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ANALYSIS OF SCIENTIFIC RESEARCH AIMED AT INCREASING THE RELIABILITY OF MACHINES AS HUMAN-MACHINE-ENVIRONMENT SYSTEMS

Kuzmina T.[1], art. scientific co-workers,

Boltianska N.[2], associate professor,

Neparko T.[3], associate professor

[1]*Russian Research Institute of Information and Technical and Economic Research on Engineering and Technical Support of the Agro-Industrial Complex, Pravdinsky, Russia*

[2]*Melitopol State University, Melitopol, Russia*

Belarusian State Agrarian Technical University, Minsk, Belarus

Summary. The article provides an analysis and synthesis of scientific research aimed at ensuring the reliability of machines as ″human-machine-environment″ systems.

Key words: machine, system, reliability, operator, performance, environment.

Formulation of the problem. Improvements in agricultural machinery and equipment are accompanied by increases in power and operating speeds, more complex designs of working elements, and an increasing number of control elements and means of displaying information about their technical condition. At the same time, the reliability of complex systems depends not only on the perfection of the design but also on the professionalism of the operators, the influence of the external environment in which they work, and the maintenance of their operability [1-3]. Based on this, a trend is emerging toward studying such a multi-functional machine as a complex human-machine-environment system ("HME").

Basic research materials. Experience with agricultural machinery, including feed preparation and distribution equipment, shows that average variable productivity under identical conditions for different operators can vary by more than a factor of 2. By improving the design, machine productivity can increase by approximately 1.5–2.0 times [4]. A trend toward declining utilization of the potential capabilities of machines is becoming increasingly apparent, with actual productivity under production conditions often amounting to 50–60% of the rated values. This is due not only to the low reliability of the machines, but also to the inconsistency of the components of the "HME" system.

In the process of upgrading multi-functional machines, measures are being taken to improve operator working conditions. Analysis shows that most machines are equipped with automated control systems for technical systems. The introduction of additional devices into the design complicates their operation and increases the information load on the operator [5].

A number of scientific and practical studies have been devoted to the study of the functioning and interrelationships of the components of the system. The works analyzed in the article [3] present issues of improving the working conditions of mobile machine operators by improving the «HME» system. However, when analyzing the results of other studies, the factors that became decisive in ensuring the reliability of agricultural machinery, such as «HME» systems, were not identified. In this regard, an analysis and synthesis of scientific and practical research into the reliability of complex technical «HME» systems would be appropriate human-machine systems in agriculture are noteworthy. The scientific paper [6] examines the reliability of the technological system "human-machine systems" for processing and harvesting crops. The main factors that influence the performance of the "human" component of the human-machine systems for processing and harvesting crops are the level of professional skill and fatigue of the machine operator. It has been

experimentally established that the level of professional skill for a combine operator averages B_{pm} =0.747. The main factors that most influence the reliability of the "environment" component of the "HMS " system are agro-landscape and weather-climatic factors. It was found that the daily productivity and performance of arable units and the reduced failure rate from the "human" component are in good agreement with the Weibull law, while from the "machine" component, they are in good agreement with the normal distribution law.

At the same time, the scientific work [7,8] examines the issues of the operational reliability of the grain harvesting system, which already encompasses four components: "man-machine-environment-transport" ("HMET"). The results of the study of the influence of the presented components on the operational reliability of the "HMET" systems are effectively used during the substantiation of work and rest regimes for machine operators, ensuring the operational management of the operation of technical equipment, taking into account their technical condition.

The study [9] examines the issues of operational reliability of human mental health systems depending on the level of operational factors, the formation of an information base for design, the development of methodological foundations for research, testing and methods for their effective use. Professor A.G. Levshin, based on differential mathematical models, established the optimal relationships between the periods of work and rest for mobile unit operators, taking into account the need for periodic renewal of their psychophysiological performance potential. Depending on changes in the operator's condition during work, it was established that the maximum weekly load cycle occurs on the 3rd or 4th day of the week, and for the seasonal cycle – 4-7 weeks of work. Based on the theory of discrete Markov chains, mathematical models of the dynamics of transient processes in the operation of technological complexes were obtained. It was established that the time for the system to transition to a steady-state

operating mode is 0.9-2.7 hours, which corresponds to the duration of the main phases of change in the performance of operators. The results obtained are of considerable interest, while it would be advisable to focus on extending the duration of the steady-state operating mode for various agricultural units.

Closely related to our research is the scientific work [10], aimed at increasing the technological reliability of the operator by improving the working conditions in the "man-machine-animal" system ("MMA"). Scientific research is formed in the direction of increasing the reliability and efficiency of the operators of mechanized processes in animal husbandry (machine milking operators as components of the "MMA" system). One of the effective solutions to the problem of improving the qualifications of operators in animal husbandry is the use of simulators, which made it possible to reduce manual labor costs by 18.6%, while the milking time per cow decreased by 43% and increased the utilization rate of milking equipment from 0.615 to 0.885. The presented approach can be used in other industries, especially when using simulators for training machine operators and technical service workers.

Worthy of attention are scientific and practical studies in the forestry sector, which identify priority areas for the development of the «HME» system: increasing personnel requirements, taking into account the composition, training, and qualifications of specialists; and studying the condition of repair and technological equipment and the state of technological operations at service companies. A model for the technological preparation of production at service companies has been developed, in which technical service processes are represented as complex dynamic systems linked into a single complex: machine, unit, parts, technological equipment, and personnel.

Conclusions. By analyzing the results of the presented scientific works, we can formulate the main directions for ensuring the reliability of agricultural machinery as complex systems "HME":

- development of theoretical models to ensure system reliability;

- study of the influence of the corresponding environment (ROB – repair and maintenance base) on the reliability of a complex system;

- formation of a set of provisions and recommendations for optimal management of the technical condition of domestic and foreign machines under the conditions of the «HME» system;

- development of methods and simulators for training operators and technical service workers for servicing complex multi-operation machines (systems).

The implementation of the presented directions will allow us to describe the behavior of human-machine communication systems and will contribute to the formation of an information base for design, development of methodological foundations for research and methods for their effective implementation.

References

1. Yeremenko, O., Abdullo, M.A., Mikhalchenko, S., Verkholantseva, V. Reducing Working fluid pulsations in planetary hydraulic machines by rational design of the distribution systems. Lecture Notes in Mechanical Engineeringthis link is disabled, 2022, pp. 133-143.

2. Клевцова Т.А., Гвоздев А.В. Оценка функционирования технологических систем малых предприятий АПК // Формирование эффективной системы менеджмента в условиях транзитивной экономики: матер. I Межд. научно-практ. конф. Мелитополь, 2024. С. 451-456.

3. Непарко Т.А., Терентьев В.В., Прокопенко И.П. Сложные производственные операции и пути повышения их эффективности // Техническое и кадровое обеспечение инновационных технологий в сельском хозяйстве: матер. Межд. научно-практ. конф. Минск, 2024. С. 145-148.