycle of machines, it should be noted that currently the technical conditions for the repair and maintenance of tractors have established the following structure of repair and maintenance effects (table 1).

Table 1.

Structure of repair and maintenance impacts for tractors

Type of repair and maintenance impact	Frequency of performance of this action, moto-h
1. Tractor running-in (TO-O)	10±5
2. Daily maintenance (ETO)	10±2
3. First maintenance (TO-1)	125±10
4. Second maintenance (TO-2)	500±20
5. Third maintenance (TO-3)	1000±20
6. Emergency Repair (AR)	according to need
7. Current repairs (TR)	2000±20
8. Major repairs (KR)	6000±20

At the same time, it should be noted that this structure of repair and maintenance impacts for modern energy-saturated tractors is insufficiently rational and requires further optimization. Further, it should be noted that in addition to those given in the work related to the optimization of the structure of the repair cycle of modern tractors, it is proposed to use a number of principles at the stage of their production and technical operation, which, according to the author, should also be taken into account when creating KSUK TOR [10, 11, 12].

These principles characterize mainly the requirements for the preparation of machines for the start of production operation:

– comprehensive preparation of agricultural machinery for the use of the system;

– active participation of the engineering and technical staff of the agricultural farm in the development and implementation of methods for optimizing the repair cycle of machines.

At the stage of development of the quality management system, its improvement based on the economic strategy of the agricultural farm administration should be based on the following additional principles [13, 14]:

– the principle of the predominance of the interests of the agricultural farm as a whole over the interests of collective and personal;

– the principle of systematic development of quality management of technical service of machines.

Research and practice have shown that the construction of KSUK TOR, taking into account the above principles, ensures the creation of an effective system with specified parameters for optimizing the structure of the repair cycle of machines.

However, the solution of economic and organizational issues and compliance with the general principles of building a technical service system are important in its development.

One of the most important directions for improving the planning of scientific, technical and production activities of agricultural enterprises of the Krasnodar Territory is to strengthen a systematic, integrated approach to the technical service of agricultural machinery. Another direction is related to the need to significantly improve the technical level and quality of agricultural machinery while simultaneously increasing its output and reducing production costs.

In order to determine specific measures to improve the effectiveness of scientific research and development (R&D) in agricultural engineering, it is necessary to thoroughly and in detail analyze the existing state of work on the creation of new equipment, trends and prospects for the development of technologies and the material and technical base of agricultural production.

When analyzing the directions of development of agricultural machinery, first of all, there is a steady growth trend in the unit capacity of tractors, working machines and vehicles intended for agriculture.

This direction has so far been associated with the solution of one of the main tasks of the development of agricultural production - optimization of the structure of the repair cycle of machines.

The following data characterize the growth trend in the energy capacity of mobile technical equipment: currently, the average power of agricultural tractors was 43.5 kw.

The capacity of individual tractor models now reaches 169...235 kw, and in the near future we can expect the appearance of ultra–high power samples - 294...334 kw.

However, with the increase in the unit capacity of tractors, combines and vehicles, a contradiction is growing, which is very difficult to resolve within the framework of traditional technological methods still used in agriculture. This is explained by the fact that with the increase in the unit capacity of technical means used in agriculture, their weight and size characteristics increase, and mechanical loads on the soil increase, which now exceed the permissible average by three times.

As a result of excessive compaction of not only arable, but also sub–arable soil layers, difficult-to-eliminate negative environmental consequences arise - air, water and biochemical exchange regimes are disrupted, fertility reserves are significantly reduced, and erosion processes increase. In this regard, the problem of optimizing the structure of the repair cycle of agricultural machinery is acute.

As can be seen from Fig. 1, over the entire life of the production operation of the machine as a whole, the Tm bearing we are considering will be restored repeatedly.

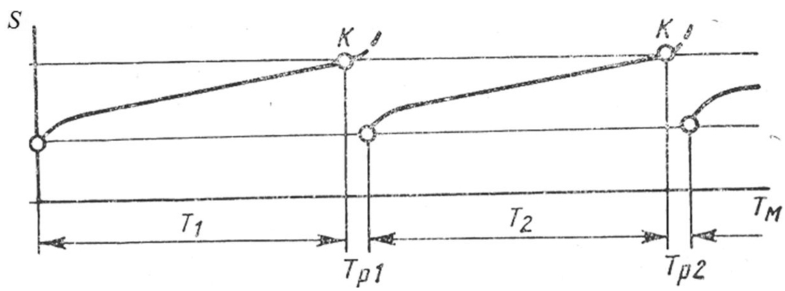

Fig. 1. The general scheme of maintaining the permissible gap in the connection by carrying out routine repairs

In turn, for a machine whose service life of parts is not equal to each other, the order of current repairs can be graphically represented as shown in Fig. 2.

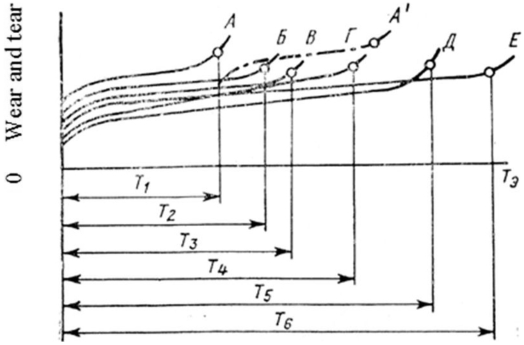

Fig.2. The wear pattern of parts with different wear rates and different service life

The following types of electroplating coatings are widely used in repair practice: chrome plating, cooling, copper plating, nickel plating, galvanizing, cadmium plating. Pressure repair of parts is of great interest for agroengineering practice. This repair method includes the following types of processing: sedimentation, indentation, distribution, compression, extraction, knurling and straightening.

It is used to restore parts that have changed the size of the working surfaces and geometric shape as a result of wear. Repair of parts by refilling antifriction alloys (babbit, lead bronze). This method restores the main and connecting rod bearings of the engines, as well as the bushings of the camshafts.

Repair of parts by electric spark buildup allows you to strengthen parts in order to increase wear resistance and build up worn parts. Repair of parts by machining as a method of repairing parts includes: repair of parts by machining to the repair size; repair by setting additional parts; repair by replacing a part of a part.

With this in mind, for parts whose service lives are formed, but not multiples of each other, according to Fig. 3, the restoration of parts A and B should be carried out through the operating time T1. In turn, for parts B and D, restoration should be carried out through the running time of T2, and parts D and E, respectively, through the running time of T3.

The general scheme allowing to optimize the general structure of the repair cycle of machines is shown in Fig. 4. In this diagram, the operating time of the machine is shown along the abscitz axis, and the maximum resource of the structural element of the machine is shown according to the ordinate [14, 15].

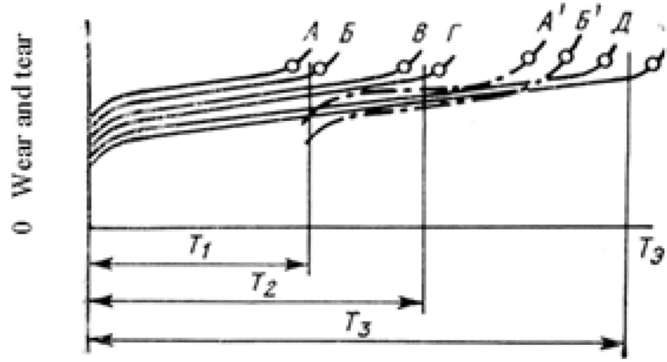

Fig. 3. A diagram of the wear of parts whose service life is formed, but not a multiple of each other

In this figure, for all groups of restored parts, a circle shows in which type of repair (current or capital) it should be placed. At the same time, it is important to note that with the increase in wear of individual structural elements of the machine, the need for one or another type of repair of its parts increases dramatically.

For example, for the case of Tc = 9T0, we will have a 10-period cycle (K = 9), the structure of which is: I I II I I II I I III. It should also be noted that at one time, associate professor of the Kuban State University Karpenko V.D. proposed a 6-period cycle, the structure of which is I II III II I IV, where I and II are the first and second emergency repairs, III current and IV capital [14].

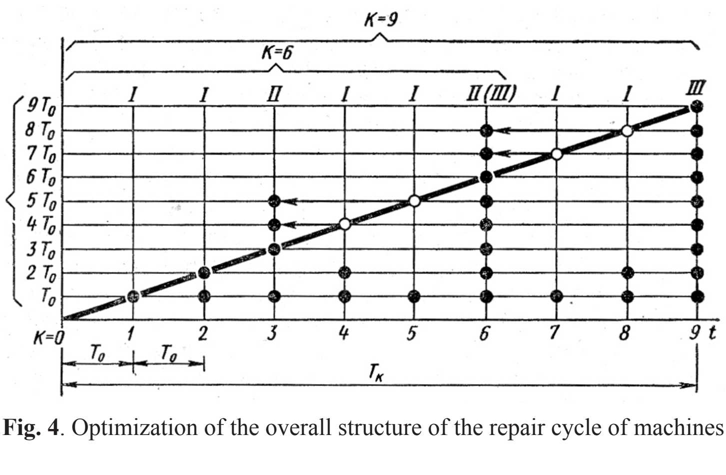

Fig. 4. Optimization of the overall structure of the repair cycle of machines

In particular, for the 10-period maintenance cycle of the MTZ-82 tractor, the following ratio will be used to optimize the repair cycle (Fig. 4):

$$\tau_{IX} = \frac{1}{9T_o}\left[9\tau_1 + 5\tau_2 + 3(\tau_3 + \tau_4 + \tau_5) + 2(\tau_6 + \tau_7 + \tau_8) + \tau_9\right] =$$
$$= \frac{1}{T_o}\left[\tau_1 + 0,555\tau_2 + 0,333(\tau_3 + \tau_4 + \tau_5) + 0,222(\tau_6 + \tau_7 + \tau_8) + 0,122\tau_9\right]. \quad (1)$$

In turn, for a 6-period maintenance cycle of a modern grain harvester «ACROS 595 Plus», you can write down such a mathematical expression that allows you to optimize the repair cycle of this combine:

$$\tau_{IV} = \frac{1}{6T_o}\left[6\tau_1 + 3\tau_2 + 2(\tau_3 + \tau_4 + \tau_5) + \tau_6 + \tau_7 + \tau_8 + \tau_9\right] =$$
$$= \frac{1}{T_o}\left[\tau_1 + 0,5\tau_2 + 0,333(\tau_3 + \tau_4 + \tau_5) + 0,167(\tau_6 + \tau_7 + \tau_8 + \tau_9)\right]. \quad (2)$$

And finally, using expressions (1) and (2), we obtain such a formula that allows us to optimize the repair cycle of a particular machine:

$$a = \frac{0,055}{T_0}(\tau_2 + \tau_6 + \tau_7 + \tau_8 - \tau_9). \quad (3)$$

Conclusion

Thus, it can be concluded that using the expressions obtained, it is possible to optimize the repair cycle of a tractor, combine harvester, car, or other agricultural machine. In particular, for the modern MTZ-82 tractor, a frequency of daily maintenance was planned equal to T_{ob} = 10 motorcycle hours and the following forms of maintenance were performed: TO-1 every 125±10 motorcycle hours, TO-2 after 500±20 hours, TO-3 after 1000±20 motorcycle hours.

These figures show that the optimal structure of the repair cycle presented here is determined by higher requirements for the reliability of modern agricultural machinery.

Conflict of interest information. The authors declare that they have no conflict of interest.

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