INCREASING THE RELIABILITY OF COMBINES FOR HARVESTING GRAIN CROPS BY METHODS OF RESERVE SUBSTITUTION

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ABSTRACT
The results of experimental studies to ensure the operability of combine harvesters for harvesting grain crops are presented. The reliability indicators of the aggregates, assemblies and parts of combine harvesters are determined, and the methods of spare parts reservation at different storage levels are justified.

Key words: combine harvester, reliability, operability, operating time to failure, average time to eliminate failure, spare parts, different levels of storage.

INTRODUCTION

The main requirements for equipment are its reliability and efficiency. Regarding agricultural machinery, these requirements are no less important, and in terms of reliability, they are higher than in industry. Insufficient reliability of agricultural machinery affects the efficiency of its use and is the cause of significant losses of agricultural products both during cultivation and, especially, during harvesting.

THE STATEMENT OF THE PROBLEM

More than half of the failures of the harvesters for technical reasons associated with the replacement of parts, components or assemblies, which are failured. Recovery time after failures depends on how quickly the service for the eliminations of failures and delivery of parts and components that have failed works. It is necessary to clarify the nomenclature and places of the deployment of spare parts including the possibility both group work harvesting machines (combines) within technological systems, and a single work.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Providing of harvesters' operability during exploitation seen in many studies (Dumenko, 2010a,b; Dumenko and Boyko, 2011; Sidorchuk and Skibchik, 2013) etc. Machine builders allow methodological errors in the design requirements and standards of machines' reliability. They give rationing of faultless work of aggregates without the 1st group of complexity, the part of which is 51-66% of the total. As a result, unreasonably, the faultless work of aggregates increases by 50-65%. Besides, work of units as a whole, significance of works, necessity of observance of optimum agrotechnical terms of their performance are not considered (D. Domuschi, pers. commun.).

In studies (Sidorchuk et al., 2011a,b) indicates that the terms of machine's work is possible, not only between probable failures, but also between scheduled maintenance. Studies indicate that in the structure of monetary costs for the operation and repair of combine harvesters, the cost of spare parts is 50-60% (Skibchik and Dnes, 2017). Late delivery of spare parts during the harvest period leads to an increase in downtime of the combine harvester fleet, delaying the start of repairs. The study notes that total downtime combine harvesters, which constitute 32-35% of the time, the downtime for technical reasons accounts for 17-20% (Enakiev et al., 2016). Thus, 60% of failures for technical reasons associated with the replacement part or unit. Thus, the ability to eliminate the failure of harvesting machines in a timely manner is associated with the presence of a spare part in the service system. The analysis shows that the elimination of 70% of failures requires the replacement of a part, assembly or unit that has failed, and the length of time to eliminate failures is mainly due to the time delivery of spare parts for combines.

The problem of organizing the technical service of complex agricultural machinery is given much

attention in economically developed countries. Maintenance (simple operations) of combines is carried out by farmers or in repair shops. Combines are repaired by farmers, dealers and manufacturers. In the United States and some European countries, the volume of repairs performed on farms is growing (D. Domuschi, pers. commun.).

In the same works it is noted that in case of breakdown of the important mechanism during working season the new detail is delivered by the emergency supply system within 8-24 h, for this purpose even air transport is used. Special service during harvesting is compulsory and sometimes around the clock.

The analysis of works on this issue showed that the available research on the reliability of modern harvesting machines requires further development in relation to specific production conditions. The research does not provide complete recommendations for the organization of delivery of spare parts from different levels of storage to the failed harvesting machine.

PURPOSE OF RESEARCHES

Improving the operability of combine harvesters - combines by reducing downtime for technical reasons with the demand for spare parts, determining their nomenclature and storage locations.

MATERIALS AND METHODS

Duration of harvesting crops depends on the availability, reliability and technical condition of harvesting machinery.

Expanding and deepening of harvesting machines' maintenance due to the increasing in its complexity, that require additional costs that are so "price" achieved by increasing reliability.

Research of the process of detection and elimination of failures of the combine harvester fleet should be carried out on such indicators as:

-number of cases of failures during harvesting;

-the complexity of restoring the efficiency of machines;

-losses of working hours caused by the removal of faults;

-expenses on elimination of failures grouped by the most important positions, components and units with the reservation of spare parts.

Optimal concentration and distribution of spare parts for various levels of storage depends on many factors: the nature and quantity of the resulting failures, the number of working combines, distances to storage, spending on storage, and shipping and eliminating failures and others.

Two types of failures are considered in the model of occurrence of failures of harvesting machines. The first is associated with various disabilities in the manufacture and repair the second associated with random factors (hitting foreign objects, shaking and so on.). The probability of the first type of failure is subject to Weibull's law, the second - the exponent, and the probability of all failures is defined as:

$$P(t)=P_1(t) \cdot P_2(t), \quad (1)$$

where: $P_1(t)$ – probability of first type failures;

$P_2(t)$ – the probability of the second kind of failures.

In conducting multivariate correlation analysis performance combine harvesters identified the following relationship:

$$y=700{,}648-32{,}456x_1+1{,}654x_{12}+8{,}99x_2+0{,}212x_{22}-12{,}850x_3-16{,}007x_4, \quad (2)$$

where: y – seasonal developments combine, physical, ha;

x_1– life harvester, year;

x_2– experience combiner specialty, year;

x_3– refusal quantity;

x_4– average recovery time, hours.

As seen from this relationship a great impact on productivity within the combine harvester affects the life of the combine, the number of failures and average recovery time.

RESULTS OF RESEARCHES

Research aimed at improving efficiency of harvesting machines, conducted in Belgorod - Dniester district of Odessa region. Productivity and balance of time changing of combines are investigated in (D. Domuschi, pers. commun., 2016) and the results of experimental studies to assess the reliability of combines Don – 1500B presented in (D. Domuschi, pers. commun.,2017).

Studies show that the harvest of a platform - pick-up and wedge belts account for 88,2% of all failures

that require replacement parts that failed. These are the main components that are objectified also assigned combine's reliability (table 1).

Table 1 Research of combines Don - 1500B on efficiency (refusal of the demand for spare parts)

Units, units, details	Number of faults	Percent of total	Work on a refusal (average), hours	Refresh time (average) hours*
Header	315	25,0	20,8	2,6/1,6
Thresher	39	3,1	337,8	7,4/4,8
Electrical	49	3,9	268,5	7,2/4,7
Hydraulic	15	1,2	877,2	6,8/4,5
Chassis	3	0,2	4336,0	9,8/7,1
Bearings	40	3,2	328,9	8,2/5,5
Driving	98	7,7	134,2	9,4/6,7
Chains	2	0,2	6579,0	2,4/1,6
Platform – wagons	699	55,5	9,4	1,7/0,9
Total	1260	100,0	10,4	3,2/2,0

** In numerator – the total time spent on the restoration of failure, the denominator – the time spent on the delivery of spare parts*

Failure of the first group of complexity is about time. Average bounce complexity in different groups of nodes and aggregates revealed that most failures of Group I accounted for such units as the platform - up (65,1%) and Reapers (28,1%) (table 2).

This replacement is performed mainly small size of parts that can be easily removed and installed. The concentration of such parts in the vicinity of working combines will significantly reduce the recovery time of disability.

Failures II of complexity combine distributed more evenly than failure I and III group complexity. Most failures accounted for electrical equipment – 29,1%, bearings – 24,2%, Driving –20,6% and thresher – 15,2% (table 2). During the season of to combine accounts for 0,5 - 1,0 waiver for one part or one unit used to eliminate denial II of complexity. Because spare parts to address these failures is advisable to store in warehouses brigades (divisions) or households. The bulk of refusals III of complexity (56%) are in the thresher. In reaper, hydraulic system and a chassis-fence have 12%, and electrical and pick – 4% (table 2). Given the fact that the refusal Group III difficulty arises in the combine about 2 - 3 seasons of spare parts to address these failures appropriate to keep in storage at the district level. This will reduce the number of reserve parts and reduce the cost of storage.

Table 2 Results distribution failures harvester Don-1500B (refusal by groups of complexity of the demand for spare parts)

Units, units, details	The number of failures pieces	Average bounce on groups of complexity					
		I group		II group		III group	
		pieces	interest	pieces	interest	pieces	interest
Header	315	301	28,1	11	6,7	3	12,0
Thresher	39	–	–	25	15,2	14	56,0
Electrical	49	–	–	48	29,1	1	4,0
Hydraulic	15	6	0,6	6	3,6	3	12,0
Chassis	3	–	–	–	–	3	12,0
Bearings	40	–	–	40	24,2	–	–
Driving	98	64	6,0	34	20,6	–	–
Chains	2	2	0,2	–	–	–	–
Platform – wagons	699	697	65,1	1	0,6	1	4,0
Total	1260	1070	100,0	165	100,0	25	100,0

When using harvesters are of the failure to eliminate that do not require a long downtime, as easy to remove damaged parts of the car, but serviceable - easily. These include segments fingers, rays, strips, hoses, belts and other. To determine the list of spare parts that limit the reliability of the harvesting method of weighting coefficients were determined by flow parameters failures and their significance.

CONCLUSIONS

Simple harvesting machines technology systems for technical reasons can reduce by reservation of spare parts to correct failures of various groups of complexity. Parts advisable to keep at various levels: the processor; in mobile technological complex warehouses; in warehouse – team (department) sector, district and regional level. Reservations parts to reduce the duration of 2–8 days harvesting, grain losses are reduced from 3,0 to 12,0 kg / ha. Implementation harvesting in optimal agronomic conditions only in terms of South steppe zone of Ukraine will increase cereal yields by an average of 10–20%.

REFERENCES

Dumenko K. N. (2010). Analysis of prospects for the development of high-reliability grain harvesting equipment in Ukraine. Energy-saving technologies and technical means for their provision in agricultural production: International. scientific-Practice conf. Young Scientists, August 25–26, 2010. Minsk. (pp.69-76).

Dumenko K. N. (2010). Research of reliability of grain harvesting combines. Agricultural Machines. Lutsk, LNTU, 20. 68-78.

Dumenko K. N., Boyko A. I. (2011). Influence of the efficiency of the maintenance area on the establishment of the functions of readiness and restoration of grain harvesting equipment.Technology and technology of agro industrial complex, 1(16). 11-14.

Sidorchuk O.V., Skibchik V. I. (2013). Planning needs for technical support for grain, oilseed and legume harvesting projects East European Journal of Advanced Technologies, 1/10 (61).76 -79.

Sidorchuk O. V., Dnes V. I., Skibchik V. I. etc. (2011). A set of main events and peculiarities of their planning in early grain harvesting projects. Mechanization and electrification of agriculture: intersection. Thematic Sciences Sb. Glevaha. 95. 375-374.

Sidorchuk O. V., Dnes V. I., Skibchik V. I. etc. (2011). Analysis of research methods and case models in projects at different stages of early grain harvest planning. Computer-integrated technologies: education, science, production: science. magazine. Lutsk. LNTU, 7. 141-144.

Skibchik V. I., Dnes V. I. (2017). Determination of the volume of losses of the grown arable crops for various parameters of technical equipment for their harvesting and post-harvesting of grain. Technologies of agroindustrial complex of the XXI century: problems and prospects of development: Coll. mater interna scientific – Practice conf. April 13–14, Nizhyn. (pp.157-159).

Enakiev Yu., Domuschi D., Mikhov M. (2016). Operational maintenance of reliability of combines at harvesting of grain. IV Scientific Congress Agricultural Machinery, Varna, Bulgaria, 22–25.06.2016., issue 17(203).(pp.87- 91). Scientific technical union of mechanical engineering.