Annotation.*The paper proves the necessity of development of new effective approaches in pedagogical technologist based on special subjective rules of acquiring knowledge. If allows to substantially increasing the efficiency of problematic training during lectures. If scientifically proves the mechanism of introducing students into active cognitive in the aspect of subjective rules of acquiring new knowledge.*

Key words: psychological and didactic aspect, problem lectures, creative thinking, convergent thinking, divergent thinking, semantic systems

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APPLICATION RESEARCH METHODOLOGY Markov random process for PROGNOSIS OF CONDUCT 'machine - tractor UNIT - INDUSTRIAL ENVIRONMENT "

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Abstract. *The paper demonstrated the use of continuous research methodology Markov chains for predicting system behavior "mechanic-machine-tractor unit and production environment" and the risk assessment of injury tractor-driver (machine) APC.*

Keywords: methods of analysis of injuries, *Markov chains, professional risk tractor-driver*

Putting problems. According to statistics on the state of occupational injuries in agriculture Ukraine (APC) continues to be one of the most traumatic national economy. Thus, over the last five years 348 Agricultural sector workers injured with lethal consequences, that is more than 13% of fatally injured during this period workers in all sectors of economy of Ukraine. And this is without taking into account the data on fatal accidents in food industries that traditionally belong to the agricultural sector.

The most traumatic and prevalent in agriculture profession is a profession tractor-driver (machine operators), since their work is connected with a variety of mobile engineering capital goods (tractors, combines, self-propelled farm machinery, etc.). It was during the application of the technology there is a large number of dangerous situations that lead to various injuries. In particular, during 2010-2014. Agrotechnological when performing operations killed 78 tractor-driver (machine), which is more than 22% of fatally injured workers in agriculture Ukraine. To develop and implement effective and efficient preventive measures and means for reducing occupational injuries AIC necessary to machine a thorough investigation of its causes based on the most suitable methods and ways of taking into account the characteristics of the mechanized processes in agricultural production. These methods are the methods of probabilistic risk assessment of the accident because these methods allow to study processes flow traumatic situations and timely develop and introduce appropriate measures and technical security. However, studies to determine the occupational risk of machine while operating various farm machinery makes it difficult to carry out deep analysis of process flow traumatic situations. Based on the above, further research on finding the most suitable methods for the quantitative determination of occupational hazards machine are relevant.

Analysis of recent research. Industrial injuries, his analysis, quantification of occupational risk and the search for effective ways to reduce its levels to acceptable limits attracts many professionals. Many publications, both domestic and foreign scientists indicate the existence of many methods and approaches to research problems at all occupational injuries and risk of injury to production in particular. These methods can mention the following as the most common: method of expert assessment [1], the method based on fuzzy sets theory [2], structural modeling method [3] statistical method [4] and so on.

In addition to the methods for risk analysis process equipment to offer the use of such methodological approaches [5]:

- Engineering (based on statistical data, calculation of frequency probabilistic safety analysis, construction wood danger);
- Model (based on constructing a model of the impact of harmful and hazardous production factors on employees);
- Expert (the probability of adverse events is determined on the basis of interviews with experts or qualified).

However, it should be noted that taken separately, they can not describe the real picture of the flow of processes traumatic situations in agriculture, and the specificity of agricultural production often makes any qualitative and quantitative analysis of these methods and approaches quite relative and conditional. Therefore, it becomes necessary to search for such theoretical principles and methodological approaches, the use of which would make it possible to more accurately and objectively investigate the risk of professional mechanics AIC, and on this basis to suggest ways to reduce it. Hence, a number of researchers [6-8] forstudy the phenomenon of occupational injuries become more widely used methods of logical and mathematical modeling. These methods can more accurately determine the risk of occurrence of accidents and injuries, which allows to develop and implement effective preventive measures.It is widely used for investigation of accidents and injuries in leading industries found probabilistic analysis techniques, where their quantitative and qualitative characteristics determined by the method of "fault tree" [9, 10]. The above method is quite effective and user-estimation of risk of injury to workers in manufacturing, but it has some limitations in the application regarding the qualitative and quantitative analysis of the dynamics of flow traumatic situations, particularly for stay forecasting system "man-machine-productionEnvironment "(hereinafter - the System" LMD ") in one of the states after a certain period of time. Instead, it can make methods, which are based on study of the behavior of elements of man, machine and the environment as an integrated production system. One of these methods is systems analysis using mathematical apparatus of Markov random processes with discrete states and continuous time.

The purpose of research

Results.

For a description of processes of nucleation, formation and occurrence of accidents applied mathematical tools developed in the theory of probabilities for Markov random processes with discrete states and continuous time in which the transition system "mechanic-MTA-production Environment "(hereinafter - the system S) from one state to another is possible at any advance is not known, random time t.

Considering the random processes with discrete states and continuous time, conveniently represent transitions S system from one state to another as being under influence of certain events or streams embodied in the notion of dangerous industrial factors as "dangerous impacts of energy". [12] Then the transition probability density λ are content intensities corresponding flow of events. The process, which takes place in the system S, will be Markov if all these streams of events will Poisson (ordinary, with no aftereffects, constant or time dependent intensity) [13, 14].

For example, was elected one of the fundamental adverse events that happen to mechanization while operating various MTA and self-propelled agricultural machines - namely, traffic accident (RTA) MTA due to collision with other vehicles or fixed obstacles. Count process flow conditions specified adverse events are presented in Fig. 1. In Fig. 1 shows that since the introduction of AIT operation system works in good condition S0, where it can be all the time his work up to decommissioning. However, as practice shows, after a period of time under streams of events with intensity λ01 system can go out of whack S1 (in this case - to work with defective lighting or signaling). However, this does not affect the ability of our system to continue to operate in a given mode. Working in state S1 under streams of events with intensity λ10, the system may return over time back to state S0 (bringing drugs lighting or signaling in good condition). However, due to certain errors mechanics, under streams of events with intensity λ12, the system can go into a state S2, characterized hit machine operators in a dangerous situation - namely, MTA zayizhdzhannya the zone collision with another vehicle or fixed obstacle.

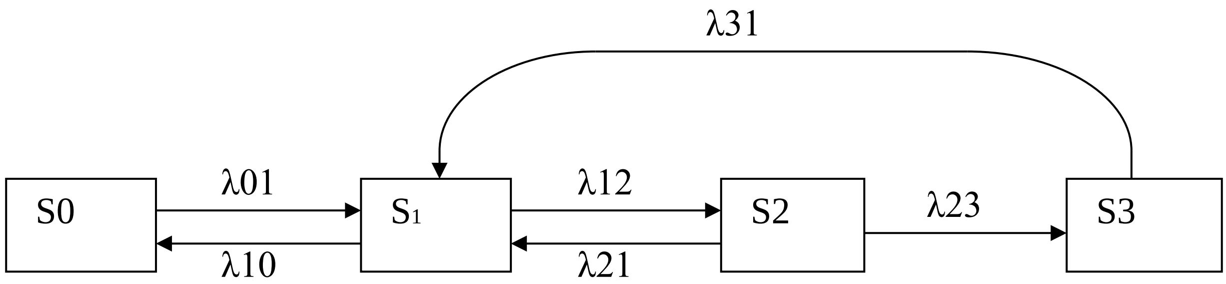

Fig. 1. Count status of course undesirable events' MTA accidents due to collision with other vehicles or fixed obstacles »: S0 - the system is in good condition; S1 - system is in failure condition (lighting and signaling devices out of order); S2 - machine operators entering a dangerous situation (ITA zayizhdzhannya the zone collision with another vehicle or fixed obstacle); S3 - transition to a dangerous situation in a critical situation (injury due to machine operators MTA collision with another vehicle or fixed obstacle).

Then there are several versions of adverse events:

– under streams of events with intensity λ21 system returns to its previous state S1, which can continue to work in the future, or later under streams of events with intensity λ10 returns to the initial state S0;

– under streams of events with intensity λ23 system goes into S3, which is characterized by the transition a dangerous situation critical (injury to machine operators as a result of the collision MTA with another vehicle or fixed obstacle) and subsequent return under streams of events with intensity λ31 in state S1, which system, similar to the circumstances by point and may continue to work, or later, under the influence of streams of events with intensity λ10, return to the initial state S0.

Knowing tagged graph states can determine the probability of our state system $P_0(t), P_1(t), P_2(t)$ and $P_3(t)$ as a function of time. Specifically, these probabilities satisfy the system of differential equations Chapman-

Kolmogorov in which functions are unknown probability states of the system [13]

$$\begin{cases} \dfrac{dP_0(t)}{dt} = -\lambda_{01}P_0(t) + \lambda_{10}P_1(t), \\ \dfrac{dP_1(t)}{dt} = \lambda_{01}P_0(t) - (\lambda_{10} + \lambda_{12})P_1(t) + \lambda_{21}P_2(t) + \lambda_{31}P_3(t), \\ \dfrac{dP_2(t)}{dt} = \lambda_{12}P_1(t) - (\lambda_{21} + \lambda_{23})P_2(t), \\ \dfrac{dP_3(t)}{dt} = \lambda_{23}P_2(t) - \lambda_{31}P_3(t) \end{cases}$$

of normalizing condition $P_0(0) + P_1(0) + P_2(0) + P_3(0) = 1.$

To consider introducing a vector function $\vec{P}(t) = (P_0(t), P_1(t), P_2(t), P_3(t))$ and a matrix of intensities:

$$\Lambda = \begin{pmatrix} -\lambda_{01} & \lambda_{10} & 0 & 0 \\ \lambda_{01} & -\lambda_{10} - \lambda_{12} & \lambda_{21} & \lambda_{31} \\ 0 & \lambda_{12} & -\lambda_{21} - \lambda_{23} & 0 \\ 0 & 0 & \lambda_{23} & -\lambda_{31} \end{pmatrix},$$

we can rewrite the system of equations Kolmogorov as the following linear matrix system of differential equations:

$$\begin{cases} \dfrac{d\vec{P}(t)}{dt} = \Lambda\vec{P}(t), \\ l\vec{P}(\cdot) = \sum\limits_{i=0}^{3} P_i(0) = 1, \ \ P_i(0) \geq 0. \end{cases} \tag{1}$$

For the solution of system (1) can apply the Laplace transform. According to [15] for functions $f(t)$ its Laplace transform is:

$$F(p) = \int_0^\infty e^{-pt} f(t)dt.$$

Then the original $f'(t)$ will match function $pF(p) - f(0).$

The inverse Laplace transform realize this:

$$f(t) = \frac{1}{2\pi i}\int_{t-i\infty}^{t+i\infty} e^{pt}F(p)dp..$$

Let the vector function $\vec{\pi}(p)$ is as follows:

$$\vec{\pi}(p) = (\pi_0(p), \pi_1(p), \pi_2(p), \pi_3(p)),$$

where: $\pi_i(p), i = \overline{0,3}$ - The relevant features images of states $P_i(t), i = \overline{0,3}$ in the case of the Laplace transform. Then the differential system (1) becomes a linear algebraic system:

$$\vec{\pi} = Q\vec{\pi} + \vec{g}, \tag{2}$$

where: Q matrix and vector $\vec{g}$ respectively are as follows:

$$Q = \frac{1}{p}\Lambda, \ \ \vec{g} = \frac{1}{p}(P_0(0), P_1(0), P_2(0), P_3(0)),$$

or in expanded form:

$$\begin{cases} \pi_0(p) = -\dfrac{\lambda_{01}}{p}\pi_0(p) + \dfrac{\lambda_{10}}{p}\pi_1(p) + \dfrac{P_0(0)}{p}, \\ \pi_1(p) = \dfrac{\lambda_{01}}{p}\pi_0(p) - \dfrac{(\lambda_{10}+\lambda_{12})}{p}\pi_1(p) + \lambda_{21}\pi_2(p) + \lambda_{31}\pi_3(t) + \dfrac{P_1(0)}{p}, \\ \pi_2(p) = \dfrac{\lambda_{12}}{p}\pi_1(p) - \dfrac{(\lambda_{21}+\lambda_{23})}{p}\pi_2(p) + \dfrac{P_2(0)}{p}, \\ \pi_0(p) = \dfrac{\lambda_{23}}{p}\pi_2(p) - \dfrac{\lambda_{31}}{p}\pi_3(p) + \dfrac{P_3(0)}{p}, \end{cases}$$

the condition $\sum_{i=0}^{3}\pi_i(p) = \dfrac{1}{p}$.

Transform the system (2) the following:

$$(I-Q)\vec{\pi} = \vec{g}\ . \tag{3}$$

There are two cases:

1) $\det(I-Q) \neq 0.$

Then there is a unique solution matrix system (3) as:

$$\vec{\pi} = (I-Q)^{-1}\vec{g}.$$

Performing normalization condition check direct substitution resulting solution;

2) $\det(I-Q) = 0.$

In this case, the solution matrix system (3) does not exist for all the right parts $\vec{g}$ But only for those and only those $\vec{g}$ Satisfying condition $P_{N((I-Q)^T)}\vec{g} = \vec{0}$. If this condition the set of solutions of this system will be as follows:

$$\vec{\pi} = (I-Q)^{+}\vec{g} + P_{N(I-Q)}\vec{c}.$$

For any vector $\vec{c} \in R^4$ Where the matrix $(I-Q)^{+}$ - For pseudo Moore-Penrose matrix (I - Q) [15].

Performing inverse Laplace transform checking and normalizing condition, find the desired distribution conditions.

For example, probabilistic calculations show features state system "LMD", which consists of the elements "mechanic-MTA-productionenvironment ". To calculate the conversion ratios of the intensities of the system used averaged statistics: State Statistics Service of Ukraine - on the number of tractors that were registered in the agricultural enterprises; Derzhsilhospinspektsiyi Ukraine - on the number of tractors that are operated with defective lights and signaling devices; OSH Ukraine - about mechanics of injuries while operating tractors with defective lights and signaling devices, and expert assessment experts on specific probabilities of states of the process flow traumatic situations.

An analysis of relevant ratios that characterize each state of the system, yielded the following ratios intensity by the average number of tractors (149,720 units) which are registered farms:

- The number of tractors that operate with serviceable lighting and signaling devices - 136,245 units (λ_{00} = 0.91);
- The number of tractors that operate with faulty lighting and signaling devices - 13,475 units (λ_{01} = 0.09);
- The number of tractors in which lighting and signaling devices are given in good condition - 10780 units (λ_{10} = 0.8);
- The number of tractors with defective lights and signaling devices that continue to operate - 2695 units (λ_{11} = = 0.2);
- The number of tractors with defective lighting and signaling, operation which led to the occurrence of traumatic situations - 1887 units (λ_{12} = 0.7);
- The number of traumatic situations that have fallen into critical - 377 cases (λ_{23} = 0.2);
- The transition from traumatic situations in defective condition - 1510 cases (λ_{21} = 0.8);
- Transfer of critical situations in defective condition - 377 cases (λ_{31} = 1.0).

Matrix transition of the system will be as follows:

$$\mathrm{P} = \begin{pmatrix} -0,09 & 0,1 & 0 & 0 \\ 0,09 & -0,8 & 0,2 & 1 \\ 0 & 0,7 & -1 & 0 \\ 0 & 0 & 0,8 & -1 \end{pmatrix}.$$

Solving Kolmogorov-Chapman and considering the condition of normalization, we get the set of probabilities of the system:

$$\begin{cases} P_0(t) = -0,0232c_1(0,3724)^t - 0,79c_3(0,9028)^t + 0,2169, \\ P_1(t) = \ \ 0,2086c_1(0,3724)^t + 0,097c_3(0,9028)^t + 0,2589, \\ P_2(t) = \ -0,7778c_1(0,3724)^t - 0,7071c_2(0,9028)^t + 0,097c_3(0,9028)^t + 0,2185, \\ P_3(t) = \ 0,5924c_1(0,3724)^t + 0,7071c_2(0,9028)^t + 0,596\,c_3(0,9028)^t + 0,3057. \end{cases}$$

In order that the condition of normalization, you must put constantC1 = C2 = C3 = 0.1.

Functions conditions can be represented as follows:

$$\begin{cases} P_0(t) = -0,00232(0,3724)^t - 0,079(0,9028)^t + 0,2169 \\ P_1(t) = \ \ 0,02086(0,3724)^t + 0,0097(0,9028)^t + 0,2589 \\ P_2(t) = \ -0,07778(0,3724)^t - 0,07071(0,44937)^t + 0,0097(0,9028)^t + 0,2185 \\ P_3(t) = \ 0,05924(0,3724)^t + 0,07071(0,44937)^t + 0,0596(0,9028)^t + 0,3057 \end{cases}$$

Based on these data graphs kinetic dependencies probability P states of the system (Fig. 2).

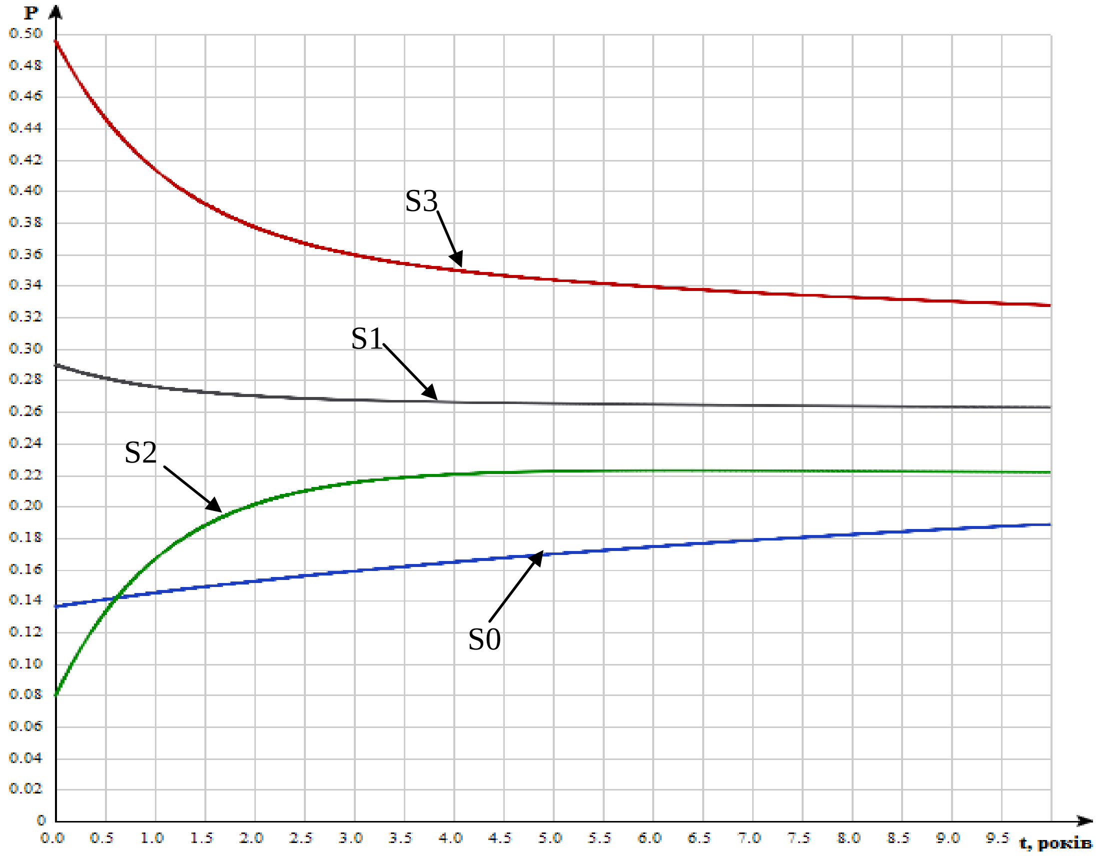

Fig. 2. Graphs kinetic dependencies probability P system states (S0, S1, S2, S3).

So, in the long term (10 years) the probability of being in a state of our system will be 0.2169 S0 in state S1 - 0,2589, in the state S2 - 0,2185, in the state S3 - 0,3057. This means that 21.69% of units operate in good condition S0, 25,89% move in defective condition S1, 21,85% go into a dangerous state S2 (will create a dangerous situation). The probability of the system go into a critical state S3 (injury to machine operators) in this case will be 30.57%. As seen from the example of the evaluation, the results can be used for predictive probability system states "LMD" in terms of risk of injury to the production machine agribusiness.

Conclusions

1. The use of continuous Markov chains as a method of probabilistic analysis of random events allows to quantify the risk of injury to the tractor-driver during operation of the machine-tractor units and find the probability at all stages of the process flow traumatic situations and predict the probability of system stay " LMD "in a particular state after a certain period of time.

2. Projected figures probability change state system "LMD" on the main production processes in agriculture indicate that in the medium and

long term this system becomes steady state operation, ie the probability of its states virtually unchanged.

List of references

1. Holmberg J. Application of the Dempster - Shafer Theory of Evidence for Accident Probability Estimates / J. Holmberg // Rel. Eng. And Syst. Safety. - 1989. - № 1. - P. 47-48.
2. Karwowski W. Fuzz modeling of risk factors for industrial accident prevention - Some empirical results / W. Karwowski, T. Marek, C. Noworol, K. Ostaszeweski // Appl. Fuzzu Ses Methodol. And Eng. - Amsterdam eti., 1989. - P. 141-153.
3. Krovak J. Kaneova simulacni metoda (KSIM) - generator scenaru / J. Krovak // Ekon.-mat. Obz. - 1988. - № 2. - C. 183-200.
4. Safety zhyznedeyatelnosty / MA Chizhov, FG Nazmuhdynova, *NK Nuhaeva, BM Azizova*. - Kazan: Kazan hosudarstvennыy tehnolohycheskyy University Press, 2001. - 132 p.
5. Risk Bondar VA, and reliability of security. The system concepts and oboznachenyy / VA Bondar, Yuri Popov // Safety of labor in industry. - 1997. - № 10. - P. 39-42.
6. Antonov GN Oh novyh approach for building a logical and veroyatnostnыh models structural safety of slozhnыh / GN Antonov, *A. Mozhaev* // Problems of safety at chrezvычaynыh situations. - M .: VINITI, 1999. - Vol. 9. - P. 14-27.
7. E. Henley J., Kumamoto H. of technical reliability of systems and evaluation of risk / Per. with English. VS Sыromyatnykova, GS Demynoy; Pod Society. Ed. *VS Sыromyatnykova*. - M .: Engineering, 1984. - 528 p.
8. S. Aronov I. Modern problems of technical safety systems and analysis of risk / I. Aronov Q. // Standartы and quality. - 1998. - № 3. - P. 45-51.
9. Aleksandrov AB Using wood otkazov method for analysis neschastnыh cases / AB Aleksandrov, VF Martыnyuk, S. Fomin, *EE Thomas* // Safety zhyznedeyatelnosty. - 2002. - № 9. - P. 6-11.
10. Lыsyuk SD Raschёt probability of poisoning with hlorhazom Using KODA IRRAS / SD Lыsyuk // Problems of safety in Ukraine. - K .: NNDIOP, 2005. - Vol. 9. - P. 46-55.
11. S. Levashov Technology Analytical investigation of cases and causes neschastnыh yntsydentov / s Levashov // Labour protection. To help expert on health. - K., 2013. - № 3. - P. 50-52.
12. Gnatyuk AA technique of continuous Markov chains for the evaluation of occupational risk operators of mobile machine-tractor units (MTA) on the production processes in agriculture Ukraine / AA Gnatyuk // Journal of Kharkov National Technical University of Agriculture them. Petro Vasilenko. - H., 2008. - Vol. 75, Vol. 2. - P. 347-351.
13. Wentzel ES Tasks and Exercises in Probability theory: Training. posobye polytechnics for students / ES Wentzel. - M .: Academy, 2003. - 440 p.
14. EB Dynkin Markovskye processes / EB Dynkin. - M .: Fyzmathyz, 1963. - 859 p.
15. Boychuk AA-Obobschenno Returning operatorы and neterovы kraevыe problem / AA Boychuk, VF Zhuravlev, A. Samoilenko. - K .: Naukova Dumka, 1994. - 315 p.

Abstract.*In this article Application prodemonstryrovano methodology of the study nepreгыvnыh Markov chains for behavior*

prediction system "mehanyzator Tractor-machine and machine-okruzhayuschaya Wednesday" and otsenki line travmyrovanyya traktorystov-mashynystov (mehanyzatorov) APC.
Keywords: methods of analysis of industrial accidents, Continuous Markov chains, professyonalnыy risk traktorystov-mashynystov

Annotation.*The paper demonstrated the use of continuous research methodology Markov chains to predict system behavior «mechanic-machine-tractor-unit-environment» and the risk of injury assessment tractor-drivers (machanizators) AIC.*
Key words: methods for analyzing injuries, continuous Markov chains, professional tractor-risk drivers

UDC 631.31

PHYSICAL AND MATHEMATICAL MODELING OF TRIBOSYSTEM "WORKING TOOL - LAND"

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Annotation.*The work presents the results of physical and mathematical modeling of tribology system "working toll - land". We dealt with the processes that occur in dynamic state in tribology system and tasks for further researches.*
Key words: ***tribosystem, physical and mathematical model, working tools, land***

Introduction. As a result of abrasive wear loss of the national product in developed countries ranges from 1 to 4% [1]. In agriculture complex working bodies of tillage machines are mostly exposed to wear. Ensuring reliability of these machines by improving the wear resistance is one of the major challenges of modern engineering.

The current stage of technological development is characterized by the use of wear-resistant materials, local hardening, heat treatment and other methods aimed to increase wear resistance of tillage machines. In these conditions, conventional methods of research of wear process are unacceptable, as working lives reach quite high values (e.g. for disk working bodies up to 3 ... 4 years).