The reliability analysis of combined harvesters in the usual conditions of operation

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Abstract. The article reflects the results of operational tests of grain harvesters of various years of production of both domestic and imported production in the farms of the Stavropol Territory. In recent years more equipment has been purchased, but its numerical volumes are still small and do not cover the needs of rural commodity producers. Consequently, the work is mainly carried out on old and worn-out equipment, which, in turn, causes an increase in the wear and tear of the farm's agricultural enterprises. Reduction of combine harvesters and, as a result, increased loads on them leads to a significant increase in the share of failures of these agricultural machines. The duration of harvesting grain directly depends on the number of combine harvesters, their reliability and productivity. The level of reliability of grain harvesters was estimated based on the results of continuous and selective timing of the work of agricultural machines. The specific weight and significance of each of the components of the averaged shift time balance are described. It is established that the productivity of combines with the proper level of maintenance does not depend on the period of their operation.

1. Introduction
Currently, the ratio of price indices is also not in favor of agricultural producers, which directly affects the flow of machinery to the agrarian enterprises of the region.

In recent years more equipment has been purchased, but its numerical volumes are still small and do not cover the needs of rural commodity producers. Consequently, the work is mainly carried out on old and worn-out equipment, which, in turn, causes an increase in the wear and tear of the farm's agricultural enterprises.

In connection with the decrease in the rate of receipt of new equipment, the task of timely and high-quality repairs, as well as maintenance of the machines available in the operational state during the period of ordinary operation, again becomes very relevant. Reduction of combine harvesters and, as a result, increased loads on them leads to a significant increase in the share of failures of these agricultural machines.

Thus, the harvesting time of grain crops directly depends on the number of combine harvesters, their reliability and productivity.

Therefore, due to a significant reduction in the number of grain harvesters and the need to clean up the given agro-technical terms, topical issues both in the Stavropol Territory and in the country as a whole are: improving the reliability of combine harvesters, reducing idle time for unproductive losses and reducing the recovery time their work.
2. Materials and methods

Work to increase the reliability of the machines and, consequently, its systems must be carried out at the design stage, and in the field of their operation, and directly during the repair.

The system of information collection and processing is a set of organizational and technical measures for obtaining the necessary and reliable information about the reliability of products [1].

The main objective of the system for collecting and processing reliability information was to obtain the data necessary to determine the actual level of reliability indicators of combine harvesters under ordinary operation conditions [2]. Sources of reliability information were selected:

- timing of the work of combine harvesters;
- data received by the correspondent method - the method of interrogation of combine operators and master-adjusters;
- primary documentation of farms.

Timing of the combine harvester was the main method when collecting information about the reliability of its aggregates and systems [3]. Moreover, both types of timing were used: continuous and selective, the methodology of which is set out above [4].

The information on the failures was divided into groups for one-dimensional reasons to identify the cause-effect relationships of various factors that reduce the reliability of the combine harvester systems - design, production and operational [5].

All harvester failures were classified according to the aggregates and systems: harvester part, engine-power unit, transmission, chassis, inclined chamber, threshing machine, separating devices, bunker, transporting devices, cabin, electrical equipment, picking platform, hydraulic units, mechanical transmission [6]. In turn, mechanical transmissions, regardless of which organs they lead, were divided into two subgroups:

- belts, chains;
- pulleys, sprockets, bushings, shafts and dowels.

3. Results and discussion

The level of reliability of combine harvesters was estimated based on the results of continuous and selective timing of work in the farms of the Stavropol Territory [7].

To identify the reserves of increasing the efficiency of the use of combine harvesters under ordinary operation conditions in conjunction with RosNIITIM in the collective farm "Russia" Novoaleksandrovsky district of the Stavropol Territory, experimental studies and continuous timing of harvesting equipment were carried out according to the method [8].

The collective farm "Russia" was chosen as an advanced economy with a high level of organization of the repair and technical service, a sufficient material and technical base and a stable financial position.

To conduct the study, according to the recommendation RosNIITIM, 10 combine harvesters of different years of production were selected, which were formed into a separate harvesting unit for work under the same conditions [9]. Based on the results of the tests, the results obtained are presented in Figure 1.

The obtained results confirmed the data that the productivity of combines with the proper level of maintenance does not depend on the period of their operation, and for the observation period its variation ranged from 5 ... 15% [9]. The maximum operating time (more than 100 tons per day) was provided by ALL harvesters regardless of the year of their release [10].

Processing of the results of research of combine harvesters in this farm showed that the average value of the coefficient of technical use was 0.7 (Figure 2).
Figure 1. The diagram of averaged values of the time components of the experimental group harvesters.

| Time Component                  | 10. July | 14. July | 15. July | 16. July | 17. July | 22. July |
|--------------------------------|----------|----------|----------|----------|----------|----------|
| bug fixing time                | 125.783  | 48.7     | 64.741   | 72.8     | 119.108  | 25.475   |
| dinner                         | 15       | 17       | 15       | 18       | 17       | 20       |
| waiting for the car            | 54.5     | 117.417  | 147.949  | 138.508  | 79.725   | 158.242  |
| crossing the field             | 0.25     | 8.05     | 1.916    | 5.171    | 2.175    | 0.284    |
| move to the field              | 8.8      | 10.925   | 7.958    | 2.566    | 4.659    | 11.834   |
| shift maintenance              | 16.41    | 14.66    | 16.2     | 15.83    | 15.71    | 14.83    |
| cleaning of the chopper        | 3.367    | 0.367    | 0.542    | 0        | 1.208    | 0        |
| unloading                      | 10.908   | 24.941   | 24.783   | 26.583   | 22.201   | 26.341   |
| turn                           | 9.525    | 9.891    | 9.917    | 11.43    | 7.417    | 8.642    |
| clean work time                | 176.39   | 208.7    | 185.45   | 232.73   | 204.28   | 214.32   |

Figure 2. Graph of complex indicators of reliability of combine harvesters for the period of observation.
But along with this, over the observed period, the average time utilization rate was 0.44. This value of the utilization factor of the shift corresponds to 44% of the net work time of the combines.

The remaining 56% of the time is spent on non-productive costs, which indicate that in order to carry out a given amount of work on harvesting, it is necessary either to increase the working time by 2.27 times, or to compensate for the period of performance of work by increasing the amount of harvesting equipment. This situation will be characterized by a lack of use of potential equipment and a significant increase in material costs for fuel and lubricants, wages, as well as costs associated with crop losses.

Figure 3. Diagram of averaged values of the time components of the shift.

The specific weight and significance of each of the components of the averaged shift time balance are presented in the diagram, taking into account the variation of these values by harvesting days and groups of harvesters (Figure 3).
The average time of net productive work of combine harvesters for the study period of production trials reached 220 minutes or 3.6 hours per day (44%). From this it follows that the combine harvester productively works part-time shift and time is spent on auxiliary operations.

Suppose all overhead costs are 100%. We will reveal each of the reasons for non-production costs. So, a significant proportion of the time is spent waiting for the car, this time can reach 43% of all unproductive costs and can vary from the remoteness of the harvested field from the grain storage. Therefore, it is advisable to use storage bins. The next significant component in non-productive costs is the total time to eliminate the occurring failures – up to 28% with a variation of 0.06-0.28. All other unproductive costs in the total amount also account for up to 28%. These include technical maintenance of equipment, moving to a cleaned area, turns, unloading the hopper without moving the harvester across the field, and other technological operations.

Further monitoring of the failures of the combine harvester contributed to the establishment of the most failing systems, such as the header 44%, mechanical drives with keyed connections 16%, the chassis 10%, hydraulics 10%, internal combustion engine 3% and other systems.

4. Conclusion
Studies have shown that currently in the Stavropol Territory there is an old and worn out harvesting equipment and, therefore, low reliability, insufficient level of repair work before cleaning, lack of diagnostic tools, insufficient spare parts in the form of spare parts and a considerable time for their delivery from the nearest companies selling parts. Further updating of the technical part of enterprises with modern, technological, productive cleaning machines is required.

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