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RESEARCH ON RELIABILITY OF SUBSYSTEMS OF GRAIN HARVESTING COMBINE

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Summary. The results of theoretical research on reliability indices of combine harvesters subsystems for effective realization of harvesting in short periods of reaping have been considered.

Key words: Reaping-machine, count of transitions, intensity of refuses, technical system, chain connection.

INTRODUCTION

Combine harvesters are difficult multioperational machines. A specific feauture of their work is the intensive exploitation during the short period of a calendar year. They work approximately for one month in a year at harvesting grains and it stipulates the special requirements to their reliability.

The insufficient level of technologies of production and quality of materials used, that reduce the reliability of machines, cause the development of wear, fatigue, corrosive and other processes which extend the period of the increase of intensity of refuses [1]. Actually, the existent harvesting equipment mainly works at the gradual decline of the level of reliability of basic subsystems which provide the technological process of harvesting [2-4].

Due to instability of the state, condition and technical maintenance of agricultural equipment, including combine harvesters, the determination of their reliability indices is rather complicated.

RESULTS AND DISCUSSION

The purpose of work is the research of reliability of subsystems of combine harvesters indices for the effective realization of field work in short periods of harvesting[1].

In accordance with classical chart the combine harvesters consist of the following basic knots which provide their functioning: reaping-machine (pickup) of grain mass, thresh vehicle, key straw shaker, crash, elevator, sieve state, bunker with on unloading device.

From the point of view of reliability such technical system is a successive chain connection of subsystems (Fig. 1.).

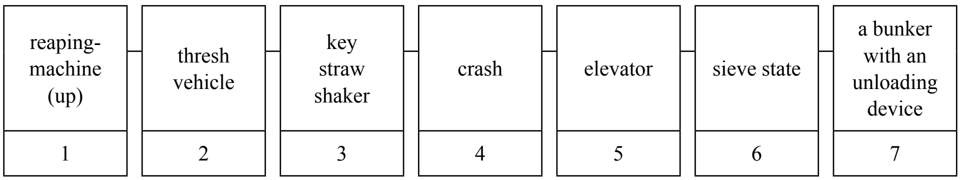

Fig. 1. General structural diagram of reliability of a grain harvester

The successive joining is known to be a basic joining for mechanical systems. The probability of faultless work in such case is determined according to the formula [3]:

$$P_c(t) = \prod_{i=1}^{n} P_i(t), \tag{1}$$

where: $P_i(t)$ – probabilities of faultless work of subsystems components;

$i=1...n$ - sequence number of subsystem.

The drawback of successive joining is that with the increase of amount of subsystems (due to the complication of equipment) the level of reliability without the application of special measures falls unavoidably[5-6].

In its turn, each of the combine subsystems can be presented as a system, consistig of subsystems of smaller grade, as well as separate elements. The hierarchy of a combine structure is in the total determined from the position of reliability, beginning from a general construction to its elements. The analysis of such structure makes it possible to determine the influence of the elements and structure constituents on the general level of reliability of a combine.

A reaping-machine (header) of a harvester combine is an independent subsystem aggregated with the basic part of machine. The constituents of the reaping-machine are a cutting vehicle, an auger, a reel and a chamber with a conveyer.

All mobile elements of the reaping-machine move due to a drive gear from a power plant of the combine. Thus, the reaping machine has the constituents which form a mechanical system, the flow diagram of reliability of which is represented on fig. 2.

Only the basic constituents which determine the possibility of carrying out the technological process of harvesting are presented on the chart. However, this chart, above all things, carries the information about the reliability connections in the system. It is evident, that, as well as in the previous chart, the successive connection of constituents is observed.

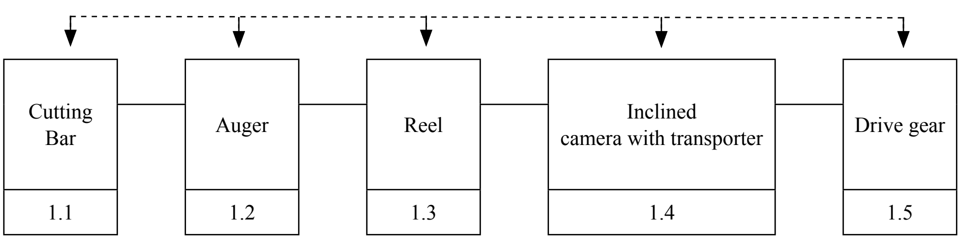

Fig. 2. Flowchart of reaper reliability

Such connection, peculiar to the mechanical systems, can be considered a basic one but at the same time the least reliable of all possible. Under the action of streams of events, related to the refuses and proceedings in a reaping-machine, the construction of trajectory of its conduct in transitions from state to state is possible (fig. 3).

The trajectory schematically represents the real situations of the possible states of the reaping machine in the periods of its operation, technical examination, adjustings and renewals. The trajectory of conduct is a composition of streams of random events and it is of stochastic character. The transition of the reaping machine to different possible states can be evidently presented as a graph of transitions (fig. 4). It takes into account not only the possible states conditioned by the action of streams of refuses and renewals, but also sets ties between the states as the orientation of events and intensity of their origin[7-8].

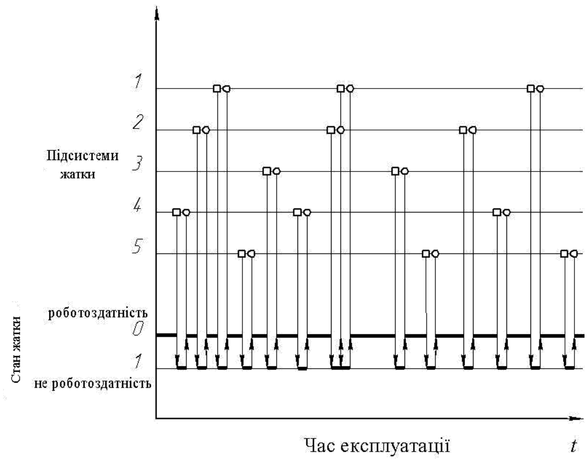

Fig. 3. Trajectory behavior of the reaping machine and its transition to different states:
□ - the moment of failure; ○ - the time of restoration.

Thus, the state of working ability is marked as “0”, and the refuse state “1”. The intensity of refuses is characterized by **λ** with an overhead index which specifies the number of subsystems and the reason for which the refuses occur, and the index below specifies the transition from the state of working ability to that of working disability. The intensity of renewals is marked accordingly as **μ** with the index above, which specifies the number of a renewed subsystem, and the lower index specifies a transition from disabled to capable working state.

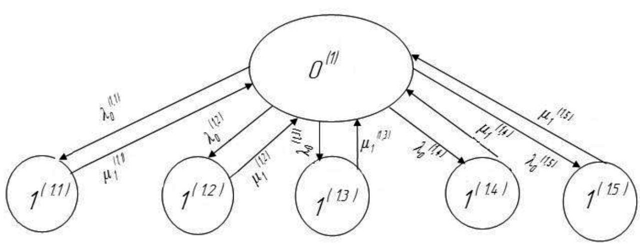

Fig. 4. Graph of reaper conversion to different states, in the state of disability and recovery

The next step of the combine elements differentiation within the reaper is to introduce the elements of the latest separately [5]. From the point of reliability the cutting device can be structured as follows (Fig. 5):

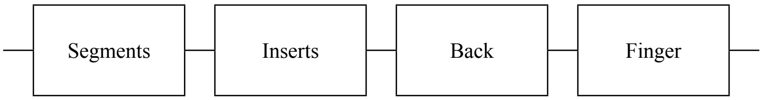

Fig. 5. Flowchart of reliability of reaper cutting device

Successive connection of elements makes a construction vulnerable to any types of refuses, and refuses form the certain streams of events, changing the system (the reaping machine) from a disabled state to a capable of working one. Operating under renewal forms the counterstreams which change the construction from the stage of repair to the capable of working state[9].

For the auger of the reaping machine, the basic characteristic damages are a bend of screws tearing them away at the places of welding, a bend of the pipe with pins and a wear of pins necks.

The wear of pins necks, as a typical damage, is also observed in reels. Alongside with it, there are cases of back pipe bend and key slot wear.

Most damages in a sloping chamber are observed in a chain conveyer which in case of wear is prolonged, and there are breaks of chain at development of cracks of fatigue. Lengthening is compensated by proper tension of chain, foreseen by periodic adjusting at technical examination.

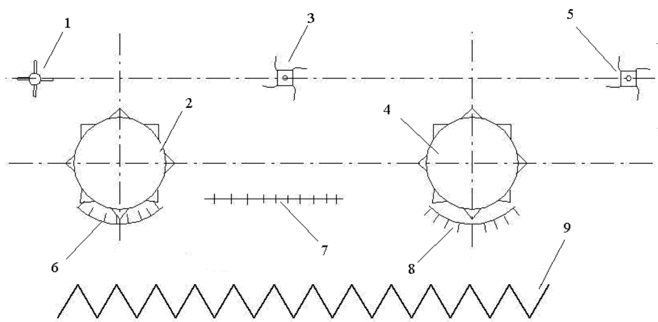

Fig. 6. Scheme of two drum threshing devices of combine harvester:
1 - receiving biter 2 – the first pulley, 3 - intermediate biter; 4 - pulley, 5 - jack biter,
6 – the first deck, 7 - support grid, 8 – the second deck, 9 - transport board cleaning.

The subsystem of a thresh vehicle consists of knots and details functionally combined between themselves. However, from the point of view of reliability the thresh vehicle is a mechanical system, intended for extracting grains from the ear. The refuse of any of the constituents of this subsystem results in the refuse of all aggregate. Therefore, the flowchart of reliability can be presented by the successive connection of elements (fig. 7).

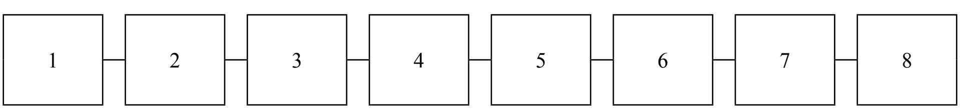

Fig. 7. Flowchart of reliability of threshing combine harvesters (designation according to Fig. 6)

The construction differs in minimum the possible amount of elements which are needed for implementation of functions for threshing grain. It also structurally meets the requirements reliability. Such construction of threshing machine requires highly reliable component elements. Otherwise, as a result of successive connection and in obedience to formula (1), a general level of probability of faultless work will be considerably low.

Graph of transitions of the thresh vehicle subsystem in different possible states at the loss of efficiency of component elements is presented in fig. 8.

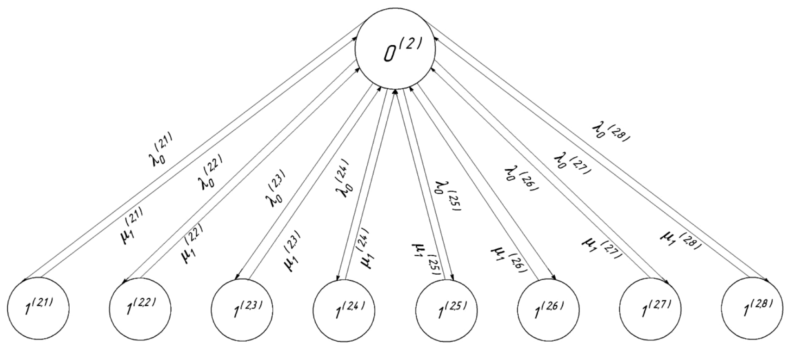

Fig. 8. Graph of conversion to possible states of threshing machine subsystem (designation according to Fig. 6)

As it is evident from the structural chart (fig. 6) and flowchart of reliability (fig. 7) the thresh vehicle subsystem differs in many elements. However, the elements of the subsystem can be grouped together according to their structural features and performed operations technology.

The first group includes the receiving, intermediate and pneumatic biter. Their characteristic defects are such as the deformation of blades, and break combs. These damages will be liquidated at renewals by smoothing the deformed details and welding at the places of breakage.

The second group is the thresh drums. The reasons of their break can be a wear of bill to a maximum state (appearance $\Delta \leq 4$ mm), or destruction at emergency damages. In any case, the whips of the drums must be changed for the new ones. Thus, such operation of renewal must be executed in a specialized workshop, as the drum at replacement of serial whips needs subsequent dynamic balancing. The consequences of emergency damages can be decreased by changing the construction of the drum and providing it with short whips. At certain calculations it is possible to replace the damaged whips in the field conditions keeping the balance of the drum in the limits of possible disbalance. The application of the system of automatic balancing is also, possible.

A similar situation, but with its own $\boldsymbol{\lambda}$ and $\boldsymbol{\mu}$ features, occurs for the concaves, which are the counteractive elements in relation to the drums at beating out the grain. A difference only lies in the method of renewing the working elements of slats. To continue the work at a maximum wear they turn to a new working verge and at achievement of complete wear they are put out of operation and fixed as a refuse. However, such operation of renewal at the existent construction of concave can be made only once.

The key straw, crash and sieve state. An important subsystem for separation of grains from a straw is a key straw shaker. The keys of the straw shaker execute a difficult spatial motion which provides the divisions of factions and their moving in the streams.

The principle of work of the subsystems of straw shaker and sieve lies in the restoration of oscillatory and forward motion necessary for division of fractions. Except for rare refuses, due to the materials, defects development of cracks or insufficient level of technological culture of production, the principal reasons for loss of efficiency in the indicated subsystems is a wear of slide bearings in a driving gear mechanism. In general, such refuses can be considered on the example of the slide bearing of strawshaker[10].

In the wide-spread Soviet combines made at Rostov-on the-Don factory «Rostselmash» the wooden lubricated bearings are used. The advantage of such bearings is the simplicity of construction, possibility of adjusting a gap and easy replacement at achievement of maximum wear[11].

Summarizing the presented analysis of structural construction of subsystems of combine harvesters it is possible to conclude, that their classical structural solutions are executed mainly on the linear chart of successive connections of elements. It is the simplest realization of the machine as a technical system fairly adapted to the real terms of the long-term effective exploitation. At such construction of difficult agricultural equipment the achievement of the necessary level of reliability is possible only due to the use of high-quality and proper materials for the details, as well as the timely regulation of servicing work.

CONCLUSIONS

The problem of support of the necessary level of reliability of combine harvesters becomes complicated due to the change of their physical condition in the process of details exploitation. Physical and chemical processes of wear of details, accumulation of damages, as a result of fatigue of materials, different types of hammerings, overloads, corrosive processes are quite common. The equipment gradually loses the initial level of readiness to the implementation of harvest work. These are natural processes which take place in the machines after the increase of their running time and the term of exploitation. The alternative can be the improvement of construction and timely skilled technical maintenance of the combine systems. Due to such actions it is possible to support the necessary level of reliability of the equipment for efficient field work and harvesting in short periods of reaping.

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BADANIA NIEZAWODNOŚCI PODSYSTEMÓW ZBOŻOWEGO KOMBAJNU

Streszczenie. Rezultaty badań teoretycznych na indeksach niezawodnosci podsystemów zbożowego kombajnu dla realizacji zbioru efektywnego ziarna w najkrótszym okresie.

Słowa kluczowe: grafy przemieszczeń, efektywność, techniczne systemy, związki koniudzow.