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System Approach to Investigation of Projects of Fire-Fighting Systems' Functioning and Development of United Territorial Communities

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Summary. The necessity of realization and specificity of projects of functioning and development of fire fighting systems of the united territorial communities is justified. The analysis of the subject area was made and the need for the development of the scientific and methodical foundations of the systematic study of project management processes of the operation and development of fire extinguishing systems in the united territorial communities was justified.

The scientific and methodical principles of system research of processes of project management of functioning and development of fire fighting systems of united territorial communities are revealed. It is established that the above scientific and methodical principles are based on the use of methods of system approach, analysis and synthesis, analogies, induction and deduction, statistical generalization.

Projects of the operation of fire extinguishing systems of the combined territorial communities are considered as organizational and technological systems, and projects of their development as organizational and technical systems, which are interrelated between separate management processes. Each of these systems has three subsystems (control, project and product). These subsystems distinguish elements (input effects, parameters and results) that have their own specific characteristics.

The substantiated characteristics of elements of separate subsystems belonging to systems of projects of operation and development of fire extinguishing systems of the combined territorial communities reflect their characteristic components. They belong to two types of interconnected systems – organizational, technological, and organizational-technical. It is proved that the specified characteristics of the elements of individual subsystems change during their operation. These changes are due to the presence of causal links between the components of the fire-fighting systems of the united territorial communities. The disclosure of the causal relationships between the components of the fire fighting systems of the united territorial communities is one of the main tasks of managing the processes in the projects of the operation and development of the respective fire extinguishing systems.

It is established that the scientific and methodological principles of research of the indicated connections in two interconnected systems (organizational, technological, organizational and technical) have their own specificity both in relation to the project environment, and in relation to the configuration of projects and the resulting product.

Key words: project, management, operation, development, research, system approach, fire extinguishing system, united territorial communities.

INTRODUCTION

At present, the project management is penetrating more and more areas of human activity.

At the same time, it remains an important and effective means of development of various industries and territories. In Ukraine, the reform of the administrative-territorial system is being implemented.

The basic level of the new administrative-territorial structure of Ukraine remains the united territorial communities.

Each of the newly formed united territorial communities has a number of tasks, the solution of which requires the implementation of relevant projects.

One of the most urgent ones that provide security is the projects of the development of fire extinguishing systems of the united territorial communities.

Implementation of any projects, including projects for the development of fire extinguishing systems of united territorial communities, requires the implementation of a number of management processes and the development of scientific and methodological principles for their implementation.

Compared to other types of projects, these management processes are specific both to the design environment and to the configuration of the projects and the resulting product.

Appropriate scientific and methodological principles should be developed for the management of projects for the development of fire extinguishing systems of the united territorial communities.

The defining and very topical issue at present is the development of scientific and methodological principles of systematic study of the processes of project management of the operation and development of fire extinguishing systems of the combined territorial communities.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Known methods and models of project management, programs and their portfolios related to the functioning and development of both organizations and certain sectors of the national economy are directed at solving a number of specific administrative tasks [1-17]. They are considered as relatively separate management processes, and in the system for the management of individual types of projects (operation or development). The existing tools for managing projects, programs and their portfolios are based on different methods and approaches. However, for the successful implementation of projects, programs and their development portfolios, organizations, industries and territories should have a database and knowledge that is formed only as a result of the implementation of projects, programs and their portfolios of their functioning. Therefore, for the effective implementation of projects, programs and their development portfolios, organizations, industries and territories should consider projects for their functioning and develop scientific and methodological principles based on a systematic approach to the investigation of relevant management processes [2, 9, 13].

The development of tools for managing projects, programs and their portfolios, based on a systematic approach, paid much attention both to domestic [2, 9], as well as to foreign scientists [18]. Based on their analysis, it can be concluded that for the management of projects, programs and their portfolios in various subject areas, the most effective tool is a systematic approach. It provides an opportunity to consider the system as a whole to study its whole and its individual elements at different times of operation. In addition, the systematic approach provides an opportunity to improve the quality of project, program and portfolio management in different subject areas, taking into account the interconnections between individual management processes.

Based on the analysis of current international standards [18-21], as well as methods and models for managing projects, programs and their portfolios for the development of fire extinguishing systems [3, 4, 6, 7], it can be argued that they systematically do not foresee the study of the processes of project management of the functioning and development of systems fire extinguishing of united territorial communities.

The scientific and methodological principles developed by us, which are based on the use of a system approach to project management of the operation and development of fire extinguishing systems of the united territorial communities, fully take into account their specificity as their design environment, and the configuration of projects and product obtained. The mentioned scientific and methodical principles underlie development of methods and models for management of projects of operation and development of fire fighting systems of united territorial communities, which will provide an increase in the quality of management of them by substantiating the correct management decisions.

OBJECTIVE

To reveal scientific and methodical principles of systematic study of processes of project management of functioning and development of fire extinguishing systems of united territorial communities.

THE MAIN RESULTS OF THE RESEARCH

To uncover the scientific and methodological principles of the study of the processes of project management of the operation ($\ddot{I}_{\hat{o}}$) and development ($\ddot{I}_{\eth}$) of the fire extinguishing systems of the united territorial communities, we use methods of systematic approach, analysis and synthesis, analogies, induction and deduction, statistical aggregation (Fig.).

The development of fire extinguishing systems of joint territorial communities involves the implementation of a purposeful and logical change in the composition and structure of these systems. This makes it possible to increase the value ($\ddot{O}_c$) of these systems. In order to ensure the development of fire extinguishing systems of the united territorial communities, it is necessary to implement development projects $\ddot{I}_{\eth}$ that are considered as organizational and technical systems (OT_nS). These projects are aimed at transferring the existing fire fighting systems of the combined territorial communities (S_n) to their desired state $(S_{\acute{a}})$.

With regard to the projects of the operation ($\ddot{I}_{\hat{o}}$) of the fire extinguishing systems of the united territorial communities, they are considered as organizational and technological systems (OT_lS). These projects belong to hybrid projects. Under hybrid projects are those projects that have a characteristic feature periodically repeated, which provides the formation of certain experience (knowledge) in their implementation [17]. The need for their implementation arises during operational and project activities. In our case, the operational activity refers to the activity of providing fire safety on the territory of separate united territorial communities. Such activities are planned and preventive. In the event of a fire on the territory of a united territorial community, fire extinguishing systems functioning ($\ddot{I}_{\hat{o}}$) with all attributes of the project activity (uniqueness, uniqueness, timeliness, limited resources, etc.) should be implemented. Consequently, the projects of the operation ($\ddot{I}_{\hat{o}}$) of the fire extinguishing systems of the united territorial communities are aimed at the elimination of individual fires that occur on their territory. They relate to the implementation of design work for the elimination of fires, which ensures the transfer of certain objects from the current state (fire) ($Đ_n$) to their desired state (eliminated fire) ($Đ_{\acute{a}}$).

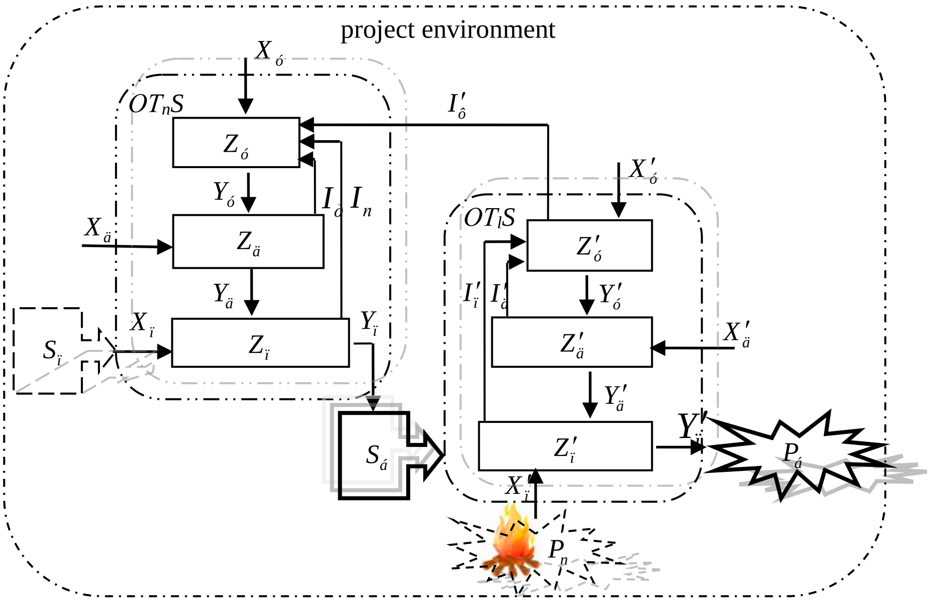

Fig. System interconnections between the projects of operation and development of fire fighting systems of the united territorial communities: OT_nS, OT_lS – accordingly organizational-technical (development) and organizational-technological (functioning) of the fire-extinguishing system; $X_{ï}$, $X_{ä}$, $X_{ó}$ – respectively, the inputs of the control subsystems, the design and product of the OT_nS; $X'_{ï}$, $X'_{ä}$, $X'_{ó}$ – respectively, the inputs of the control subsystems, the design and the OT_lS; $Z_{ï}$, $Z_{ä}$, $Z_{ó}$ – respectively, the parameters of the control subsystems, the project and the product of the system OT_nS; $Z'_{ï}$, $Z'_{ä}$, $Z'_{ó}$ – respectively, the parameters of the control subsystems, the project and product OT_lS; $Y_{ï}$, $Y_{ä}$, $Y_{ó}$ – respectively, the results of management subsystems (managerial decisions), project (actions) and product (transformation) of the OT_nS; $Y'_{ï}$, $Y'_{ä}$, $Y'_{ó}$ – respectively, the results of the subsystem management (management decisions), the project (actions) and product (transformation) OT_lS; , $S_{ï}$, $S_{á}$ – respectively, the existing and desired state of the OT_nS; $Ð_{ï}$, $Ð_{á}$ – respectively, the existing and desired state of OT_lS.

When considering projects and from a systematic approach, we can note that the corresponding OT_nS and OT_lS systems that describe them are artificial and temporarily created. They consist of characteristic elements, which are reflected by the corresponding characteristics (tab.).

Mentioned in tabl. the characteristics reflect the characteristic elements (constituents) of the corresponding subsystems belonging to two types of interconnected systems.

They change during their operation. These changes are due to the presence of causal relationships between the elements of the subsystems, the disclosure of which is one of the main tasks of project management and fire fighting systems of the combined territorial communities. Further researches require the development of scientific and methodological grounds for the study of the connections between the elements of the subsystems of two interrelated systems (OT_nS and OT_lS).

First of all, let's consider the system of OT_lS, which describes the implementation of projects $Ï_{ô}$ for the operation of fire fighting systems in the united territorial communities. This system is intended for the transfer of a separate object from the state P_n (fire) to the state (eliminated fire). At the same time, the characteristics of the fire on a separate object ($X'_{ï}$) are different and unique. There are at least two fires of the same characteristics in nature. Therefore, each fire is unique, and it notes the uniqueness of the project $Ï_{ô}$.

Characteristics ($X'_{ï}$) of a fire are: the type of object on which the fire occurred (γ); total area that can burn (S); potential combustion rate (W); the value of material assets that may be lost (B). These characteristics will be called the technological characteristics of combustion. In addition, the following characteristics of the combustion object are important characteristics of the fire-fighting objects: access to the fire along the perimeter of the object (P_g); distance from the combustion object to the location of the fire units (L), etc. [7].

Considering it, we can write a managerial ($Y'_{ó}$) operation that deals with the identification (O_{y1}) of the combustion object:

$$O_{y1} : \Phi = (\gamma, W, S, B, P, L), \qquad (1)$$

where: Φ – physical characteristics of the object of combustion.

These characteristics belong to the parameters of the subsystem project of the operation of the fire fighting systems of the united territorial communities and determine the configuration ($K_{ô}$) of the projects of the operation of the fire extinguishing systems of the combined territorial communities, which for the most part changes during their life cycle.

Table. Components of organizational-technical (development) and organizational-technological (functioning) of fire extinguishing systems of the combined territorial communities

Subsystem	Element	Marks	Characteristics
Organizational-technical system (OT_nS) fire extinguishing of united territorial communities			
management	incoming influences	$X_{\hat{o}}$	plurality of characteristics of the project environment of development projects
		$I'_{\hat{o}}$, $I_{\ddot{a}}$, $I_{\ddot{\imath}}$	accordingly, information on the implementation of the projects of operation, implementation of actions and transformations of fire extinguishing systems
	parameters	$Z_{\hat{o}}$	configuration of the subsystem management of development projects
	results	$Y_{\hat{o}}$	management decisions on implementation of actions in development projects
project	incoming influences	$X_{\ddot{a}}$	resources for development projects
	parameters	$Z_{\ddot{a}}$	configuration of development projects
	results	$Y_{\ddot{a}}$	a set of actions for the development of fire extinguishing systems of united territorial communities
product	incoming influences	$X_{\ddot{\imath}}$	a set of characteristics of the existing fire extinguishing system
	parameters	$Z_{\ddot{\imath}}$	product development design
	results	$Y_{\ddot{\imath}}$	indicators of the value of the desired fire extinguishing system
Organizational-technological system (OT_lS) fire extinguishing of the combined territorial communities			
management	incoming influences	$X'_{\hat{o}}$	characteristics of the project environment of operation projects
		$I'_{\ddot{a}}$, $I'_{\ddot{\imath}}$	accordingly information on the implementation of actions and transformations in the projects of operation
	parameters	$Z'_{\hat{o}}$	Configuration of the operation management subsystem
	results	$Y'_{\hat{o}}$	management decisions on the implementation of actions in the projects of operation
project	incoming influences	$X'_{\ddot{a}}$	resources for performance projects
	parameters	$Z'_{\ddot{a}}$	configuration of operation projects
	results	$Y'_{\ddot{a}}$	a set of actions in the projects of operation
product	incoming influences	$X'_{\ddot{\imath}}$	fire characteristics on a separate object
	parameters	$Z'_{\ddot{\imath}}$	project product configuration configuration
	results	$Y'_{\ddot{\imath}}$	performance indicators

Typically, the configuration $K_{\hat{o}}$ is displayed by the design and technical parameters ($Z'_{\ddot{a}}$). The change in the configuration $K_{\hat{o}}$ of firefighting operation projects $\ddot{I}_{\hat{o}}$ of united territorial communities during their life cycle is an important scientific and practical problem in managing these projects. It is solved mainly in two stages: 1) preparatory; 2) design and technological.

The preparatory stage for the projects $\ddot{I}_{\hat{o}}$ is special. He characterizes the readiness of fire and rescue units of voluntary fire protection for exits to extinguish fires. This readiness depends on the organization of the work of fire teams (the presence of a round-the-clock duty of the fire department at the depot, or the collection of members from the community, etc.). That is, the preparatory stage of the relevant projects is characterized by the willingness of the teams to leave for a fire. However, this readiness does not mean that any project $\ddot{I}_{\hat{o}}$ of the operation of fire fighting systems of the united territorial communities will start on time. The untimely receipt of information ($I'_{\ddot{\imath}}$) about the occurrence of a fire on one or another object, as well as the time spent on moving the fire and rescue teams from their place of deployment (fire depots) to the object of combustion, are the main reasons for delaying the launch of the relevant projects. This, as is known, predetermines the state of a fire (the state of combustion of an object) prior to the implementation of design and technological works. It is precisely this state that determines the scope and timing of design and technological works (works on the extinguishing of fires).

Thus, the projects $\ddot{I}_{\hat{o}}$ of the operation of fire extinguishing systems of the combined territorial communities are special. Their origin is largely due to the time when objects are ignited, as well as the time spent on moving fire and rescue teams to combustion objects.

Therefore, before the implementation of projects $\ddot{I}_{\hat{o}}$, we have a state of fire of a particular object of combustion, which is characterized by the following physical indicators: 1) the perimeter of the fire; 2) its area; 3) volume of combustion; 4) the volume of burnout of material values. In addition, before the project starts $\ddot{I}_{\hat{o}}$, there may be loss of people and animals in the facility and potential victims in the danger zone [7].

The identification of these components and their incorporation into the fire fighting projects $\ddot{I}_{\hat{o}}$ of the integrated territorial communities largely determines the success of the fire fighting. Therefore, the following operation (O_{y2}) in the management of projects $\ddot{I}_{\hat{o}}$ for the operation of fire extinguishing systems of united territorial communities is the identification of the state of fires (Θ) is an integral part of the process:

$$\hat{I}_{\acute{o}2} : \Theta \rightarrow \gamma , \tag{2}$$

$$\left(Pr, S_r, Q_r \right) \wedge G_n \in \gamma . \tag{3}$$

where: P_r, S_r, Q_r – respectively perimeter, area and volume of combustion cell of a single object; γ – object of combustion; G_n – potential victims of a fire.

Consequently, at the time of project $\ddot{I}_{\hat{o}}$ launch, the organizational and technological system (OT_lS) should have information ($I'_{\ddot{i}}$) on the state of the combustion object that needs to be transformed through the implementation of appropriate actions in the operation projects:

$$I'_{\ddot{i}} :\Leftrightarrow \left({}^{2}{}_{\hat{O}} + {}^{2}{}_{\Theta} \right) . \tag{4}$$

where: ${}^{2}{}_{\hat{O}}, {}^{2}{}_{\Theta}$ – respectively, information on the state of the object of combustion and fire that occurred in it.

Timely receiving of information $I'_{\ddot{i}}$ is an important prerequisite for the success of projects $\ddot{I}_{\hat{o}}$ – minimizing losses from fires and correspondingly increasing the value of these projects. Without going into the analysis of the methods and system of obtaining this information, we note that the perspective direction is to obtain it mostly in automatic mode.

Based on the information $I'_{\ddot{i}}$ received in the management subsystem with a given configuration ($\hat{E}_{\hat{o}}$), which includes project $\ddot{I}_{\hat{o}}$ managers (head of fire and rescue units, duty depots, etc.) and means for making managerial decisions (information and analytical systems, algorithms, methods, etc.), management decisions are made ($Y'_{\acute{o}}$) regarding the implementation of actions in the projects of the operation of the fire extinguishing systems of the united territorial communities. Based on managerial decisions, the design and technological parameters ($Z'_{\ddot{a}}$) of the projects $\ddot{I}_{\hat{o}}$ of the operation of fire extinguishing systems of the combined territorial communities are substantiated. These parameters are based on the availability of resources ($X'_{\ddot{a}}$) in the fire extinguishing system of the combined territorial communities. They include the material and technical base of fire depots and human resources (dispatchers, drivers, guardians, etc.). They largely affect the parameters of ($Z'_{\ddot{a}}$) the subsystem, which represents the configuration ($\hat{E}_{\hat{o}}$) of the firefighting operation projects $\ddot{I}_{\hat{o}}$ of the combined territorial communities.

One of the main tasks of managing these projects $\ddot{I}_{\hat{o}}$ is to ensure successful implementation of the projects of the operation of the fire fighting systems of the united territorial communities. There is agreement on the content and time of the project (implementation of actions on the elimination of the fire) with available resources. Establishing this correspondence is carried out between the parameters (configuration $\hat{E}_{\hat{o}}$) $Z'_{\ddot{a}}$ and the characteristics $X'_{\ddot{a}}$ (resources $R_{\hat{o}}$) of the subsystem OT_lS.

At the same time, it is believed that the configuration $\hat{E}_{\hat{o}}$ depends on the characteristics $X'_{\ddot{i}}$ of the fire on a separate object (Θ та $\hat{O}$), which are variables in time t, and from the resources $R_{\hat{o}}$ available in the fire and rescue subdivision, which are constant at the time of the fire:

$$\hat{E}_{\hat{o}} = f\left(\Theta, \hat{O}, R_{\hat{o}} \right) , \tag{5}$$

where: $\hat{E}_{\hat{o}}$ – configuration of the project $\ddot{I}_{\hat{o}}$ of functioning of the fire extinguishing system of the united territorial communities; Θ, $\hat{O}$ – the characteristics of the fire and the combustion object respectively; $R_{\hat{o}}$ – resources for the elimination of the fire.

In order to coordinate in time the configuration $\hat{E}_{\hat{o}}$ of projects $\ddot{I}_{\hat{o}}$ with the characteristics Θ and $\hat{O}$ the object of combustion, it is necessary to distinguish between those characteristics that change in time. These include the characteristics of the state of combustion cells – Θ which are represented in the formula (2). The characterization of the state of combustion objects $\hat{O}$ – represented in formula (1) – is largely unchanged in time. In this case, it should be noted that in certain combustion objects, their characteristics $\hat{O}$ can also be changed in order to ensure the success of the implementation of the projects $\ddot{I}_{\hat{o}}$ of the operation of fire fighting systems of the combined territorial communities.

In addition, implementing fire extinguishing design projects $\ddot{I}_{\hat{o}}$ of joint territorial communities often encounter problems of localization of the fire in order to prevent its propagation to other objects. In other words, the design and technological parameters $Z'_{\ddot{i}}$ represented by the configuration of the ($K'_{\ddot{i}p}$) product of the projects $\ddot{I}_{\hat{o}}$ of the operation of the fire fighting systems of the united territorial communities are determined not only by the characteristics of the state of the objects $\hat{O}$ and their combustion centers Θ, but also taking into account the presence of the neighboring objects and the distance to them from fire cell. It is precisely for them that there is a risk of fire from an existing fire. All of the above stipulates a management task that concerns not only the reconciliation of the configuration $\hat{E}_{\hat{o}}$ of the projects $\ddot{I}_{\hat{o}}$ of the fire-fighting systems of the combined territorial communities from the fire characteristics $X'_{\ddot{i}}$ of the separate object (Θ та $\hat{O}$) and the available resources $R_{\hat{o}}$, but also the identification (identification) of the objects of the configuration of these projects for execution of additional works related to the protection of adjacent (neighboring) objects in relation to the object on which the fire occurred.

On the basis of the foregoing, concerning the organizational and technological systems of OT_lS, which concern the implementation of the projects $\ddot{I}_{\hat{o}}$ of the operation of the fire fighting systems of the united territorial communities, one can distinguish the following set of actions $Y'_{ä}$ that concern: 1) the salvation of people, animals and material values; 2) extinguishing the fire cell, changing its condition; 3) changes in the state of the combustion object in order to improve the rescue and extinguishing processes; 4) protection against the ignition of adjacent (neighboring) objects [7].

The above functions are carried out through the implementation of appropriate actions (design and technical work), which are component projects $Ï_{p}$.

In order to carry out these actions, it is necessary to involve existing resources $R_{ô}$ (performers, technical means, material and technological, etc.).

In this case, there are managerial tasks concerning the justification: 1) the sequence of execution of design and technological works of different types; 2) provision of their human resources (executors); 3) provision of their technical means; 4) provision of their material and technological resources. As a result of solving the above tasks, appropriate management decisions are made and instructions are issued regarding their implementation.

Consequently, on the basis of the foregoing, we may note that during the implementation of the projects $Ï_{p}$ of the operation of the fire fighting systems of the united territorial communities, the processes of managing the configuration, content, time, and resources should be systematically implemented. Between them there are system interconnections, the effectiveness of which ensures obtaining the maximum value from the implementation of the projects $Ï_{p}$ of the operation of fire fighting systems of the combined territorial communities. In addition, there are specific causal relationships between the specified management processes in the projects $Ï_{p}$, which greatly influence the type and sequence of solving a plurality of managerial tasks.

Consider the system of OT_nS, which describes the implementation of projects $Ï_{p}$ for the development of fire extinguishing of the combined territorial communities. It is temporary and intended for the transfer of firefighting systems of the combined territorial communities from the existing state S_n to the desired state $S_{á}$. At the same time, the characteristics of the existing state of fire extinguishing systems of the united territorial communities (X_n) are constant. These include the characteristics of ($X_{ï÷}$) fire and rescue units (FRUs), serving the separate united territorial communities; characteristics ($X_{ç}$) of the territorial zone of the combined territorial communities and objects of fire protection; damage ($З$) from fires:

$$X_n = f\left(X_{ï÷}, X_{ç}, Ç\right). \tag{6}$$

Characteristics $X_{ï÷}$ of the FRUs serving individual united territorial communities include the number ($ï_{ï÷}$) of the PRH and their available resources ($R_{ï÷}$) for the elimination of fires:

$$X_{ï÷} :\Leftrightarrow \left(ï_{ï÷}, R_{ï÷}\right). \tag{7}$$

Resources $R_{ï÷}$ available for FRUs for elimination of fires include human ($R_{ë}$), technical ($R_{ô}$) and material ($R_{ì}$):

$$R_{ï÷} :\Leftrightarrow \left(R_{ë}, R_{ô}, R_{ì}\right). \tag{8}$$

Characteristics ($X_{ç}$) of the territorial zone of the united territorial communities and objects of fire protection include the number ($ï_{íñ}$) of population in separate settlements of the united territorial communities, the presence ($ï_{î}$) and characteristics ($\hat{O}$) of the objects in separate settlements of the united territorial communities, territorial location (Ψ) of individual settlements of the combined territorial communities relative to the FRUs:

$$X_{ç} :\Leftrightarrow \left(ï_{íñ}, ï_{î}, \hat{O}, \Psi\right). \tag{9}$$

The territorial location (Ψ) of settlements of the united territorial communities relative to the FRUs is characterized by distance (L) and state (ε) of the roads between them:

$$\Psi :\Leftrightarrow \left(L, \varepsilon\right). \tag{10}$$

At the same time, losses ($З$) from fires have two components of losses - material values ($З_м$) and loss of people ($З_л$):

$$Ç :\Leftrightarrow \left(Ç_{ì}, Ç_{ë}\right). \tag{11}$$

Each of these components belongs to the configurations ($\hat{I}_{ê}$) of the development projects $Ï_{ð}$ of fire extinguishing of the combined territorial communities. With this in mind, we can write a managerial ($Y_{ó}$) operation that identifies the configuration objects ($\hat{I}_{ê}$) of the design environment $Ï_{ð}$ for the development of fire fighting systems in the united territorial communities:

$$\hat{I}'_{ó1} : \hat{I}_{ê} = \left(ï_{ï÷}, R_{ï÷}, ï_{íñ}, ï_{î}, \hat{O}, \Psi, Ç_{ì}, Ç_{ë}\right). \tag{12}$$

The characteristics (12) specified in the expression determine the configuration ($K_n^{ð}$) of projects $Ï_{ð}$ for the development of fire extinguishing systems of the combined territorial communities. Typically, the configuration $K_n^{ð}$ is represented by a set of parameters ($Z_{ä}$) (configuration bases) that change throughout the life cycle of the specified projects. The justification of effective configuration databases is carried out in several stages, taking into account the changing configuration of the project environment.

The substantiation of effective project $Ï_{ð}$ configuration databases relates to the assessment of the existing state of the fire-fighting systems of the united territorial communities. This assessment is performed on the criterion of value, which is determined on the basis of relevant organizational and technological indicators - losses ($З$) from fires. At this stage, there are problems concerning the substantiation of the objectives (ξ) of the development projects of fire extinguishing of the combined territorial communities.

At the same time, the objective of the substantiation of the goals includes: 1) the analysis of the factors of the value of the fire-fighting systems of the combined territorial communities for their current state and the identification of the contradictions between them ($^{2}_{ñó}$); 2) the formation of a plurality of scenarios $\{\tilde{N}_{ö}\}$ for the transfer of firefighting systems of united territorial communities from the existing $S_{ï}$ to the desired state $S_{á}$; 3) defining among effective scenarios ($\tilde{N}_{ö}^{â}$) that provide maximum value; 4) development of a conceptual plan ($\hat{E}_{Ï}$) of projects for the development of fire extinguishing systems of united territorial communities.

$$\hat{I}'_{ó2} : \xi = \left({}^{2}_{ñó} \rightarrow \{\tilde{N}_{ö}\} \rightarrow \tilde{N}_{ö}^{â} \rightarrow \hat{E}_{Ï} \right). \quad (14)$$

Consequently, the disclosure of a systematic approach to the study of project operation ($\ddot{I}_{ô}$) management processes and the development ($\ddot{I}_{p}$) of fire extinguishing systems of the combined territorial communities enabled the main components of the relevant systems to be identified, as well as identifying the main characteristics of the state of the requirements for their products that determine the configuration (parameters) of the relevant projects. The time-instability of the characteristics of the state of requirements (combustion centers) to extinguish fires is the reason of the time-instability of the firefighting project configuration, which is determined by the content, time and resources necessary for the implementation of design and technological works and fire and rescue functions in the projects of the operation ($\ddot{I}_{ô}$) of fire fighting systems of the combined territorial communities. Realization of projects of development ($\ddot{I}_{p}$) of fire extinguishing systems of joint territorial communities requires definition of their configuration according to the criterion of maximum value of their product (desirable fire extinguishing system of the combined territorial communities). The justification of the value of their product is based on the simulation of the projects of the operation ($\ddot{I}_{ô}$) of the fire extinguishing systems of the combined territorial communities, which allows to predict the relevant organizational and technological indicators and determine the values of value.

CONCLUSIONS

1. Based on the analysis of the state of the subject area, the necessity to implement the projects for the operation and development of fire fighting systems of the united territorial communities and the specifics of their project environment was substantiated.

2. The performed analysis of the toolkit for project management indicates the need to develop a scientific and methodological framework for a systematic study of project management processes for the operation and development of fire suppression systems of the united territorial communities.

3. The scientific and methodological foundations of the systematic study of the processes of project management of the operation and development of fire extinguishing systems of the united territorial communities are based on the use of methods of system approach, analysis and synthesis, analogies, induction and deduction, statistical aggregation.

4. On the basis of the conducted research the expediency of systematic consideration of the projects of operation and development of fire fighting systems of the united territorial communities as the appropriate organizational, technological and organizational-technical systems was substantiated.

5. It has been established that each of these systems has three subsystems (control, project and product) that contain their elements (input effects, parameters and results) that have their own specific characteristics.

6. Further researches require the development of scientific and methodological grounds for the study of the links between the elements of subsystems of two types of interrelated systems (organizational, technological, organizational and technical).

7. The indicated administrative tasks for the implementation of fire extinguishing projects made it possible to find out that their solution is possible by means of statistical simulation of relevant projects, which is based on knowledge in the subject field.

REFERENCES

1. **Try`guba A. 2014.** Argumentation of the parameters of the system of purveyance of milk collected from the private farm-steads within a single administratinve district. *Econtechhod: An international quarterly journal on economics in technology, new technologies and modelling processes*. Lublin-Rzeszów. No 4 (3). 23-27.

2. **Tryguba A. M. 2017.** System-design basis of development of technological structures of production of dairy products. *Author's abstract of the dissertation of the doctor of technical sciences*. 05.13.22. Odessa. 48.

3. **Ratushnyi R. T. 2005.** System-design bases of management of development of technological structures of production of dairy products. *Author's abstract of the dissertation of the candidate of technical sciences* 05.13.22. L'viv. 19.

4. **Shcherbachenko O. 2017.** Organizational and technological backgrounds of project configuration management for firefighting. *TEKA*. Lublin-Rzeszow, No 17 (3). 49-53.

5. **Tatomyr A. V. 2009.** Matching service design configurations. and serviced systems (concerning electric power supply of agricultural enterprises for use of wind energy). *Dissertation author's abstract of the candidate of technical sciences* 05.13.22. L'viv. 20.

6. **Zaver V. B. 2012.** Methods and models of identification of configuration of projects of reengineering of fire extinguishing systems of mountain forest forests. *Author's abstract of the dissertation of the candidate of technical sciences* 05.13.22. L'viv. 20.

7. **Sydorchuk O. V., Ratushnyi R. T., Bondarenko V. V., Bashyns'kyj O. I., Zaver V. B. 2015**. Project planning of fire extinguishing systems reengineering projects on the basis of modeling. *Monograph*. L'viv. 362.

8. **Sydorchuk O. V., Tryguba A. M., Sydorchuk L. L. 2017.** Engineering of cooperative production of dairy products: system-design basis. *Monograph*. Nizhyn 2016. 352.

9. **Tryguba A. M., Sholud'ko P. V., Sydorchuk L. L., Boyarchuk O. V. 2016.** System-valued principles of management of integrated milking development programs on basis of modeling. *Bulletin of the National Technical University "Kharkiv Polytechnic Institute". Collection of scientific works*. Kharkiv. No 2 (1174). 103-107.

10. **Krasowski E., Sydorchuk O., Sydorchuk L. 2015.** Modeling and Management of the Technical and Technological Potential in Agricultural Production. *TEKA*. Lublin-Rzeszow, No 15 (4). 79-84.

11. **Sydorchuk O. V., Ratushnyi R. T., Shcherbachenko O. M., Ratushnyi A. R., Sivakovs`ka O. V. 2015.** Processes of configuration management of system products and projects. *Announcer of Lviv State University of Life Safety*. L'viv, 2015. No 12. 50-58.

12. **Tryguba A., Sydorchuk L., Shelega I., Sivakovska E. 2015.** Management of the value of projects of techno-technological service cooperatives. *MOTROL*. Commission of Motorization and Energetics in Agriculture. Lublin-Rzeszów. No 17 (3). 161-167.

13. **Sydorchuk O., Ratushnyi R., Shcherbachenko O., Sivakovs'ka O. 2016.** Harmonization of system-product configurations and their projects. *Managing the development of complex systems*. Collection of scientific works. Kyiv. No 25. 58-65.

14. **Tryguba A. M., Sharybura A. O. 2011.** Processes of management of integrated projects of agrarian production. *MOTROL*. Commission of Motorization and Energetics in Agriculture. Lublin-Rzeszów. No 13D. 37-42.

15. **Sydorchuk O., Tryguba A., Chaban A., Kovalyshyn S., Panyura Ja., Malanchuk O. 2012.** Organizational options for project configuration. *MOTROL*. Commission of Motorization and Energetics in Agriculture. Lublin-Rzeszów. No 14 (4). 70-74.

16. **Sydorchuk O., Tryguba A., Makarchuk O. 2013.** Estimation of values of service programs of agricultural production. *MOTROL*. Commission of Motorization and Energetics in Agriculture. Lublin-Rzeszów. No 15 (4). 147-152.

17. **Sydorchuk O., Ratushnyi R., Sivakovs'ka O., Shelega O. 2014.** Identification and features of hybrid project management. *Project Management, System Analysis and Logistics. Series: technical science*. Kyiv. No 14 (1). 216-220.

18. **ISO 21500. 2012.** Guidance on project management, http://www.projectprofy.ru.

19. **Guide to the Project Management Body of Knowledge. 2008.** PMBOK Guide. Fifth Edition. URL: http://www.pmi.org.

20. **GOST R 54869-011. 2011.** Proyektnyj menedzhment. Trebovaniya k upravleniyu proyektom». Moskva. Standartinform. 34.

21. **PRIENCE 2. 2009.** Managing successful project with PRIENCE2. TSO Blackwell and other accredited agents. 315.

СИСТЕМНЫЙ ПОДХОД К ИССЛЕДОВАНИЮ ПРОЕКТОВ ФУНКЦИОНИРОВАНИЯ И РАЗВИТИЯ СИСТЕМ ПОЖАРОТУШЕНИЯ ОБЪЕДИНЕННЫХ ТЕРРИТОРИАЛЬНЫХ ОБЩИН

Аннотация. Обоснована необходимость реализации и специфика проектов функционирования и развития систем пожаротушения объединенных территориальных общин. Выполнен анализ предметной области и обоснована необходимость разработки научно-методических основ системного исследования процессов управления проектами функционирования и развития систем пожаротушения объединенных территориальных общин.

Раскрыто научно-методические основы системного исследования процессов управления проектами функционирования и развития систем пожаротушения объединенных территориальных общин. Установлено, что указанные научно-методические основы базируются на использовании методов системного подхода, анализа и синтеза, аналогий, индукции и дедукции, статистического обобщения.

Проекты функционирования систем пожаротушения объединенных территориальных общин рассматривают как организационно-технологические системы, а проекты их развития как организационно-технические системы, которые взаимосвязаны между собой отдельными процессами управления. Каждая из указанных систем имеет по три подсистемы (управление, проект и продукт). В этих подсистемах выделяют элементы (входные воздействия, параметры и результаты), которые имеют свои специфические характеристики.

Обоснованные характеристики элементов отдельных подсистем, принадлежащих к системам проектов функционирования и развития систем пожаротушения объединенных территориальных общин, отражают их характерные составляющие. Они принадлежат к двум видам взаимосвязанных систем – организационно-технологических и организационно-технических.

Доказано, что указанные характеристики элементов отдельных подсистем меняются во время их функционирования. Эти изменения происходят благодаря наличию причинно-следственных связей между составляющими систем пожаротушения объединенных территориальных общин.

Раскрытие причинно-следственных связей между составляющими систем пожаротушения объединенных территориальных общин является одной из главных задач управления процессами в проектах функционирования и развития соответствующих систем пожаротушения.

Установлено, что научно-методические основы исследования указанных связей в двух взаимосвязанными системами (организационно-технологическими и организационно-техническими) имеют свою специфику как относительно проектной среды, так и по конфигурации проектов и полученного продукта.

Ключевые слова: проект, управление, функционирование, развитие, исследования, системный подход, система пожаротушения, объединенные территориальные общины.

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Analysis of Modes of Motion of Rotation Mechanism of Jib Crane

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Summary. In the article it is given a dynamic model of the rotation mechanism of a tower crane and the system of differential equations that was obtained by using the Lagrange equation of the second kind, which describes the motion of the loaded rotation mechanism. After the solution of the equations under certain parameters of the crane, it was conducted a dynamic analysis of the rotation mechanism. It has been theoretically proved that during the operation of the rotation mechanism in the elements of the drive and the construction arise dynamic loads that lead to the destruction of the structure and, as a consequence, reduce the reliability and productivity of the crane. It has been researched that the maximum values of the loads arise during the transitive processes of motion (starting, braking). To minimize the loads, which arise during the operation of the rotation mechanism of a jib crane, the optimization the modes of motion has been carried out. The RMS value of the speed of alteration of the elastic moment in the drive mechanism (optimal control 1) and the RMS value of acceleration of effort alteration in the drive mechanism (optimal control 2) were chosen to be the optimization criteria. As a result of solution of the previously set tasks, the optimal control modes of the rotation mechanism of the crane were established. The optimal the modes of motion have considerable advantages in comparison with the manual control mode that was obtained as a result of dynamic analysis. The analysis of graphical dependencies obtained from the tasks solution shows that usage of optimal the modes of motion for the drive system results into the smooth nature of change in the kinematic characteristics of the crane, comparing to the manual operation. The smooth speeding up and effort application enhances the operation of the rotating mechanisms of a tower crane. The results obtained from this research can be further used for specification and improvement of existing engineering methods of the calculating of rotation mechanisms of cranes with a load on flexible suspension both on the stage of their designing and during real time operation.

Key words: load-lifting machinery, tower/jib crane, starting, dynamic model, mathematical model, analysis, modes of motion, rotation mechanism, dynamic loads, optimization, criteria, RMS (root mean square).

INTRODUCTION

During the loading and unloading works the considerable dynamic loads emerge in the elements and construction of the working rotation mechanism of a jib crane [1–3], which result into the limitation of working speeds, deterioration and destruction of details and the construction itself [4–7]. Consequently, the efficiency of the loading and unloading operations as well as the reliability of operation of the rotation mechanism of the crane decreases [8–9]. One way to reduce these loads is to select the modes of motion of the drive mechanisms, which remove the undesirable phenomena from the whole construction of the crane as well as from its individual elements [10–11]. The necessary rotation mode of the crane can be selected by optimizing the transients using a given criteria, depending on the objectives of the design of the crane or conditions of its use [12–14]. In order to improve the rotation mode and reduce the dynamic loads in the drive elements of the crane rotation mechanism, it is necessary to select the criteria that show the effect of these loads during a certain period of operation of the crane. Such criteria can be the RMS values of loads and their derivatives by time during the transient processes [15–17].

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Many scientists have been engaged in the dynamics of the lifting machinery motion research [18–27]. They examined various ways to study the fluctuations of load on a flexible suspension.

When considering the mechanism of rotation of the jib crane there is a significant swing of cargo on the flexible suspension and fluctuations of the elements of the drive and the overall construction [1–5]. These fluctuations lead to the instability of the motion of the rotating parts of the drive elements of the rotation mechanism, which affects the quality of loading and unloading operations, the performance and reliability of the crane operation and increases the probability of emergencies that are undesirable [6–7]. Improvement of the constructional and operational characteristics of the rotation mechanism and the crane in general is achieved by optimizing the modes of motion on the start and stop intervals [10–14]. In article [28] the methods of diagnostics of a structural (general) state of a tower crane are considered. It was researched the brake laws of the corresponding hierarchical restoration that can reduce the amplitude of vibration [29]. In article [30] we consider an approach in which the arrow is represented as a continuous beam and the toughness of the tower is taken into account. Also, when optimizing the motion schedules of crane mechanisms, there is a problem of choosing the optimization criteria [15–17]. It is advisable to choose criteria that evaluate the operation of the crane or a separate mechanism during a certain time of motion. Such criteria may be criterial actions that represent integral functionals [31–35]. The integral criteria include the RMS values of the existing dynamic loads and their derivatives by time [33–35].

For criteria that represent the RMS values of operating loads and their derivatives by time, it is advisable to use variational optimization methods, since they provide a sufficiently high level of smoothness of the motion modes of the elements of crane mechanisms [11–17, 31–37].

OBJECTIVE

The objective of this study is to analyze the obtained optimal motion modes and compare them with manual control on the natural mechanical characteristics of the operation of the mechanism of rotation of a jib crane.

THE MAIN RESULTS OF THE RESEARCH

For dynamical analysis of the mechanism of rotation of a jib crane, a three mass dynamic model has been selected (Fig. 1). In this model, it is assumed that all the elements of the crane are absolutely solid, except for the elements of the transmission mechanism of the drive and the flexible suspension of the load.

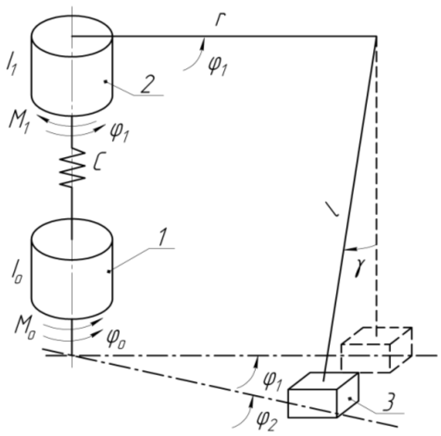


Fig. 1. Dynamic model of the turning mechanism of the crane: 1 – drive; 2 – rotary part; 3 – the load.

The angular coordinates of the rotation of the mass of the elements of the drive reduced to the axis of rotation φ_o, rotary tower with a jib relative to its own axis of rotation φ_1 and the load φ_2 were taken as generalized coordinates of a dynamic model.

On the basis of the chosen dynamic model, using the Lagrange equations of the second kind, a mathematical model is constructed, which is a system of three differential equations of the second order

$$\begin{cases} I_o\ddot{\varphi} = M_o - C(\varphi_o - \varphi_1); \\ I_1\ddot{\varphi}_1 = C(\varphi_o - \varphi_1) - mr^2 g(\varphi_1 - \varphi_2)/l - M_1; \\ \ddot{\varphi}_2 = g(\varphi_1 - \varphi_2)/l, \end{cases} \quad (1)$$

where: I_o – the moment of inertia of the drive mechanism, reduced to the axis of rotation of the crane; I_1 – moment of inertia of the tower and the jib, reduced to the axis of rotation of the crane; m – weight of cargo; M_o – the driving moment on the shaft of the electric drive motor, reduced to the axis of rotation of the crane; M_1 – the moment of the forces of static resistance, reduced to the axis of rotation of the crane; l – the length of the flexible suspension of the load; r – departure of cargo (the length of the arm of the crane); C – the coefficient of rigidity of the drive mechanism, reduced to the axis of rotation of the crane; g – gravitational acceleration.

The driving moment of the drive mechanism in the system of equations (1) is determined from the static mechanical characteristic using the Kloss formula:

$$M_o = \frac{2M_{кр} \cdot u \cdot \eta}{\dfrac{s}{s_{кр}} + \dfrac{s_{кр}}{s}}, \quad (2)$$

where: $M_{кр}$ – critical moment on the electric motor shaft; u – gear ratio of the drive mechanism; η – energy conversion efficiency of the drive mechanism (coefficient of performance); s, $s_{кр}$ – respectively sliding and critical sliding of an asynchronous motor, which are determined by dependencies:

$$s = 1 - \frac{\dot{\varphi}_1 u}{\omega_o}; \quad s_{кр} = s_н\left(\lambda + \sqrt{\lambda^2 - 1}\right). \quad (3)$$

Here $s_н = 1 - \omega_н/\omega_o$ – nominal sliding of an electric motor; $\omega_н$, ω_o – respectively nominal and synchronous angular velocities of the rotor of the electric motor; $\lambda = M_{кр}/M_н$ – overload capacity of the electric motor; $M_н$ – nominal moment on the shaft of the electric motor.

Having substituted dependencies (2) and (3) into the system of equations (1), we get the final form of a mathematical model for the research of the dynamics of motion of the rotation mechanism of the jib crane, which is a system of nonlinear differential equations of the second order. Such equations cannot be integrated analytically, so for their solution the numerical methods from the software product "Mathematica" are used.

The solution results are presented below in graphical form.

In order to improve the operation of the crane rotation mechanism, the criterion for optimizing the modes of motion has been chosen, which is the RMS value of the speed of alteration of the elastic moment in the drive mechanism. It has the next form:

$$\dot{M}_{o1c\kappa} = \left[\frac{1}{t_1}\int_0^{t_1} \dot{M}_{o1}^2 dt\right]^{1/2} \to \min, \quad (4)$$

where: t – time; t_1 – duration of the transition process (starting, stopping); $\dot{M}_{o1}$ – the speed of alteration of the elastic moment in the drive mechanism.

This criterion is an integral functional with the minimum condition of the Euler-Poisson equation

$$\sum_{i=3}^{5}(-1)^i \frac{d^i}{dt^i}\frac{\partial f}{\partial \overset{(i)}{\varphi}_2} = 0, \quad (5)$$

where: $f = \dot{M}_{o1}^2$.

After differentiation we obtain a linear uniform differential equation of the 10th order with constant coefficients:

$$\overset{X}{\varphi}_2 + 2\cdot k^2 \cdot \overset{VIII}{\varphi}_2 + k^4 \cdot \overset{VI}{\varphi}_2 = 0; \quad (6)$$

$$k = \sqrt{\left(1+\frac{mr^2}{I_1}\right)\frac{g}{l}}. \quad (7)$$

Here k – frequency of the fluctuations of the system.

The solution of the differential equation (6) has the next form:

$$\varphi_2 = C_1 + C_2 t + C_3 t^2 + C_4 t^3 + C_5 t^4 + C_6 t^5 + \\ + (C_7 + C_8 t)\cdot \sin kt + (C_9 + C_{10} t)\cdot \cos kt, \quad (8)$$

where: $C_1, C_2, ..., C_{10}$ – constants, which are determined from the boundary conditions of motion. For the process of starting the rotation mechanism of the jib crane, we have such boundary conditions where φ_1 and $\dot{\varphi}_1$ expressed through the coordinate φ_2 and its derivatives by time:

$$\begin{cases} t=0: \ \ \varphi_2 = 0, \ \ \dot{\varphi}_2 = 0, \ \ \ddot{\varphi}_2 = 0, \ \ \dddot{\varphi}_2 = 0; \\ t = t_1: \ \ \dot{\varphi}_2 = \omega_y, \ \ \ddot{\varphi}_2 = 0, \ \ \dddot{\varphi}_2 = 0. \end{cases} \quad (9)$$

where: ω_y – fixed speed of rotation of the crane.

The solution of equation (8) contains ten arbitrary constants $C_i\ (i = 1,2,...,10)$ and for their determination the specified boundary conditions (9) are not sufficient. Therefore, in accordance with the foregoing, we find the variation of the functional (4).

By virtue of arbitrariness $\delta\varphi_2(t_1)$, $\delta \overset{IV}{\varphi}_2(t_1)$ and $\delta \overset{IV}{\varphi}_2(0)$ we obtain:

$$\overset{V}{\varphi}_2(0) + k^2 \dddot{\varphi}_2(0) = 0; \\ \overset{V}{\varphi}_2(t_1) + k^2 \dddot{\varphi}_2(t_1) = 0; \\ \overset{IX}{\varphi}_2(t_1) + 2k^2 \overset{VII}{\varphi}_2(t_1) + k^4 \overset{V}{\varphi}_2(t_1) = 0 \quad (10)$$

Conditions (10) together with the boundary conditions (9) clearly determine the extremus of the family (8).

To solve the equations, the software "Mathematica" was used.

As a result of the solution the optimal modes of motion have been obtained.

In addition, it has been solved the task where the value of acceleration of the effort alteration in the drive mechanism has been taken as an optimization criterion of the rotation of the jib crane.

In this case, the optimization criterion for the crane rotation mode will look like:

$$\ddot{M}_{01c\kappa} = \left[\frac{1}{t_1}\int_0^{t_1} \ddot{M}_{01}^2 dt\right]^{1/2};$$

$$\ddot{M}_{01c\kappa} = \left[\frac{1}{t_1}\left(I_1 \frac{l}{g}\right)^2 \int_0^{t_1}\left(\overset{VI}{\varphi}_2 + k^2 \overset{IV}{\varphi}_2\right)^2 dt\right]^{1/2} \to \min. \quad (11)$$

The minimum criterion of (11) is the Euler-Poisson equation of 12th order

$$\overset{XII}{\varphi}_2 + 2k^2 \overset{X}{\varphi}_2 + k^4 \overset{VIII}{\varphi}_2 = 0, \quad (12)$$

where: $k = \sqrt{\left(\frac{I_1 + mr^2}{I_1 \cdot l/g}\right)}$ – frequency of the fluctuations of the system.

The analytic solution of the differential equation is represented by the following dependence.

$$\varphi_2 = C_1 + C_2 t + C_3 t^2 + C_4 t^3 + C_5 t^4 + C_6 t^5 + \\ + C_7 t^6 + C_8 t^7 + (C_9 + C_{10} t)\sin kt + (C_{11} + C_{12} t)\cos kt \quad (13)$$

where: $C_i\ (i = 1,2,...,12)$ – constants, which are determined from the boundary conditions of motion.

To determine the constants $C_i\ (i = 1,2,...,12)$ the boundary conditions of motion are used with φ_1 and $\dot{\varphi}_1$ are expressed via the coordinate φ_2 and its derivatives by time:

$$\begin{cases} t=0: \quad \varphi_2=\dot{\varphi}_2=\ddot{\varphi}_2=\dddot{\varphi}_2= \\ =\overset{V}{\varphi}_2=0, \quad \overset{IV}{\varphi}_2=-\dfrac{M_1 g}{I_1 l}; \\ t=t_1: \quad \varphi_2=\dfrac{\omega_y t_1}{2},\ \dot{\varphi}_2=\omega_y,\ \ddot{\varphi}_2=\dddot{\varphi}_2= \\ =\overset{V}{\varphi}_2=0, \quad \overset{IV}{\varphi}_2=-\dfrac{M_1 g}{I_1 l} \end{cases} ,(14)$$

where: ω_y – fixed speed of rotation of the crane.

Note that in this task all conditions are determined from the condition of the absence of fluctuations after the start-up process.

To solve the equations, the software "Mathematica" was used.

Calculations have been made for the mechanism of rotation of the jib crane

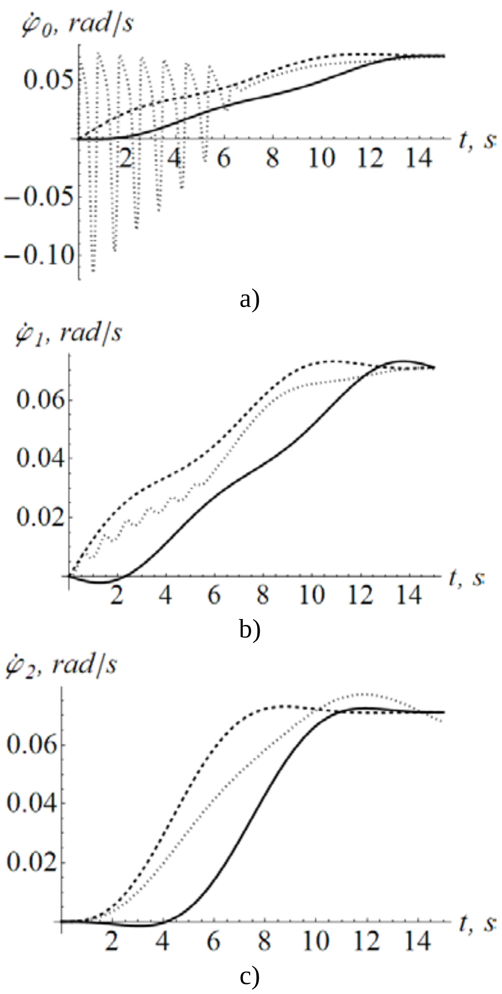


Fig. 2. Dependencies of alterations of angular velocities of: a) the rotor of the engine; b) the rotation part; c) the cargo under condition of (·····) manual control, (---) optimal contol 1, (—) optimal control 2.

QTZ-80 with parameters:

$$I_o=71626{,}115\,kg\cdot m^2;$$

$$I_1=4920738{,}85\,kg\cdot m^2;$$

$$C=6626669{,}045\,N\cdot m/rad;\quad m=2000\,kg;$$

$$r=40\,m;\quad l=30\,m;\quad M_1=1288{,}79\,N\cdot m;$$

$$M_{н}=36{,}8\,N\cdot m;\quad u=1355{,}2;\quad \eta=0{,}86;$$

$$\omega_y=0{,}071\,rad/s;\quad t_1=15\,s;\quad \omega_o=95\,rad/s;$$

$$\omega_{н}=95{,}04\,rad/s;\quad \lambda=2{,}8;\quad g=9{,}81\,m/s^2.$$

As a result of the solution of the set objectives, optimal modes of motion have been obtained. They are presented in graphical form (Fig. 2 – Fig. 6).

The article also specifies the mode of rotation of the crane with manual control according the mechanical characteristics of the engine during start-up. The optimization by the criterion of the RMS value of the velocity of alteration in the elastic moment in the drive mechanism is represented by the mode (optimal control 1) and by the criterion of the RMS value of acceleration of the alteration of effort in the drive mechanism by the mode (optimal control 2).

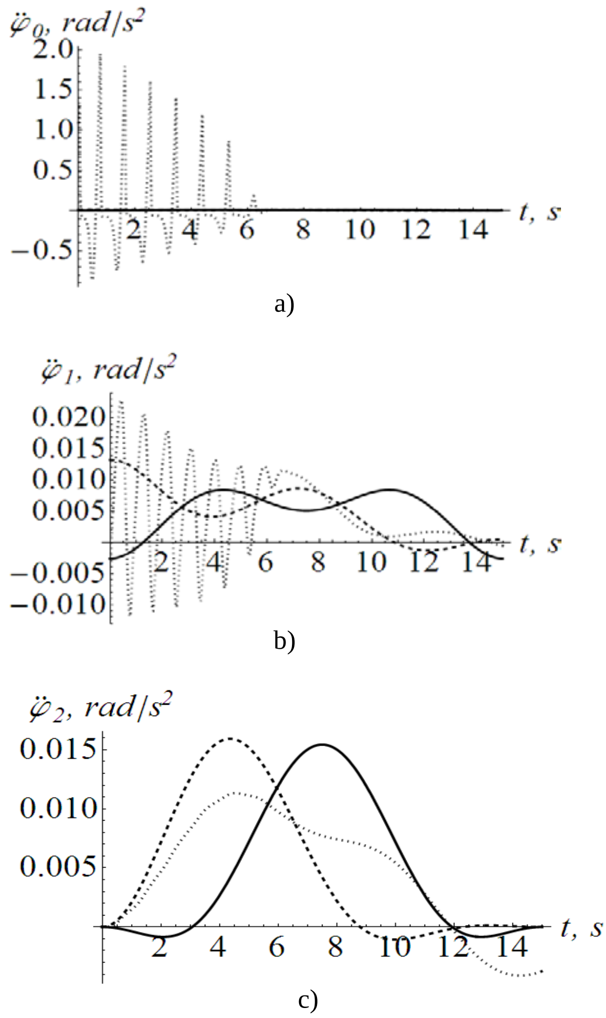
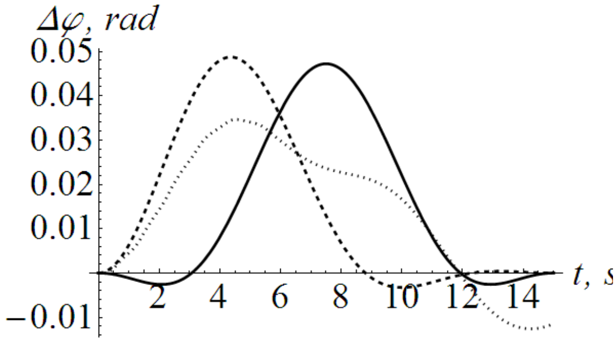
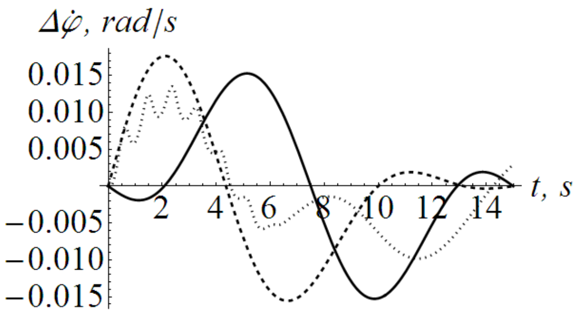


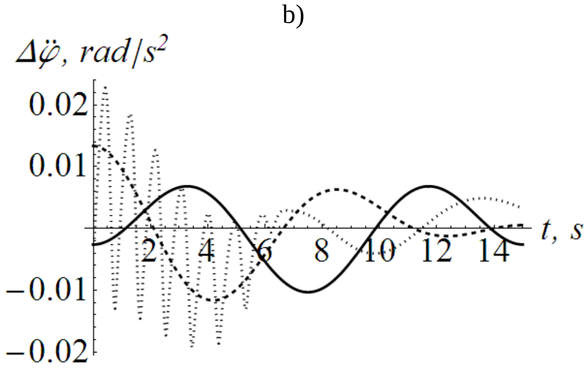
Fig. 3. Dependencies of alterations of angular accelerations of: a) the rotor of the engine; b) the rotation part; c) the cargo under condition of (·····) manual control, (---) optimal contol 1, (—) optimal control 2



a)

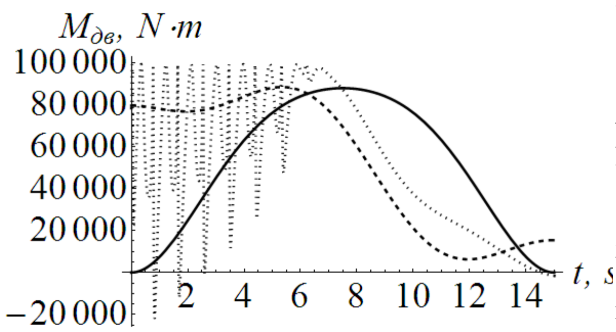


b)

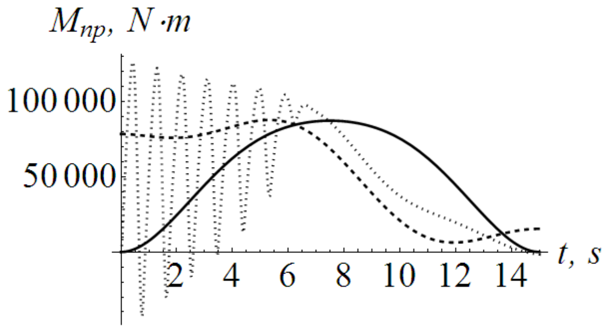


c)

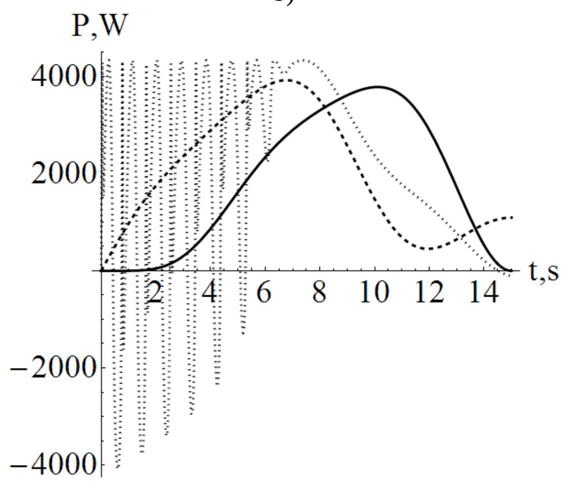
Fig. 4. Dependencies of alterations of: a) angular coordinate; b) speed; c) acceleration of the deviation of the flexible suspension of the load from the vertical under condition of (·····) manual control, (---) optimal contol 1, (—) optimal control 2



a)



b)



c)

Fig. 5. Dependencies of alteration of:

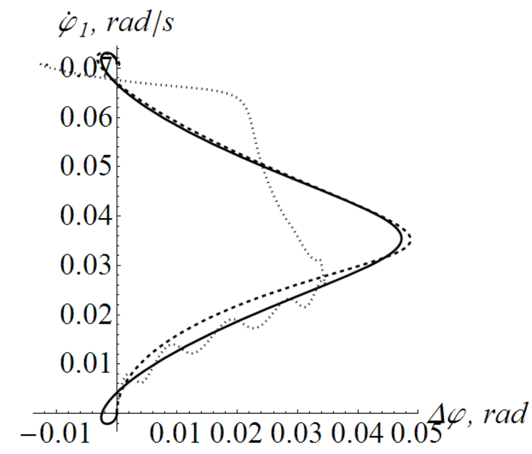
a) engine driving moment; b) the elastic moment in the drive; c) the power of the drive under condition of (·····) manual control, (---) optimal contol 1, (—) optimal control 2

From the graphic dependencies (Figs. 2–6) obtained from the solution of optimization tasks one can see that the kinematic, power and energetic characteristics of the jib system at the start-up of the rotation mechanism with the first and second optimal modes of motion, in comparison with the manual control, have smooth character of change indicating the absence of significant dynamic loads in the drive.

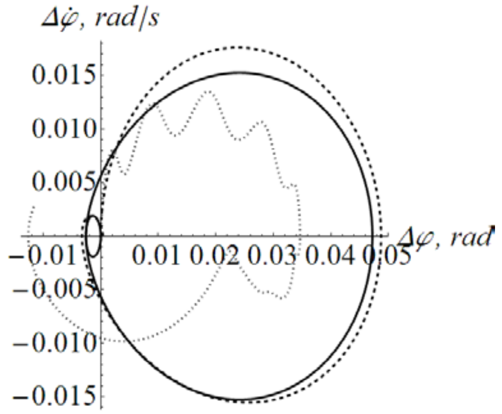
It has been carried out the comparison between the obtained results of dynamic analysis under the condition of manual control and the optimal modes of motion in terms of RMS (Table 1) and maximum (Table 2) values of kinematic, power and energetic characteristics of the jib system.

From the analysis of the RMS indicators summarized in the Table 1 one can see that the kinematic characteristics of the jib system when applying optimal modes of motion (optimal control 1 and optimal control 2) are slightly better compared to the manual control.

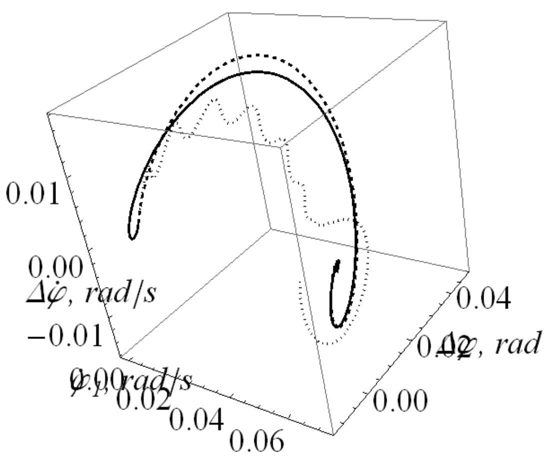
Optimal control 2 in comparison with manual control has made it possible to reduce the RMS values of the rotational speed of the engine rotor by 35 %, the rotational part of the crane by 16 % and the load by 15 %, as well as the angular accelerations of the rotor of the engine by 58 times, the rotational part by 33 %, and the deviation of the load by 40 %.



a)



b)



c)

Fig. 6. Phase portraits: a), b) flat; c) volumetric under condition of (·····)manual control, (---) optimal contol 1, (—) optimal control 2

The deviation of the RMS values of the torque on the electric motor shaft has decreased by 0.8 %, in the drive mechanism by 6.5 %, and the drive power by 20 %.

From the analysis of the maximum values of the characteristics summarized in Table 2, one can also see some improvement of the characteristics when using the optimal starting modes compared to the manual control. That includes the RMS value of the acceleration of the alteration of the elastic moment in the drive mechanism.

The values of the angular velocities of the engine rotor have improved by 62 %, the speed of the load by 8 %, and the angular accelerations of the engine rotor by 249 times, the rotation part of the crane by 2,7 times and cargo deviation by 2,2 times.

In addition, the maximum values of the torque on the shaft of the engine have improved significantly by 13 % as well as the drive mechanism by 43 % with the increase in engine power by 12 %.

It should be noted that the deviations of some indicators have deteriorated: the maximum values have become slightly larger, but the form of the alteration of these characteristics has become better, they have become smooth, which provides a reduction of dynamic loads in the jib system.

From the conducted analysis it can be concluded that by practically all parameters the optimal modes of starting the mechanism of rotation of the jib crane, which are, the criterion of the RMS value of acceleration of the alteration of the elastic moment in the drive mechanism and the criterion of the RMS value of the speed of torque alteration in the drive, have advantages over manual control. Both the maximum and the RMS values of kinematic, power and energetic characteristics have been improved.

From the given phase portraits (Fig. 6) it can be seen that the contours of the phase trajectories of both optimal control 1 and the optimal control 2 motion modes are closed, indicating the absence of fluctuations in the drive elements and in the load on the flexible suspension after the start-up process, in contrast to manual control, where the contour is not closed, indicating the presence of fluctuations of the load after the start-up process.

Table 1. Characteristics of the mechanism of rotation for the RMS deviation

Characteristics		RMS deviation: Manual control	RMS deviation: Optimal Control 1	RMS deviation: Optimal Control 2	Decrease in characteristics
Angular velocity, *rad/s*	engine rotor,	0,058	0,054	0,043	1,35
	rotational part	0,051	0,055	0,044	1,16

End of Table 1

Characteristics		RMS deviation			Decrease in characteristics
		Manual control	Optimal Control 1	Optimal Control 2	
Angular velocity, *rad/s*	cargo	0,054	0,058	0,047	1,15
	cargo deviation	0,007	0,009	0,009	0,77
Angular acceleration, *rad/s*^{2}	engine rotor,	0,291	0,006	0,005	58,2
	rotational part	0,008	0,006	0,006	1,33
	cargo	0,007	0,008	0,008	0,88
	cargo deviation	0,007	0,006	0,005	1,4
Toruqe, *N·m*	engine	60584,1	60883,9	60118,1	1,008
	in the drive	63640,4	60482,9	59751,9	1,065
Power of drive, *W*		2806,06	2348,89	2312,24	1,2
Cargo deviation, *rad/s*		0,02	0,023	0,023	0,87

Table 2. Characteristics of the mechanism of rotation for maximum values

Characteristics		RMS deviation			Decrease in characteristics
		Manual control	Optimal Control 1	Optimal Control 2	
Angular velocity, *rad/s*	engine rotor,	0,115	0,0725	0,071	1,62
	rotational part	0,071	0,073	0,073	0,97
	cargo	0,078	0,073	0,072	1,08
	cargo deviation	0,013	0,0165	0,0151	0,86
Angular acceleration, *rad/s*^{2}	engine rotor,	1,92	0,0127	0,0077	249,35
	rotational part	0,023	0,0135	0,0085	2,7
	cargo	0,011	0,016	0,0154	0,7
	cargo deviation	0,022	0,013	0,010	2,2
Torque, *kN·m*	engine	99,6	89	88	1,13
	in the drive	126,1	89	88	1,43
Power of drive, *kW*		4,25	3,9	3,8	1,12
Cargo deviation, *rad/s*		0,034	0,049	0,047	0,72

CONCLUSIONS

1. The three mass dynamic model of the mechanism of rotation of the jib crane (Fig. 1) has been constructed and a mathematical model (1) has been built for it using the Lagrange equations of the second kind, on the basis of which it has been performed a dynamic analysis of the mechanism of rotation of the crane using certain parameters of the jib system.

2. It has been established that the maximum values of loads arise at the beginning of the motion, that is, during the transients (start-up, braking) of the system of the rotation mechanism of the jib crane, which are characterized by a significant amplitude and frequency of oscillations that fade over time. Dynamic loads during operation of the rotation mechanism of the tower crane are undesirable. They result in reduced reliability, performance as well as faster failure of the drive and the structure itself, and as a result lead to emergency situations during the crane operation.

3. It has been performed the optimization of the rotation mode of the tower crane according to the criteria of the RMS value of the velocity of alteration of the elastic moment in the drive mechanism and the RMS value of the acceleration of the alteration in the elastic moment in the drive mechanism, which have improved compared to the ones manual control. Optimal modes of motion have allowed to provide a smooth, non-oscillating motion of the rotation mechanism, which minimizes the dynamic loads in the drive and the elements of the crane construction. From the analysis of graphic dependencies it is evident that practically all of the characteristics: kinematic, power and energetic characteristics have been improved using the optimal modes of motion compared to the manual control. The obtained optimal modes of motion of the rotation mechanism of the tower crane are realized with the help of a mechatronic control system of a drive motor.

REFERENCES

1. **Loveikin V. S., Pylypaka S. F., Kadykalo I. O. 2017.** Dynamic analysis of the mechanism of rotation of

the jib crane. *Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK.* Kiev. Vol. 258. 192–202.

2. **Loveikin V. S., Chovnyuk Yu. V., Mel'nichenko V. V. 2013.** Analysis of the fluctuations of cargo on a flexible suspension when turning the boom of a load-lifting crane. Hoisting and transport equipment. 4(40). 4–16.

3. **Grigorov O. V., Petrenko N. O. 2006.** Hoisting machines: navch. posibnik. NTU „HPI". 304.

4. https://ua.korrespondent.net/tag/5912.

5. https://ua.korrespondent.net/world/3625450-u-tsentri-nui-yorka-vpav-kran-ye-zhertvy#13.

6. https://ua.korrespondent.net/world/russia/3917077-u-moskvi-vpav-20-metrovyi-bashtovyi-kran.

7. https://ua.korrespondent.net/ukraine/3934788-na-prykarpatti-kran-vpav-na-vantazhivku-ye-zhertvy.

8. https://ua.korrespondent.net/tag/5912.

9. https://ua.korrespondent.net/world/3625450-u-tsentri-nui-yorka-vpav-kran-ye-zhertvy#13.

10. **Loveikin V. S., Romasevych Yu. O. 2012.** Analysis and synthesis of modes of motion of mechanisms of load-lifting machines. Kiev. CP «KOMPRÍNT». 299.

11. **Loveikin V. S., Romasevych Yu. O. 2016.** Dynamics and optimization of modes of motion of bridge cranes. Kiev. CP «KOMPRÍNT». 314.

12. **Loveikin V. S., Romasevych Yu. O. 2010.** Optimization of the transition modes of the mechanical systems of the direct variation method. Kiev. Nizhyn. Publisher of P.P. Lysenko M.M. 184.

13. **Loveikin V. S., Romasevych Yu. O. 2011.** Optimization of regimes of crane mechanisms. Kiev. Nizhyn. Publisher of PP Lysenko M.M. 307.

14. **Romasevich Yu. A., Shumilov G. V. 2011.** Optimization behavior of variation boom of hoisting crane for singular kinematical criterions. *MOTROL.* Vol. 13b. 167–173.

15. **Loveikin V. S., Mel'nichenko V. A. 2013.** Optimization of the dynamic rotation mode of the boom. Motrol. Vol. 15 (3). 70–75.

16. **Loveikin V. S., Chovnyuk Yu. V., Kadykalo I. O. 2017.** Optimization of modes of motion of rotating mechanism of cranes. *Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK.* Kiev. Vol. 262. 177–190.

17. **Loveikin V. S., Loveikin Yu. V., Kadykalo I. O. 2017.** Optimization of mode of motion of rotation mechanism of illicit small tap on criterion of RMS value of rate of change of elastic torque in drive. Scientific *Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK.* Kiev. Vol. 275. 10–22.

18. **Gerasimyak R. P., Naydenko O. V. 2007.** Features of the electric drive control of the boom mechanism during the rotation of the crane with suspended load. *Electrical machinery and electrical equipment.* 68. 11–15.

19. **Gerasimyak R. P., Leshchev V. A. 2008.** Analysis and synthesis of crane electromechanical systems. Odessa: SMIL. 192.

20. **Rubio-Avila J. J., Alcantara-Ramirez R., Siller-Alcala I. I. 2007.** Design, construction, and control of a novel tower crane. *International Journal Of Mathematics And Computers In Simulation*. 1 (2).

21. **Annenkova O. S., Frantsen G. E. 2008.** Construction tower cranes and lifts for the erection of multi-storey buildings. Barnaul: AltGTU. 206.

22. **Loveykin V. S., Romasevich Yu. O. 2011.** Dynamic analysis of the acceleration of the trolley on the natural mechanical characterization. *Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK.* Kiev. Vol. 166 (1). 46–49.

23. **Loveykin V. S., Romasevich Yu. O. 2013.** Dynamics of machines. «KOMPRINT». 227.

24. **Loveykin V. S., Romasevich Yu. O. 2014.** Analysis and synthesis of optimal control motion lifting crane direct variational method. *Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK.* Kiev. Vol. 196 (1). 129–139.

25. **Loveykin V. S., Chovnyuk Yu. V., Limar P. V., Melnichenko V. V. 2014.** Dynamic model motion bunk suspended on a flexible suspension, while turning the tap. *Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK.* Kiev. Vol. 196 (1), 162–171.

26. **Aftandilyants, E.G., Loveykin, V.S., Shevchuk, O.G. (2015).** Analysis of the construction boom cranes. Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK. Kiev. Vol. 212 (1). 121–130.

27. **Loveykin V. S., Palamarchuk D. A. 2015.** Optimization of motion hinge-articulated jib crane system. TsP «KOMPRINT». 224.

28. **Shengchun Wang, Rongsheng Shen, Tonghong Jin, Shijun Song. 2012.** Dynamic behavior analysis and its application in tower crane structure damage identification. *Advanced Materials Research. Trans tech publications*, Switzerland. Vols 368-373. 2478–2482.

29. **Rong Gao, Jing Yang, Gang Luo, Congxun Yan. 2013.** The Simulation of rotary motion of the flexible multi-body dynamics of tower crane. *Advanced Materials Research. Trans tech publications*, Switzerland. Vols 655–567. 281–286.

30. **Florentin Rauscher, Oliver Sawodny. 2017.** An elastic jib model for the slewing control of tower cranes. Elsevier. Science Direct. IFAC PapersOnLine. Vol 50–1 9796–9801.

31. **Zubko N. F. 2013.** Prediction of dynamic coefficients in elements of crane mechanisms. *Bulletin of the Odessa National Maritime University*. 2(38). 63 – 71.

32. **Loveikin V. S., Yaroshenko V. F., Romasevich Yu. O. 2007.** Optimization of transitional modes of motion of the mechanism of motion of the trolley of hoisting machines. *Bulletin of the Kharkiv National Technical University of Agriculture named after Petro Vasilenko*. 59 (2). 452–460.

33. **Loveikin V. S., Chovniuk Yu. V., Liashko A. P. 2014.** The crane's vibrating systems controlled by mechatronic devices with magnetorheological fluid: the nonlinear mathematical model of behavior and optimization of work regimes. *Scientific bulletin of National Mining University Scientific and technical journal*. Dnipro.Vol. 6. 97–102.

34. **Loveikin V. S., Romasevych Yu. O. 2017.** Dynamic optimization of a mine winder acceleration mode. *Scientific bulletin of National Mining University Scientific and technical journal*. Dnipro.Vol. 4. 55–61.
35. **Loveikin V. S., Romasevych Yu. O., Stekhno O. V. 2017.** Optimization of modes of change of departure of cargo of a tower crane. Kiev. CP «KOMPRÍNT». 172.
36. **Sa Y. H., Yi K. Y., Kim J. O. 2001.** An attitude control and stabilization of an unstructured object using balancing beam, new construction machinery. *IEEE International Symposium On Industrial Electronics Proceedings*. Pusan. South Korea.Vols. I–III. 792–797.
37. **D'yakonov V. P. 2004.** Mathematica 4.1 / 4.2 / 5.0 in mathematical and scientific-technical calculations. SOLON – Press. 696.

АНАЛИЗ РЕЖИМОВ ДВИЖЕНИЯ МЕХАНИЗМА ПОВОРОТА СТРЕЛОВОГО КРАНА

Аннотация. В статье приведена динамическая модель механизма поворота башенного крана и система дифференциальных уравнений, полученной с помощью уравнений Лагранжа второго рода, что описывает движение механизма поворота с грузом. После решения уравнений при определенных параметрах крана проведено динамический анализ механизма поворота. Теоретически доказано, что при работе механизма поворота в элементах привода так и в конструкции возникают динамические нагрузки, приводящие к разрушению конструкции и, как следствие, уменьшают надежность и производительность крана. Исследовано, что максимальные значения нагрузок возникают во время переходных процессов движения (пуск, торможение). Для минимизации нагрузок, возникающих во время работы механизма поворота стрелового крана проведена оптимизация режимов движения. За оптимизационные критерии избраны среднее значение скорости изменения упругого момента в приводном механизме (оптимальное управление 1) и среднее значение ускорения изменения усилия в приводном механизме (оптимальное управление 2). В результате решения поставленных задач установлены оптимальные режимы управления механизмом поворота крана. Оптимальные режимы движения по сравнению с режимом ручного управления, полученный в результате проведенного динамического анализа, имеют значительные преимущества. Анализ графических зависимостей полученных в результате решения поставленных задач показывает, что использование оптимальных режимов движения для системы привода дает плавный характер изменения кинематических характеристик крана по сравнению с ручным управлением. Плавное нарастание скоростей и приложения усилий улучшает работу механизма поворота башенного крана.

Полученные в данном исследовании результаты могут быть в дальнейшем использованы для уточнения и совершенствования существующих инженерных методов расчета механизмов поворота кранов с грузом на гибком подвесе как на стадиях их проектирования / конструирования, так и в режимах реальной эксплуатации.

Ключевые слова: грузоподъемная техника, башенный/стреловой кран, пуск, динамическая модель, математическая модель, анализ, режимы движения, механизм поворота, динамические нагрузки, оптимизация, критерии, среднее значение.

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Mathematical Model Boundary Nimble Technical Information of Local Operational Monitoring of Farmland

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Summary. A model of quality management implementation technological operation based on revised data size and performance variability of soil environmental condition of agricultural land using technical systems, depending on the state of agrobiological farmland. This model enables agrobiological given the state of the soil environment to take prompt management solution agrobiological as via tractor control unit, agricultural machines, technical systems, operational monitoring of agricultural land.

Ensuring the necessary quality of implementation processes is possible by next generation technology using information technology operational monitoring of the local soil environment with the use of operational control and technical state machine workflows (weight ratio 0,22-0,73), precision driving mobile units (0,08-0,32), operational management working bodies of machines for rational algorithm (0,37-0,51).

Further growth of crop mechanization efficiency associated with improved quality of technological processes, primarily due to operational condition monitoring and workflows machines, precision driving mobile units operating control machines working bodies for rational algorithm.

Designs developed technology of new generation with controlled quality performance processes allow for an increase in productivity - up to 20% fuel cost reduction and process materials by 15-20%, to obtain economic benefit - 1700 UAH. / Ha and reduce adverse human impact of technology on environment.

Significance of referred to the economy, food security and environmental security of Ukraine with the support of concerned departments and producers - a pledge unconditional implementation of crop Ukraine advanced information technologies based on the achievements of the national agricultural research and development controls.

Key words: quality technological operation, variability of soil environment agrobiological technical system condition monitoring.

INTRODUCTION

Modern high demands on the economic efficiency of agricultural production in view of the economic characteristics of the climatic zones of Ukraine, dictate the need for a radical overhaul of approaches to technology agricultural production, including the use of new effective information technology systems of local operational monitoring soil environment farmland built on new technologies the use of technical systems operational monitoring placed on mod machine and tractor units [1-15].

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

The main requirement for these units is to ensure the quality control of the execution of manufacturing operations. This requires the use of modern information technology and robotics mechatronic control systems associated with technical systems agrobiological operative monitoring of agricultural land, sensor quality control of manufacturing operations, which in the current context of development called "intelligent" or "smart" machines (Smart machinery) [13-15].

These "smart" machines with sensors monitoring the operational status of agricultural land should be widely used in all stages of agricultural crop production, basic tillage, sowing (planting) during the care of crops during the growing season and at harvest. This makes it possible to provide adequate quality of manufacturing operations while optimizing the cost of their production. In fact, "smart" machines must adapt to the state of agrobiological soil environment [13-15].

Execution of these tasks involves a retrofit / refurbishment of existing and the use of new agricultural machine and tractor units [13-15].

It should be noted that the importance and usefulness of these machine-tractor units particularly high during seeding (planting), because this process operation is actually the "foundation" of the future harvest [13-15].

Analysis of studies and publications shows that the traditional factors of agricultural production efficiency by optimizing the mechanics and construction materials, the use of advanced engineering materials (heavy-duty plastic, metal alloys, etc.) at the present stage of technological development, do not give significant efficiency gains.

One promising direction is to ensure the required quality of execution processes by obtaining higher (compared with physiological capacity) of information management and operational workflow of cars and on the basis of the transition to new advanced technologies using "smart" agricultural machines. Therefore there is a need for their development and use.

It is obvious that in such circumstances there is a need fundamentally new approaches to maintaining agricultural production, which is to ensure the quality of technological operations. The quality of technological operations is an integral indicator of agricultural production within agrobiological field. The quality of implementation of the basic processes in the plant is ensured by integrated information technology systems agrobiological local operational monitoring of agricultural land [13-15].

OBJECTIVE

The article is a mathematical model to describe the boundary nimble information technology systems of local operational monitoring of agricultural land in the performance of technological operations to ensure the quality of their performance.

THE MAIN RESULTS OF THE RESEARCH

By using information technology systems agrobiological local operational monitoring of agricultural land along with the technological operation is necessary in solving problems limiting speed of execution of work. The importance of this task is determined by its terms of reference.

When setting targets to limit bystrodiyi executive working bodies of agricultural units based on data obtained from the information technology systems of local operational monitoring of agricultural land is assumed that the length of time $t_\alpha \le t \le t_\beta$. During which the system should be transferred from one state $x(t_\alpha) = x^\alpha$ to another $x(t_\beta) = x^\beta$ Determined in advance. But not exclude the situation when the time $t = t_\beta$ end of the process is not specified, but determined in the implementation of technological operations along the solution. For example, one of these conditions may be a requirement to carry out the management as soon as possible. This, of course, have to take into account the limitations on the resources of government, realizing the actions and manage (limited supply of energy inadmissibility of the use of control forces exceed certain secure borders, and so on. P.). If such restrictions interpreted as requiring limited appropriately selected intensity x [and] management $u(t) t_\alpha \le t \le t_\beta$. The problem of marginal performance can be formulated as follows.

Suppose that the equation of motion information technology systems, operational monitoring of local farmland soil environment in the performance of technological operations asked equation of motion control system:

$$x = \mathrm{A}(t)x + \mathrm{B}(t)u + \omega(t), \tag{1}$$

primary x^α and final x^β value of the phase vector x (t) and due to restrictions on the chosen intensity x control u (t):

$$x[u] \le \mu . \tag{2}$$

We need to find time $t = t_\beta^o$ and the corresponding control possible $u^o(t)(t_\alpha \le t \le t_\beta^o)$. Satisfying the following conditions:

1) Management $u^o(t)$ management decides at $(t_\alpha \le t \le t_\beta^o)$;

2) the inequality:

$$x[u^o] \le \mu . \tag{3}$$

3) that would not have been time $t = t_\beta$ and possible management $u(t) t_\alpha \le t \le t_\beta$. To solve the problem of boundary control equation (2) should be performed inequality $t_\beta^o \le t_\beta$.

Conditions (2) and (3) require some explanation. The fact that the determination of the expression x [and] may depend on the value of t_β. Which is to be determined. For example, it may be given as:

$$x[u] = \left\{ J \int_{t_\alpha}^{t_\beta} \| u(\tau) \|^2 \, d\tau \right\}^{1/2} .$$

In this case, the intensity should be marked $x[u]$ symbol $x[u(\tau), t_\alpha \le \tau \le t_\beta]$ and limit the expression (2) can be recorded as:

$$x[u(\tau), t_\alpha \le \tau \le t_\beta] \le \mu . \tag{4}$$

However, to reduce the indexes t_α and t_β the designation for the intensity of x will be omitted. In particular, the deal further in the task of limiting the speed limit on record $u(t)$ in (2), understanding this record, in terms of the formula (4).

If the managed system is described by generalized linear equation:

$$dx = \mathrm{A}(t)xdt + \mathrm{B}(t)dU + dW, \tag{5}$$

then this system targets to limit speed may be formulated by (1) the need to control the expression $dU^0(t)(t_\alpha \le t \le t_\beta^0)$ must be sought in the class of possible generalized departments.

Equation management $u^0(t)$ and $dU^0(t)(t_\alpha \le t \le t_\beta^0)$, the boundary conditions for the marginal performance system (1) and (5), will be called the best in speed and number $\mathrm{T}^0 = t_\beta^0 - t_\alpha$. Equal to the shortest time of transition from the initial state to the final CL ha called optimal time transition.

When solving problems for research speed limit information and technical systems operational monitoring of local state agrobiological soil environment farmland take the next device functional analysis:

1) management's intensity [and] the norm p*[s] function $u(t)(t_\alpha \le t \le t_\beta^0)$ in some functional space $B^*\{u(\tau)\}$. Then the formula (1) and its corresponding modification to the system (5) pereformulyuyetsya limits for classes in the departments (t) and generalized admissible controls and dU (t).

As the transition occurs in the same way optimal control, so keep in mind that everywhere we further restrict ourselves only to those values $x[u(\tau),(t_\alpha \le \tau \le t_\beta)] = \rho^*[u(\tau),(t_\alpha \le \tau \le t_\beta)]$ for which the equality $\rho^*[u(\tau),t_\alpha \le \tau \le \sigma] = \rho^*[u(\tau),t_\alpha \le \tau \le \vartheta]$ for all functions $u[\tau]$. That meet the conditions $u(\tau)=0$ at $\tau \ge \vartheta$. Here ϑ and σ - any are related to inequality $\vartheta < \sigma$.

Further, we consider the case when the time $t = t_\alpha$ will change. Then symbols $\rho^*[u(\tau),\tau \ge t_\alpha]$ will mark size $\rho^*[u(\tau),t_\alpha \le \tau \le \vartheta]$ if any - which ϑ. Which may be the end point of the process.

Circulation restrictions:

$$\rho^*[u(\tau),\tau \ge t_\alpha] \le \mu . \tag{6}$$

These restrictions will mean that in the management process can be used in any capacity $u(\tau)(\tau \ge t_\alpha)$. Satisfying condition $\rho^*[u(\tau),t_\alpha \le \tau \le \vartheta] \le \mu$. (If any - which $\vartheta > t_\alpha$). It is in this sense should be understood as restricting entry and formula (6) in any apparent concrete form, such as:

$$\left[\int_{t_\alpha}^{\infty} \|u(\tau)\|^2 d\tau\right]^{1/2} \le \mu . \tag{7}$$

Equation (7) can reach a large number of actual restrictions.

Often problems at the maximum speed limit $u(\tau)$ has the asymmetric shape $a_j \le u_j \le b_j$, and $a_j \ne -b_j$. However, in this case the change of variables u_j on ν_j. You can build equation (7) to limit the type $\rho^*[\nu] \le \mu$. It's enough to do, for example, the conversion:

$$\nu_j = \left(u_j - \frac{a_j + b_j}{2}\right)\frac{2\mu}{b_j - a_j} . \tag{8}$$

and assume $\rho^*[\nu] = \max_j \sup_\tau \{|\nu_j(\tau)|\}$.

∞ symbol is chosen at the same time as the upper limit of the integral in (7) just for the purpose to emphasize that point $t = t_\beta > t_\alpha$, When the management process, we may be unknown and we have over time $t \ge t_\alpha$ own resource management, equal $\mu(t_\alpha)$. Similar comments should be borne in mind when recording management evaluation $u(\tau)$ at $t \ge t_\alpha$ will be used by the general character intensity $x[u(\tau),\tau \ge t_\alpha]$.

Note that the task of limiting speed can be set for the case when the system (1) or (5) shall be translated as soon as possible with a given state $x(t_\alpha) = x^\alpha$ a predetermined point x^β phase space and on in some areas Q final state x^β. It should also be borne in mind that the vector x^β under the terms of the task may depend on t_β. This situation arises in cases where you need to calculate the maximum bystrodiyu object that moves $x(t)$ not a fixed point $x = x^\beta$. But it is necessary to determine at a given movement $x = x^\beta(t)$.

The problem about the speed limit information technology systems agrobiological local operational monitoring of agricultural land. To solve this problem you need to find a control law $u^0(t)$. Which puts the system (1) from the state $x(t_\alpha) = x^\alpha$ a state $x(t_b) = x^b$ a short time $T^0 = t_b^0 - t_a$ for a given limited:

$$x[u] \le \mu . \tag{11}$$

Where as Minimax rule can specify the following path on the task of limiting speed.

Let $t_\beta > t_\alpha$ - a fixed time. Then be presented solutions for optimal impact $u_T(t)$ switching system (1) from the state $x(t_\alpha) = x^\alpha$ to position $x(t_b) = x^b$ during $T = t_\beta - t_a$ and thus have the lowest possible rate $\rho^*[u_T] = x[u_T] = \min$. If now we change time t_β. Then:

1) We find that any $t_\beta > t_\alpha$, which means that each number $T > 0$. Will meet certain optimal control $u_T(t)$ and some of its intensity $x[u_T]$. Which is therefore a function of T.

2) Or, in any case, be solved at values t_β with a set. Changes are needed then the arguments are obvious.

Let $x[u_T] = x_T$ and consider the inequality:

$$x_T \le \mu . \tag{12}$$

While it is obvious that the best time of transition T^0 under the constraint (11) is the smallest of positive numbers T. Would meet the conditions (12). Combining this fact with Minimax rule, we get the following result.

Let $h_T^0(\tau)$ $(t_\alpha \le \tau \le t_\beta = t_\alpha + T)$ - the minimum feature found under Rule Minimax, then:

$$\rho[h_T^0(\tau)] = \min_{s\,T} \rho[B' s_T(\tau)] = \rho_T . \tag{13}$$

Where $s_{\mathrm{T}}(t)$ traffic related system (13) that satisfies the boundary conditions s't (t_β) s (T) = 1. Then the smallest of numbers $\mathrm{T} = t_\beta - t_a$. Satisfies the relationship:

$$\rho_{\mathrm{T}} \geq \frac{1}{\mu}. \qquad (14)$$

Would be the best time of transition T°, and therefore at this time optimal control will be described by the following equation $u_{\mathrm{T}}^0(t) = u^0(t)$ $(t_\alpha \leq t \leq t_\beta^0 = t_\alpha + \mathrm{T}^0)$ will be desired, for optimum performance control. Thus, according to the rules Minimax, optimal for performance management will look $\rho^*[u^0(\tau)] = 1/\rho_{\mathrm{T}^0}$ and will stand out among all admissible controls $u(\tau)$ $(t_\alpha \leq t \leq t_\beta^0)$ the norm $\rho^*[u(\tau)] = 1/\rho_{\mathrm{T}^0}$ maximum property features a minimum $h_{\mathrm{T}^0}^0(\tau)$.

Formulated way to solve the problem on the speed limit is to construct models to determine the smallest positive number T, corresponding to the condition (14). The process of finding the most optimal for performance management should determine the maximum property contained in Regulation Minimax. If the value of ρ_{T} is a continuous function T (which, indeed, there is a broad class of cases), for finding the value T° instead of the condition (4) is convenient to use the equation:

$$\rho_{\mathrm{T}} = \frac{\min}{{}^{s}\mathrm{T}}\left[\mathrm{B}'(\tau) s_{\mathrm{T}}(\tau) = \frac{1}{\mu} \right]$$
$$s_{\mathrm{T}}'(t_\beta) c(\mathrm{T}) = 1. \qquad (15)$$

The smallest positive root of the equation and give optimum transition time T °.

Given that the expression $\rho[\mathrm{B}' s_{\mathrm{T}}(\tau)]$ uniform in vector $l = s(t_\beta)$. Because inequality (14) or equation (15) with the condition $s_{\mathrm{T}}'(t_\beta) c(\mathrm{T}) = 1$. You can replace the inequality:

$$\min_{\|s_{\mathrm{T}}\|=1} \left\{ -s_{\mathrm{T}}'(t_\beta) c(\mathrm{T}) + \mu\rho\left[\mathrm{B}'(\tau) s_{\mathrm{T}}(\tau)\right] \right\} \geq 0,$$

or in accordance with the equation

$$\min_{\|s_{\mathrm{T}}\|=1} \left\{ \mu\rho\left[\mathrm{B}'(\tau) s_{\mathrm{T}}(\tau)\right] - s_{\mathrm{T}}'(t_\beta) c(\mathrm{T}) \right\} = 0,$$

sometimes it may be more convenient to work with these ratios. Then equation (15) can still replace a ratio that does not contain $\rho[h(\tau)]$,

$$\min_{\|s_{\mathrm{T}}\|=1} \left[\max_{x[u(\tau)] \leq \mu} \int_{t_\alpha}^{t_\beta} \mathrm{B}'(\tau) s_{\mathrm{T}}(\tau) u(\tau) d\tau - s_{\mathrm{T}}'(t_\beta) c(\mathrm{T}) \right] = 0.$$

The way a computational algorithm is not a problem with the calculation by using numerical methods, such as the question of choosing the initial approximation or questions about the rate of convergence of the computing process. When considering certain restrictions (11), and especially in solving specific problems these common difficulties can be overcome somehow.

For example, suppose that you need to solve the problem of boundary management information technology system operational monitoring of local farmland soil environment (1) while limiting energy control action, that is if:

$$x[u] = \left[\int_{t_\alpha}^{\infty} \|u(\tau)\|^2 d\tau \right]^{1/2} \leq \mu. \qquad (16)$$

In this case, the task of speed limit enforcement work of information technology systems, local operational monitoring soil environment farmland solved with the least difficulty. The fact that optimal management provided a minimum of energy is in a closed form and can not therefore excluding $l_i^0(\mathrm{T})$ of relations (3), record the intensity of chemotherapy optimal control, and hence the value $\rho_{\mathrm{T}} = 1/x_{\mathrm{T}}$. In the form of an explicit function of time T. Indeed, taking into account equation (11), we obtain that:

$$x_{\mathrm{T}} = \left[\int_{t_\alpha}^{t_\beta} \|u^0(\tau)\|^2 d\tau \right]^{1/2} = \left[\frac{\sum_{i,k=1}^{n} c_i c_k D_{ik}}{D} \right]^{1/2}. \qquad (17)$$

where $c = c(\mathrm{T}) = \{c_i(\mathrm{T})\}$ - vector (15).

It is easy to establish that HT (7) is a continuous function of T, unless D ≠ 0. But the last condition is met in any case, if the system (1) is completely controllable. Then the value $\rho_{\mathrm{T}} = 1/x_{\mathrm{T}}$ will also feature continuous and definition T0 can use equation (15), which takes the form:

$$\sum_{i,k=1}^{n} c_i(\mathrm{T}) c_k(\mathrm{T}) D_{ik}(\mathrm{T}) - \mu^2 D(\mathrm{T}) = 0. \qquad (18)$$

Thus, in this case the task of limiting the speed is reduced to the smallest positive root of the equation T0 (18). It is optimal for speed control $u^0(t)$ determined by formulas (18), in which instead of t_β substituted $t_\beta^0 = t_\alpha + \mathrm{T}^0$.

Let the material point movement which has described the system of differential equations (18) need to switch out $x_\alpha = \{-1,0,1,0\}$ at $t_\alpha = 0$ in position $x^\beta = \{0,0,0,0\}$ the fastest way. This inequality must be satisfied:

$$\int_{t_\alpha}^{\infty} \left[u_1^2(\tau) + u_2^2(\tau) \right] d\tau \leq \mu^2. \qquad (19)$$

According chosen above general ways of solving the problem find function ρ_{T}. Based on the equation (17), we get:

$$\rho_{\mathrm{T}} = \frac{1}{x_{\mathrm{T}}} = \left[g^2 \mathrm{T} + \frac{24}{\mathrm{T}^3} \right]^{-\frac{1}{2}}, \qquad (20)$$

and accordingly equation (18) is written as:

$$g^2\mathrm{T}^4 - \mu^2\mathrm{T}^3 + 24 = 0. \qquad (21)$$

Let T0 - the smallest of these roots, then according to formula (18) for optimal performance management is defined by:

$$u_2^0(t) = \frac{6}{\left[\mathrm{T}^0\right]^3}\left(\mathrm{T}^0 - 2t\right),$$

$$u_2^0(t) = \frac{6}{\left[\mathrm{T}^0\right]^3}\left(\mathrm{T}^0 - 2t\right) + g\left(0 \le t \le \mathrm{T}^0\right),$$

from which it follows that the steepest descent from the point {-1, 0, 1, 0} to point {0, 0, 0, 0} is carried out in a straight line.

This example shows that, generally speaking, the function ρ_{T} no monotony property, which can be very useful for numerical determination of T0 from equation (25). However, if the example of disassembled discarded g, then the function $\rho_{\mathrm{T}} = \left(\mathrm{T}^3/24\right)^{1/2}$ is strictly monotonically increasing, and then each $\mu > 0$. Equation (21) will have only positive root, which delivers optimum transition time T0. It appears that the said property features monotony ρ_{T} is not specific only to this example and if appropriate assumptions this property takes place in a rather general restrictions (21) to control the intensity of exposure. Namely, even in the equation (21) $\omega(t) \equiv 0$ and $x^\beta = 0$. Then we can show that the function ρ_{T} is not monotonically decreasing function of T. To prove this fact, we recall that the value ρ_{T}. You can search from the condition:

$$\begin{aligned}\rho_{\mathrm{T}} &= \min \rho\left[\mathrm{B}'(\tau)s(\tau)\right] = \\ &= \min \rho\left[\mathrm{B}'(\tau)S[\tau, t_\alpha]l\right]\end{aligned}, \qquad (22)$$

at $s'(t_\alpha)x^\alpha = l' \quad x^\alpha = -1$. Suppose that for each t>0 among. Found $l_i^0(\mathrm{T}) = s_i^0(t_\alpha)$ from the condition (22). Then, taking into account this condition, we obtain the obvious inequality:

$$\begin{aligned}\rho_{\mathrm{T}} + \Delta\mathrm{T} &= \rho\left[\mathrm{B}'(\tau)S[\tau, t_\alpha]l^0(\mathrm{T}+\Delta\mathrm{T}),\right. \\ &\left. t_\alpha \le \tau \le t_\alpha + \mathrm{T} + \Delta\mathrm{T}\right] \ge \\ &\ge \rho\left[\mathrm{B}'(\tau)S[\tau, t_\alpha]l^0(\mathrm{T}+\Delta\mathrm{T}),\right. \\ &\left. t_\alpha \le \tau \le t_\alpha + \mathrm{T}\right] \ge \min_l \rho\left[\mathrm{B}'(\tau)S[\tau, t_\alpha]l,\right. \\ &\left. t_\alpha \le \tau \le t_\alpha + \mathrm{T}\right] = \rho_{\mathrm{T}}, (\Delta\mathrm{T} > 0). \end{aligned} \qquad (23)$$

Thus, we see that, indeed, the variable is monotonous, non decreasing function of the size of T. important to emphasize that in many cases the choice of intensity x [s] with the full controllability of the system (21) in the ratio (23) will be carried out strictly inequality, ie function ρ_{T} is strictly monotonically increasing function of T. For example, in the case discussed above restrictions on energy management (23) according to (2) and (23) will be:

$$\begin{aligned}&\rho_{\mathrm{T}+\Delta\mathrm{T}}^2 - \rho_{\mathrm{T}}^2 \ge \\ &\ge \int_{t_\beta}^{t_\beta+\Delta\mathrm{T}} \left\|\mathrm{B}'(\tau)S[\tau, t_\alpha]l^0(\mathrm{T}+\Delta\mathrm{T})\right\|^2 d\tau,\end{aligned} \qquad (24)$$

The right side of inequality (24) is strictly positive, unless the system (1) is completely controllable since then the vector function $h^{[i]}(\tau)$ - column matrix $\mathrm{B}'(\tau)S[\tau, \quad t_\alpha]$ - linearly independent. When restricting the maximum control force (21) we have:

$$\begin{aligned}&\rho_{\mathrm{T}+\Delta\mathrm{T}} - \rho_{\mathrm{T}} \ge \\ &\ge \int_{t_\beta}^{t_\beta+\Delta\mathrm{T}} \gamma\left\{\mathrm{B}'(\tau)S[\tau, t_\alpha]l^0(\mathrm{T}+\Delta\mathrm{T})\right\} d\tau,\end{aligned} \qquad (25)$$

and the right side of this inequality with the full controllability of the system will again be strictly positive.

If restrictions on impulse control action (25) value of the difference $\rho_{\mathrm{T}+\Delta\mathrm{T}} - \rho_{\mathrm{T}}$ is just as responsible and integral functions:

$$\rho_{\mathrm{T}} = \min_l \quad \sup_\tau \gamma\left[\mathrm{B}'(\tau)S[\tau, t_\alpha]l\right] \text{ at } \quad l'x^\alpha = -1$$

That is, generally speaking, not only decreasing function of T.

Continuity of functions describing the manufacturing process is checked easily under conditions $\omega(t) \equiv 0, x^\beta = 0$ for a wide range of values x[s], for example, in the case of responsible energy management to limit or control the maximum power when the system is fully controllable.

Properties strict monotony and continuity of ρ_{T} are important for solving the problem on the speed limit for the following reasons. Suppose there is at least one number T1 for which exists among departments allowed administration $u^{(1)}(t)$. That puts the system out x^α in position x^β during $t_\beta^{(1)} - t_\alpha = \mathrm{T}_1$ provided $\rho^*\left[u^{(1)}\right] = x\left[u^{(1)}\right] \le \mu$. Then it will be just inequality $\rho_{\mathrm{T}1} \ge 1/\mu$. If the function ρ_{T} is continuous and if the relation:

1) lim ρ_{T} = 0 for $\mathrm{T} \to 0$. It is possible to say that there is the smallest positive integer T^0. In which the equality $\rho_{\mathrm{T}^0} = 1/\mu$.

If the same function ρ_{T} strictly monotonic, then this number will only T0, that is, when the above assumption that ensure strict monotone continuous function ρ_{T}, Equation (25) has a single positive root T = T0, which determines the best time of the transition process. In addition, based on the implicit function theorem, it is easy to check that, subject to strict monotony variable ρ_{T} value T0 - the root of (25) - depend continuously on the coordinates x_i^α and the parameters of the system. Particularly useful properties listed in solving problems in cases where the problem of optimal control provided corresponding minimum intensity dares in a closed form.

If you're looking for optimal performance management while limiting the intensity of a controlled impact on the equation of the form:

$$x[u] = \sup \quad \max\left(\left|u_j(\tau)\right|\right) \le \mu \quad \left(j = 1,...,r, \tau \ge t_\alpha\right). \tag{26}$$

This ratio is again performed obviously in the case of restrictions on the maximum power or control action and can not take place while limiting the impulse control force. The latter may be T0 = 0.

Equation (25) to determine T0 takes the form:

$$\rho_{\mathrm{T}} = \int_{t_\alpha}^{t_\alpha+\mathrm{T}} \left(\sum_{j=1}^{r} \left| \sum_{i=1}^{n} l_i^0(\mathrm{T}) h_{ij}(t_\alpha + \mathrm{T}, \tau) \right| \right) d\tau = \frac{1}{\mu}. \tag{27}$$

where $h_{ij}(t_\beta, \tau)$ - elements pulse transition matrix $H[t_{\beta,}\tau] = S^{'}[\tau, t_\beta]\mathrm{B}(\tau)$, and $l_i^0(\mathrm{T})$ numbers that give solution to the problem:

$$\min\left[\int_{t_\alpha}^{t_\alpha+\mathrm{T}} \left(\sum_{j=1}^{r} \left| \sum_{i=1}^{n} l_i\, h_{ij}(t_\alpha + \mathrm{T}, \tau) \right| \right) d\tau \right] = \rho_{\mathrm{T}}. \tag{28}$$

provided $\sum_{i=1}^{n} l_i c_i(\mathrm{T}) = 1$.

As we already know, the problem (28) in the general case is not resolved, unfortunately, in a closed form. Therefore, determining T0 the equation (28) by any numerical method we have at every step to find new numerical values of $l_i^0(\mathrm{T})$. If it is determined that the function ρ_{T} continuous and tends strict monotony, then finding T0 can offer the following scheme accounts that implements a simple process of successive approximation. Choosing from a number of reasonable arguments T1, define minimum function $h_{\mathrm{T}}^0(\tau)$. If you find that $\rho\left[h_{\mathrm{T}_1}^0(\tau)\right] = \rho_{\mathrm{T}_1} > 1/\mu$. Then take T2 equal to 2.1 T, and if the contrary inequality $\rho_{\mathrm{T}_1} < 1/\mu$. It is necessary to put T2 = 2T1. So, let T2 defined. If the initial approximation was T1 $\rho_{\mathrm{T}_1} > 1/\mu$ again proved $\rho_{\mathrm{T}_2} > 1/\mu$. Then think again T3 = T 2/2, and so so long until you arrive at the inequality $\rho_{\mathrm{T}_j} < 1/\mu$. Thus, the required number of turns T0 trapped in the fork $\mathrm{T}_j < \mathrm{T}^0 < \mathrm{T}_{j-1}$. Then clear manner the sequence of compressed segments containing T0. If it was $\rho_{\mathrm{T}_j} < 1/\mu$ and then got $\rho_{\mathrm{T}_2} < 1/\mu$. Then choose T3 = 2T2, and doing so for as long as fail $\rho_{\mathrm{T}_j} > 1/\mu$. Then T0 again enters the plug $\mathrm{T}_{j-1} < \mathrm{T}^0 < \mathrm{T}_j$ and so on d. This process will continue until then, until satisfied with the set up equality $\rho\left[h_{\mathrm{T}_m}^0(\tau)\right] = 1/\mu$. As a result of the sequence numbers be built T1, T2, ..., Tm, ... that converges to T0. This convergence has easily unless the problem really has a solution, that is, if lim $\rho_{\mathrm{T}} > 1/\mu$ at $\mathrm{T} \to \infty$. After T0 determined is optimal for speed control in the case (26) is written according to (22) of the formula:

$$u_i^0(t) = \mu \operatorname{sgn} h_{\mathrm{T},i}^0(t) \quad \left(t_\alpha \le t \le t_\alpha + \mathrm{T}^0, i = 1,...,r\right). \tag{29}$$

It is clear that we needed to find the root of (25) In addition to the simple calculation schemes can be applied and other computational procedures to effectively solve this problem. One of them is. For example, assume that j - step process of successive approximations at $\mathrm{T} = \mathrm{T}_j$ realized the inequality

$$\rho\left[h_{\mathrm{T}_j}^0(\tau), \quad t_\alpha \le \tau \le t_\alpha + \mathrm{T}_j\right] = \rho_{\mathrm{T}_j} < 1/\mu.$$

If the following approximation T_{j+1} select from the condition $\rho\left[h_{\mathrm{T}_j}^0(\tau), \quad t_\alpha \le \tau \le t_\alpha + \mathrm{T}_{j+1}\right] = 1/\mu$ then T_{j+1} being more T_j. Not to exceed, however, the unknown quantity T as

$$\rho\left[h_{\mathrm{T}_{j+1}}^0(\tau), \quad t_\alpha \le \tau \le t_\alpha + \mathrm{T}_{j+1}\right] =$$
$$= \rho_{\mathrm{T}_{j+1}} \le \rho\left[h_{\mathrm{T}_j}^0(\tau), \quad t_\alpha \le \tau \le t_\alpha + \mathrm{T}_{j+1}\right] = \frac{1}{\mu}.$$

CONCLUSIONS

1. Ensuring the necessary quality of implementation processes is possible by next generation technology using information technology operational monitoring of the local soil environment with the use of operational control and technical state machine workflows (weight ratio 0,22-0,73), precision driving mobile units (0,08-0,32), operational management working bodies of machines for rational algorithm (0,37-0,51).
2. Further growth of crop mechanization efficiency associated with improved quality of technological processes, primarily due to operational condition monitoring and workflows machines, precision driving mobile units operating control machines working bodies for rational algorithm.
3. Designs developed technology of new generation with controlled quality performance processes allow for an increase in productivity - up to 20% fuel cost reduction and process materials by 15-20%, to obtain economic benefit - 1700 UAH. / Ha and reduce adverse human impact of technology on environment.
4. Significance of referred to the economy, food security and environmental security of Ukraine with the support of concerned departments and producers - a pledge unconditional implementation of crop Ukraine advanced information technologies based on the achievements of the national agricultural research and development controls.

REFERENCES

1. **Sendreev J. N. 1976.** Management. Moscow. Nauka. 424.

2. **Krasovskyy N. N. 1968.** Motion Control Theory. Moscow. Nauka, 474.

3. **Roytenberh Y. A. 1978.** Automatic Management. Moscow. Nauka, 551.

4. **Egorov A. I. 1988.** Management systems. Kiev. High School. 276.

5. **Pontryagin L. S. 1961.** Mathematic theory processes. Moscow. Nauka, 391.

6. **Vladimir Donets, Svetlana Kochubey, Vitaly Yatsenko, Alexander Brovarets Taras Kazantsev, Vadim Brovchenko. 2014.** Spectral-field studies satellite validation remote vegetation. *TEKA*. Vol. 16, No 3. 195-201.

7. **Brovarets A. A. 2013.** Monitoring devices for field parameters at AIC. TEKA. № 11 (50). 131-141.

8. **Brovarets A. A. 2011.** Analysis of the disturbing irregularities ahrofoniv. *MOTROL*. №13B. 161-166.

9. **Robson M. A. 1996.** Practical guide to business process re-engineering. London. Gower Publishing Std, 96.

10. **Scherer F. M**. **1990.** Industrial market structure and economic performance. Boston, USA: Hongliton Mifflin Co. 90.

11. **Erlich A**. **1996.** Technical analysis of commodity and financial markets. Moscow: INFRA. 196.

12. **MacConnel L. 1993**. Ekonopis: Principles, problems and politics. Moscow. Manager, 103.

13. **Karibskiy A. V. 1989.** Modeling the development of the structure of large-scale production and transport systems. I, II. Automatics and telemechanics. №2. 116-131, №4. 139-154.

14. **Karibskiy A. V. 1996.** Business plan: financial and economic analysis and performance criteria. (methods of analysis and evaluation). Preprint. Moscow: Institute for Control Sciences, 19.

15. **Karibskiy A. V. 1991.** Managing the development of large-scale system. *Mathematics and Computers in Simulation*. 287-293.

16. **Shestakov N. V. 1991.** Use of computer modeling methods in the investment planning of petrochemical industries. *Abstracts of the International Scientific and Practical Conference "Management of large systems."* M.I.PU. 391.

17. **Karibskiy A. V. 1998.** Information technologies and features of financial and economic analysis of large investment projects in the oil industry. *World of Communication*. № 7-8. 72-77.

18. **Bakhrakh L. D., Bliskavitsky A. A. 1993.** The successes of physical sciences. V. 162, No. 2. 160.

19. **Landau L. D. 1982.** Electrodynamics of continuous media. Moscow. Nauka. 624.

20. **Brovarets O. O. 2011.** Analysis of the structure of perturbing roughnesses of agrofones. *MOTROL*. No. 13B. 161-166.

21. **Rogovskii Ivan. 2014.** Stochastic models ensure the efficiency of agricultural machines. **MOTROL**. Lublin. 2014. Vol. 16. No 3. 296-302.

22. **Rogovskii Ivan. 2016.** Graph-modeling when the response and recovery of agricultural machinery. *MOTROL*. Lublin. Vol. 18. No 3. 155-164.

23. **Rogovskii Ivan. 2017.** Analytical provision of regular preventive maintenance of agricultural machinery and system implementation. MOTROL. Lublin. Vol. 19. No 3. P. 185-191.

24. **Rogovskii Ivan. 2017.** Choice of model class and method of modeling the resilience of agricultural machinery. *TEKA*. Lublin–Rzeszów. 2017. Vol. 17. No 3. 101-114.

МАТЕМАТИЧЕСКАЯ МОДЕЛЬ ПРЕДЕЛЬНОЙ БЫСТРОЙ ИНФОРМАЦИОННО-ТЕХНИЧЕСКОЙ СИСТЕМЫ ЛОКАЛЬНОГО ОПЕРАТИВНОГО МОНИТОРИНГА СОСТОЯНИЯ СЕЛЬСКОХОЗЯЙСТВЕННЫХ УГОДИЙ

Александр Броварец

Аннотация. Построенная модель управления качествами выполнения технологической операции на основе уточненных данных величины показателей и параметров вариабельности состояния грунтовой среды сельскохозяйственных угодий с использованием технических систем в зависимости от агробиологического состояния сельскохозяйственных угодий. Данная модель дает возможность учитывая агробиологическое состояние грунтового среда принять оперативное решение для управления агробиологическим состоянием с помощью управления машинно-тракторным агрегатом, сельскохозяйственной машиной, технической системы оперативного мониторинга состояния сельскохозяйственных угодий.

Обеспечение требуемого качества выполнения технологических процессов возможно за счет техники нового поколения с использованием информационно-технических систем локального оперативного мониторинга почвенной среды с использованием средств оперативного контроля технического состояния и рабочих процессов машин (коэффициент весомости 0,22-0,73), точности вождения мобильных агрегатов (0,08-0,32), оперативного управления рабочими органами машин за рациональным алгоритмом (0,37-0,51).

Дальнейший рост эффективности механизации растениеводства связано с повышением качества выполнения технологических процессов, в первую очередь за счет оперативного контроля технического состояния и рабочих процессов машин, точности вождения мобильных агрегатов, оперативного управления рабочими органами машин за рациональным алгоритмом.

Разработанные образцы техники нового поколения с управляемой качеством выполнения технологических процессов позволяют обеспечить увеличение производительности труда – до 20%, уменьшение расходов топлива и технологических материалов на 15-20%, получить экономический эффект – свыше 1700 грн./га и уменьшить вредное антропогенное воздействие техники на окружающую среду.

Значимость указанной работы для экономики, продовольственной обеспеченности и экологической безопасности Украины при поддержке ее заинтересованными ведомствами и производителями

– залог безусловного внедрения в растениеводство Украины передовых информационных технологий на основе достижений отечественной аграрной науки и разработок средств управления.

Ключевые слова: качества технологической операции, вариабельность грунтовой среды, техническая система агробиологическое состояние, мониторинг.

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Realization of Optimum Mode of Movement of Roller Forming Installation on Acceleration of Fourth Order

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Summary. For the purpose of increase in reliability and durability of roller forming installation the optimum mode of back and forth motion of the forming cart on acceleration of the fourth order is calculated. Kinematic characteristics of the forming cart at the optimum mode of the movement on acceleration of the fourth order are calculated. The design of roller forming installation with the drive from the high-moment step engine which is built in the rolling rollers of the forming cart is offered and provides the optimum mode of back and forth motion of the forming cart on acceleration of the fourth order. Use in installation of the specified driving mechanism leads to improvement of quality of a surface to the processed concrete mix, reduction of dynamic loadings in elements of the driving mechanism, to disappearance of excess destructive loads of a frame design and, respectively, to increase in reliability and durability of installation in general. As a result of the conducted researches for the purpose of increase in reliability and durability of roller forming installation the optimum mode of back and forth motion of the forming cart on acceleration of the fourth order is calculated.

Kinematic characteristics of the forming cart at the optimum mode of back and forth motion on acceleration of the fourth order are calculated.

The design of roller forming installation with the drive from the high-moment step engine which is built in the rolling rollers of the forming cart with a possibility of realization of the optimum mode of back and forth motion on acceleration of the fourth order is offered.

The design of the drive of installation in a type of the cam mechanism is offered and the cam profile for providing the optimum mode of back and forth motion of the forming cart on acceleration of the fourth order is constructed.

Results of work can be used further for specification and improvement of the existing engineering methods of calculation of driving mechanisms of cars of roller formation both at design/designing stages, and in the modes of real operation. Also results of work can be useful at design or improvement of mechanisms with back and forth motion of executive elements.

Key words: roller forming installation, mode of movement, step engine, drive.

INTRODUCTION

In the existing installations of superficial consolidation of concrete goods the crank ram or hydraulic drive of back and forth motion of the forming cart with the condensing rollers is used [1-3]. During the constant starting and brake modes of the movement there are considerable dynamic loadings in elements of the driving mechanism and in elements of the forming cart which can lead to premature getting out of installation of the working condition.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

In the existing theoretical and pilot studies of cars of roller formation of concrete goods it is proved their design data and efficiency [1-3]. At the same time not enough attention is paid to a research to the operating dynamic loadings and the modes of the movement that considerably influences work of installation and quality of finished goods [4-19]. During the constant starting and brake modes of the movement there are considerable dynamic loadings in elements of the driving mechanism and in elements of the forming cart that can lead to premature getting out of installation of the working condition [4-19]. In work [20] optimization of the dynamic mode of a reversal of roller forming installation is carried out. However in such mode acceleration and acceleration of the second order (breakthrough) of the cart are of great importance in his extreme provisions. By optimization of the breakthrough mode of a reversal of installation [21] acceleration of the cart in extreme provisions changes smoothly, however the breakthrough changes sharply and is of rather great importance. Optimization of the mode of a reversal of roller forming installation on acceleration of the third about [22, 23] leads to the fact that in extreme provisions of the cart acceleration and breakthrough change smoothly, however acceleration of the third order at the same time is of rather great importance and changes sharply from zero to the maximum value. Therefore urgent there is a problem of improvement of the driving mechanism of roller forming installation for the purpose of providing such mode of the movement of the forming cart at which dynamic loadings in elements of installation would decrease and its durability increased.

OBJECTIVE

The purpose of work consists in improvement of a design of the driving mechanism of roller forming installation for increase in her reliability and durability.

THE MAIN RESULTS OF THE RESEARCH

Coefficients of unevenness of the movement and dynamism can be criteria of the mode of the movement of mechanisms and cars [24]. In this work as criterion of the mode of the movement the criteria action which is integral on time with sub integral function which expresses a measure of the movement or action of system is used. For the optimum mode of the movement on acceleration of the fourth order we will have criterion of an optimality of the movement in a look:

$$I_Z=\int_0^{t_1} Q\,dt \to \min, \tag{1}$$

where: t – time; t_1 – duration of the movement of the cart from one extreme situation in another; Q – energy of accelerations of the fourth order:

$$Q=\frac{1}{2}\cdot m\cdot \overset{V}{x}{}^2, \tag{2}$$

where: m – mass of the forming cart; $\overset{V}{x}$ – acceleration of the fourth order.

Poisson's equation is a condition of a minimum of criterion (1):

$$\frac{\partial Q}{\partial x}-\frac{d}{dt}\frac{\partial Q}{\partial \dot{x}}+\frac{d^2}{dt^2}\frac{\partial Q}{\partial \ddot{x}}-\frac{d^3}{dt^3}\frac{\partial Q}{\partial \dddot{x}}+ \\ +\frac{d^4}{dt^4}\frac{\partial Q}{\partial \overset{IV}{x}}-\frac{d^5}{dt^5}\frac{\partial Q}{\partial \overset{V}{x}}=0, \tag{3}$$

where: x, $\dot{x}$, $\ddot{x}$, $\dddot{x}$, $\overset{IV}{x}$ – movement coordinate, speed, acceleration, acceleration of the second order and acceleration of the third order of the cart respectively.

From expression (3) it is possible to write down:

$$\frac{\partial Q}{\partial x}=\frac{\partial Q}{\partial \dot{x}}=\frac{\partial Q}{\partial \ddot{x}}=\frac{\partial Q}{\partial \dddot{x}}=\frac{\partial Q}{\partial \overset{IV}{x}}=0;$$

$$\frac{\partial Q}{\partial \overset{V}{x}}=m\cdot \overset{V}{x}; \tag{4}$$

$$\frac{d^5}{dt^5}\frac{\partial Q}{\partial \overset{V}{x}}=m\cdot \overset{X}{x}=0.$$

From the last equation (4) we receive the differential equation and its decisions:

$$\overset{X}{x}=0;\quad \overset{IX}{x}=C_1;\quad \overset{VIII}{x}=C_1\cdot t+C_2;$$

$$\overset{VII}{x}=\frac{1}{2}\cdot C_1\cdot t^2+C_2\cdot t+C_3;$$

$$\overset{VI}{x}=\frac{1}{6}\cdot C_1\cdot t^3+\frac{1}{2}\cdot C_2\cdot t^2+C_3\cdot t+C_4;$$

$$\overset{V}{x}=\frac{1}{24}\cdot C_1\cdot t^4+\frac{1}{6}\cdot C_2\cdot t^3+\frac{1}{2}\cdot C_3\cdot t^2+ \\ +C_4\cdot t+C_5;$$

$$\overset{IV}{x}=\frac{1}{120}\cdot C_1\cdot t^5+\frac{1}{24}\cdot C_2\cdot t^4+\frac{1}{6}\cdot C_3\cdot t^3+ \\ +\frac{1}{2}\cdot C_4\cdot t^2+C_5\cdot t+C_6;$$

$$\dddot{x}=\frac{1}{720}\cdot C_1\cdot t^6+\frac{1}{120}\cdot C_2\cdot t^5+\frac{1}{24}\cdot C_3\cdot t^4+ \\ +\frac{1}{6}\cdot C_4\cdot t^3+\frac{1}{2}\cdot C_5\cdot t^2+C_6\cdot t+C_7;$$

$$\ddot{x}=\frac{1}{5040}\cdot C_1\cdot t^7+\frac{1}{720}\cdot C_2\cdot t^6+\frac{1}{120}\cdot C_3\cdot t^5+ \\ +\frac{1}{24}C_4\cdot t^4+\frac{1}{6}C_5\cdot t^3+\frac{1}{2}C_6\cdot t^2+C_7 t+C_8;$$

$$\dot{x}=\frac{1}{40320}C_1\cdot t^8+\frac{1}{5040}C_2\cdot t^7+\frac{1}{720}C_3\cdot t^6+ \\ +\frac{1}{120}C_4\cdot t^5+\frac{1}{24}C_5\cdot t^4+\frac{1}{6}C_6\cdot t^3+ \\ +\frac{1}{2}\cdot C_7\cdot t^2+C_8\cdot t+C_9;$$

$$x=\frac{1}{362880}\cdot C_1\cdot t^9+\frac{1}{40320}\cdot C_2\cdot t^8+ \\ +\frac{1}{5040}\cdot C_3\cdot t^7+\frac{1}{720}\cdot C_4\cdot t^6+\frac{1}{120}\cdot C_5\cdot t^5+ \\ +\frac{1}{24}C_6\cdot t^4+\frac{1}{6}C_7\cdot t^3+\frac{1}{2}C_8\cdot t^2+C_9\cdot t+C_{10}, \tag{5}$$

where: C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8, C_9, C_{10} – integration constants which are defined from boundary conditions.

Boundary traffic conditions of the cart from one extreme situation in another the following: entry conditions

– $t=0$, $x=x_0$, $\dot{x}=0$, $\ddot{x}=0$, $\dddot{x}=0$, $\overset{IV}{x}=0$; final conditions – $t=t_1$, $x=x_1$, $\dot{x}=0$, $\ddot{x}=0$, $\dddot{x}=0$, $\overset{IV}{x}=0$. Here x_0 and x_1 – coordinates of extreme provisions of the center of mass of the cart. Having substituted boundary conditions in the equations (5), we receive:

$$t=0: \quad C_{10}=x_0; \quad \tilde{N}_9=0; \quad \tilde{N}_8=0; \quad \tilde{N}_7=0; \quad \tilde{N}_6=0; \tag{6}$$

$$t=t_1: \begin{cases} \frac{1}{362880}\cdot C_1\cdot t_1^9+\frac{1}{40320}\cdot C_2\cdot t_1^8+ \\ +\frac{1}{5040}\cdot C_3\cdot t_1^7+\frac{1}{720}\cdot C_4\cdot t_1^6+ \\ +\frac{1}{120}\cdot C_5\cdot t_1^5+x_0=x_1; \\ \frac{1}{40320}\cdot C_1\cdot t_1^8+\frac{1}{5040}\cdot C_2\cdot t_1^7+ \\ +\frac{1}{720}\cdot C_3\cdot t_1^6+\frac{1}{120}\cdot C_4\cdot t_1^5+ \\ +\frac{1}{24}\cdot C_5\cdot t_1^4=0; \\ \frac{1}{5040}\cdot C_1\cdot t_1^7+\frac{1}{720}\cdot C_2\cdot t_1^6+ \\ +\frac{1}{120}\cdot C_3\cdot t_1^5+\frac{1}{24}\cdot C_4\cdot t_1^4+ \\ +\frac{1}{6}\cdot C_5\cdot t_1^3=0; \\ \frac{1}{720}C_1\cdot t_1^6+\frac{1}{120}C_2\cdot t_1^5+\frac{1}{24}C_3\cdot t_1^4+ \\ \quad +\frac{1}{6}\cdot C_4\cdot t_1^3+\frac{1}{2}\cdot C_5\cdot t_1^2=0; \\ \frac{1}{120}\cdot C_1\cdot t_1^5+\frac{1}{24}\cdot C_2\cdot t_1^4+\frac{1}{6}\cdot C_3\cdot t_1^3+ \\ \quad +\frac{1}{2}\cdot C_4\cdot t_1^2+C_5\cdot t_1=0. \end{cases} \tag{7}$$

Having solved system of the equations (7), we receive integration constants C_1, C_2, C_3, C_4 and C_5:

$$\begin{aligned} C_1&=25401600\cdot\frac{(x_1-x_0)}{t_1^9}; \\ C_2&=-12700800\cdot\frac{(x_1-x_0)}{t_1^8}; \\ C_3&=2721600\cdot\frac{(x_1-x_0)}{t_1^7}; \\ C_4&=-302400\cdot\frac{(x_1-x_0)}{t_1^6}; \\ C_5&=15120\cdot\frac{(x_1-x_0)}{t_1^5}. \end{aligned} \tag{8}$$

We will accept amplitude of movement of the forming cart $\Delta x=x_1-x_0$. Having substituted certain constants of integration (6) and (8) in the equations (5) we receive expressions for definition of kinematic characteristics of the forming cart when moving from one extreme situation to another at the optimum mode of back and forth motion on acceleration of the fourth order:

$$\begin{aligned} x&=x_0+\Delta x\cdot\left(\begin{array}{l}70\cdot\frac{t^4}{t_1^4}-315\cdot\frac{t^3}{t_1^3}+540\cdot\frac{t^2}{t_1^2}- \\ -420\cdot\frac{t}{t_1}+126\end{array}\right)\cdot\frac{t^5}{t_1^5}; \\ \dot{x}&=630\cdot\Delta x\cdot\left(\frac{t^4}{t_1^4}-4\cdot\frac{t^3}{t_1^3}+6\cdot\frac{t^2}{t_1^2}-4\cdot\frac{t}{t_1}+1\right)\cdot\frac{t^4}{t_1^5}; \\ \ddot{x}&=2520\cdot\Delta x\cdot\left(\begin{array}{l}2\cdot\frac{t^4}{t_1^4}-7\cdot\frac{t^3}{t_1^3}+9\cdot\frac{t^2}{t_1^2}- \\ -5\cdot\frac{t}{t_1}+1\end{array}\right)\cdot\frac{t^3}{t_1^5}; \\ \dddot{x}&=2520\cdot\Delta x\cdot\left(\begin{array}{l}14\cdot\frac{t^4}{t_1^4}-42\cdot\frac{t^3}{t_1^3}+45\cdot\frac{t^2}{t_1^2}- \\ -20\cdot\frac{t}{t_1}+3\end{array}\right)\cdot\frac{t^2}{t_1^5}; \\ \overset{IV}{x}&=15120\cdot\Delta x\cdot\left(\begin{array}{l}14\cdot\frac{t^4}{t_1^4}-35\cdot\frac{t^3}{t_1^3}+30\cdot\frac{t^2}{t_1^2}- \\ -10\cdot\frac{t}{t_1}+1\end{array}\right)\cdot\frac{t}{t_1^5}; \\ \overset{V}{x}&=15120\cdot\Delta x\cdot\left(\begin{array}{l}70\cdot\frac{t^4}{t_1^4}-140\cdot\frac{t^3}{t_1^3}+90\cdot\frac{t^2}{t_1^2}- \\ -20\cdot\frac{t}{t_1}+1\end{array}\right)\cdot\frac{1}{t_1^5}. \end{aligned} \tag{9}$$

Having accepted amplitude of movement of the forming cart $\Delta x=0{,}4m$ and duration of the movement of the forming cart from one extreme situation to another $t_1=3s$, on the equations (9) kinematic characteristics of the forming cart at the optimum mode of back and forth motion on acceleration of the fourth order have been calculated. By results of calculations schedules of the optimum mode on acceleration of the fourth order of change of movement (Fig. 1, a), speeds (Fig. 1, b), accelerations (Fig. 1, c), accelerations of the second order (Fig. 1, d), accelerations of the third order (Fig. 1, e), accelerations of the fourth order are constructed (Fig. 1, f) at the movement of the forming cart of one extreme situation in another.

The law of the movement of the cart described by the equations (9) can be carried out by the drive from the high-moment step engine which is built in the rolling rollers of the forming cart of installation. At the same time the law of change of angular speed of the driving step engine is described by the equation:

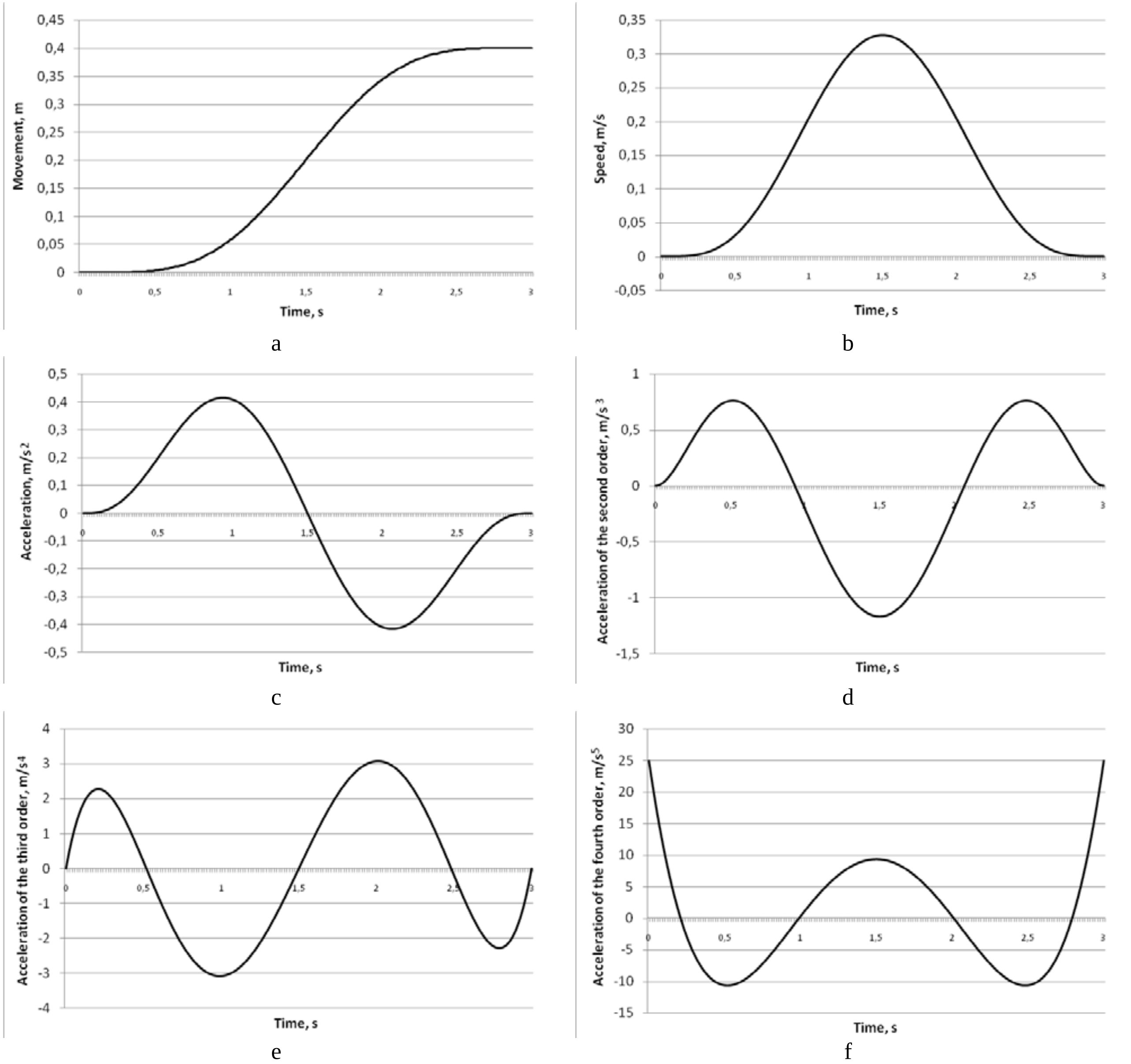

Fig. 1. Schedules of change of movement – a, speed – b, acceleration – c, accelerations of the second order – d, accelerations of the third order – e and accelerations of the fourth order – f.

at the optimum mode of the movement carts on acceleration of the fourth order

$$\dot{\varphi} = 630\frac{\Delta x}{R}\cdot\left[\frac{t^4}{t_1^4} - 4\frac{t^3}{t_1^3} + 6\frac{t^2}{t_1^2} - 4\frac{t}{t_1} + 1\right]\cdot\frac{t^4}{t_1^5}, \quad (10)$$

$$0 \le t \le t_1.$$

Similarly the law of change of angular speed of the driving step engine at the movement of the forming cart is defined in the opposite direction:

$$\dot{\varphi} = -630\frac{\Delta x}{R}\cdot\left[\begin{array}{l}\frac{(t-t_1)^4}{t_1^4} - 4\frac{(t-t_1)^3}{t_1^3} + \\ +6\cdot\frac{(t-t_1)^2}{t_1^2} - \\ -4\cdot\frac{(t-t_1)}{t_1} + 1\end{array}\right]\frac{(t-t_1)^4}{t_1^5}, \quad (11)$$

$$t_1 \le t \le 2t_1;$$

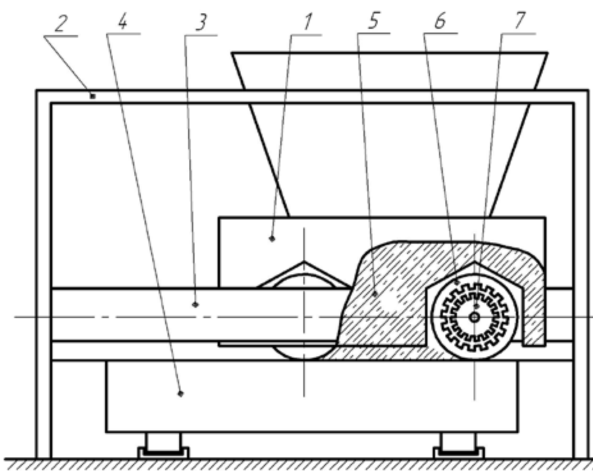

Fig. 2. Roller forming installation with the drive from the step engine.

For the purpose of reduction of dynamic loadings in elements of installation and for increase in her reliability the design of roller forming installation with the drive from the high-moment step engine for ensuring back and forth motion of the forming cart with the optimum break-through mode of a reversal (Fig. 2) is offered. Installation consists from the forming cart 1 which is mounted on the portal 2 and carries out back and forth motion in guides 3 over emptiness of a form 4. The forming cart contains the giving bunker 5 and the rolling rollers 6 on axis 7.

The cart is set in back and forth motion by means of the high-moment step engine which is built in rollers, and the axis of a roller plays a stator role, and a roller – a rotor [25].

Transforming the first expression (9) for a case when the beginning of coordinates is counted from the average provision of his movement, we will receive:

$$x=\frac{\Delta x}{2}\left[2\cdot\left(\begin{array}{l}70\cdot\frac{t^4}{t_1^4}-315\cdot\frac{t^3}{t_1^3}+\\ +540\cdot\frac{t^2}{t_1^2}-420\cdot\frac{t}{t_1}+126\end{array}\right)\cdot\frac{t^5}{t_1^5}-1\right]. \quad (12)$$

The law of the movement of the cart described by the equation (12) can be carried out by the drive with the cam mechanism (fig. 3) of back and forth motion of the cart. At the same time the movement of the cart in one direction is carried out due to turn of a cam 1 on a half of a turn (that is $\varphi=\pi$) and in the returnable direction on a half of a turn; a full motion cycle of the cart – for one turn of a cam. It is necessary for implementation of the described law of the movement of the cart that the increment of radius of a cam corresponded to an increment to movement of the cart. According to it the variable radius of a cam is defined by dependence:

$$\rho=\frac{b}{2}+\frac{\Delta x}{2}\left[2\cdot\left(\begin{array}{l}70\cdot\frac{t^4}{t_1^4}-315\cdot\frac{t^3}{t_1^3}+\\ +540\cdot\frac{t^2}{t_1^2}-420\cdot\frac{t}{t_1}+\\ +126\end{array}\right)\frac{t^5}{t_1^5}-1\right], \quad (13)$$

where: b – distance between pushers 2 (Fig. 3).

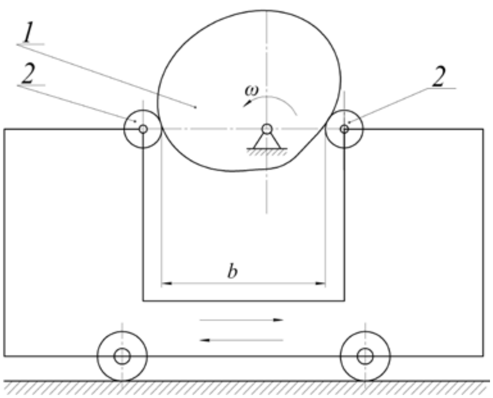

Fig. 3. The scheme of the mechanism with the cam drive of back and forth motion of the cart.

Time t can be excluded from dependence (13) as $t=\varphi/\omega$, and $t_1=\pi/\omega$. Here φ – angular coordinate of turn of a cam, and ω – angular speed of a cam. After the corresponding transformations the radius of a cam which describes his profile contacts angular coordinate the following expression:

$$\rho=\frac{b}{2}+\frac{\Delta x}{2}\cdot\left[2\cdot\left(\begin{array}{l}70\cdot\frac{\varphi^4}{\pi^4}-315\cdot\frac{\varphi^3}{\pi^3}+\\ +540\cdot\frac{\varphi^2}{\pi^2}-420\cdot\frac{\varphi}{\pi}+\\ +126\end{array}\right)\cdot\frac{\varphi^5}{\pi^5}-1\right], \quad (14)$$

$$0\le\varphi\le\pi$$

Similarly the cam profile on the site of his turn from π to 2π which is described by the radius changing on dependence is defined:

$$\rho=\frac{b}{2}-\frac{\Delta x}{2}\left[2\left(\begin{array}{l}70\frac{(\varphi-\pi)^4}{\pi^4}-\\ -315\frac{(\varphi-\pi)^3}{\pi^3}+\\ +540\frac{(\varphi-\pi)^2}{\pi^2}-\\ -420\frac{(\varphi-\pi)}{\pi}+\\ +126\end{array}\right)\frac{(\varphi-\pi)^5}{\pi^5}-1\right], \quad (15)$$

$$\pi\le\varphi\le 2\pi$$

For prevention of blows of a cam about pushers at change of the direction of the movement of the cart (14) and (15) profile of a cam (fig. 4) described by the equations have such appearance that its diameter the d constant and is equal to distance between pushers b ($d=b$) in any situation.

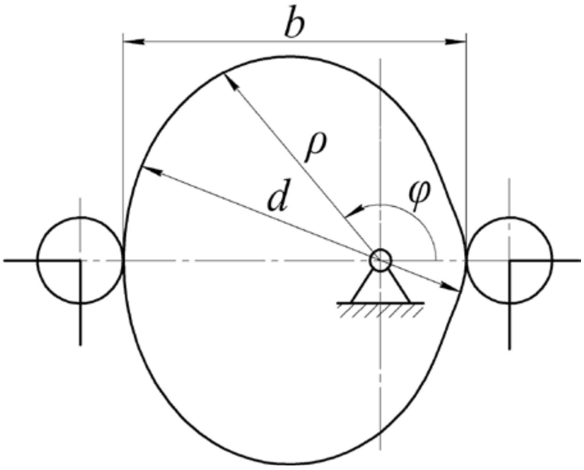

Fig. 4. The cam profile realizing the optimum mode of the movement on acceleration of the fourth order

For the purpose of reduction of dynamic loadings in elements of installation and for increase in her reliability it is offered an installation design with the driving mechanism for providing the optimum mode of back and forth motion of the forming cart on acceleration of the fourth order (Fig. 5). The driving mechanism is executed in the form of pivotally the cam mechanisms installed on the portal which contact to the pushers which are rigidly attached to the forming cart.

Installation contains 1 forming cart 2 mounted on the motionless portal which contains in itself the giving bunker 3 and the rolling rollers 4 and carries out reciprocating the movement in guides 5 over emptiness of a form 6 [26]. The cart is set in motion by means of two drives 7 attached to the portal 1 in the form of the cam mechanisms rotating with a constant angular speed ($\omega = const$), but different in the direction and contact to two pushers 8 which are rigidly connected to a cart 2 frame. Existence of two pushers 8 from each party of the forming cart 2 allows to create a rigid power chain at her direct and returnable movement.

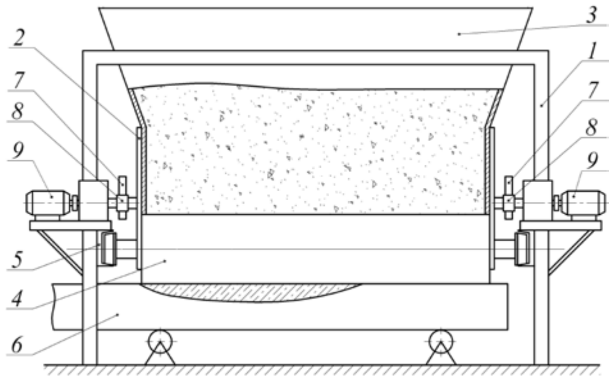

Fig. 5. Roller forming installation with the cam driving mechanism.

When using in installation of the drive from the high-moment step engine which is built in the rolling rollers which law of change of angular speed is described by the equations given above quality of the processed concrete mix increases, dynamic loadings in drive elements decrease, excess destructive loads of a frame design decrease and, respectively, durability of installation in general increases.

When using in installation of the cam driving mechanism from each party of the forming cart the possibility of her axial distortion is prevented, the quality of the processed concrete mix increases, dynamic loadings in drive elements decrease, excess destructive loads of a frame design decrease and, respectively, the durability of installation in general increases.

CONCLUSIONS

1. As result of conducted researches for purpose of increase in reliability and durability of roller forming installation optimum mode of back and forth motion of the forming cart on acceleration of fourth order is calculated.
2. Kinematic characteristics of the forming cart at the optimum mode of back and forth motion on acceleration of the fourth order are calculated.
3. The design of roller forming installation with the drive from the high-moment step engine which is built in the rolling rollers of the forming cart with a possibility of realization of the optimum mode of back and forth motion on acceleration of the fourth order is offered.
4. The design of the drive of installation in a type of the cam mechanism is offered and the cam profile for providing the optimum mode of back and forth motion of the forming cart on acceleration of the fourth order is constructed.
5. Results of work can be used further for specification and improvement of the existing engineering methods of calculation of driving mechanisms of cars of roller formation both at design/designing stages, and in the modes of real operation. Also results of work can be useful at design or improvement of mechanisms with back and forth motion of executive elements.

REFERENCES

1. **Garnec V. M. 1991.** The progressive the forming units and complexes of concrete. Kyiv, Budivelnyk, 1991, 144.

2. **Kuzin V. N. 1981.** Technology of roller formation of flat articles from fine-grained concrete: The abstract of the thesis for a degree of the candidate of science, Moscow, 1981, 20.

3. **Rjushin V. T. 1986.** Research of working process and development of a method of calculation of cars of roller formation of concrete mixes. The thesis for a degree of Candidate of Technical Sciences, Kyiv, 1986, 186.

4. **Loveykin V. S., Garnec V. M., Pochka K. I. 2004.** Patent of Ukraine for an invention № 67091A. Installation for formation of products from concrete mixes, № u2003076371 it is stated 08.07.2003; it is published 15.06.2004, Bulletin №6.

5. **Loveykin V. S., Pochka K. I. 2004.** The dynamic analysis of roller forming installation with the rekuperativ drive. Dynamics, durability and reliability of farm vehicles: *Works of the First International scientific and technical conference (DSR AM-I)*, on October 4-7, 2004, Ternopil (Ukraine), 507-514.

6. **Loveykin V. S., Pochka K. I., 2003.** The power analysis of roller forming installation with the rekuperativ drive. *Scientific and technical magazine «Technology of construction»*, Kyiv, 2003, No 14, 27-37.

7. **Loveykin V. S., Pochka K. I. 2005.** The analysis of unevenness of the movement of roller forming installation with the rekuperative drive. *Scientific and technical and production magazine «Hoisting-and-transport equipment»*, 2005, No 4, 19-33.

8. **Loveykin V. S., Pochka K. I., Palamarchuk D. A. 2004.** Optimization of design data of the driving mechanism of roller forming installation with the rekuperative drive. *Scientific and technical magazine «Technology of construction»*, Kyiv, 2004, No 15, 40-48.

9. **Pochka K. I. 2008.** Development and the analysis of roller forming installation with the rekuperativ drive. The abstract of the thesis for a degree of Candidate of Technical Sciences, Kyiv, KNUCA, 2008, 24.

10. **Loveykin V. S., Kovbasa V. P., Pochka K. I. 2010.** The dynamic analysis of roller forming installation

with energetically balanced drive. *Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APC*, Kyiv, 2010, No 144, part 5, 338-344.

11. **Loveykin V. S., Kovbasa V. P., Pochka K. I. 2011.** The power analysis of roller forming installation with energetically balanced drive. *Scientific bulletin of the Tavriysky State Agro Technological University*, Melitopol, 2011, No 1, Tom 2, 16-23.

12. **Loveykin V. S., Pochka K. I. 2010.** The analysis of unevenness of the movement of roller forming installation with energetically balanced drive. V*ibrations in the equipment and technologies*, 2010, No 4 (60), 20-29.

13. **Loveykin V. S., Pochka K. I. 2010.** Optimization of design data of roller forming installation with energetically balanced drive. *MOTROL*. Motorization and power industry in agriculture, Lublin, 2010, Tom 12 B, 9-18.

14. **Loveykin V. S., Pochka K. I. 2004.** The analysis of the movement of roller forming installation with the balanced drive. *Bulletin of the Kharkiv national automobile and road university*, 2004, No 27, 95-101.

15. **Loveykin V. S., Pochka K. I. 2005.** The power analysis of roller forming installation with the balanced drive. S*cientific bulletin of National agricultural university*, 2005, No 80, 346-356.

16. **Loveykin V. S. 1989.** Assessment of the movement of mechanisms and cars. *Hoisting-and-transport equipment*, Kyiv, Tehnika, 16-18 (in Russian).

17. **Lovejkin V. S., Shumilov G. V. 2011.** Optimization of the mode of change of a departure of the tower crane behind single kinematic criteria. *MOTROL*. Motorization and power industry in agriculture, Lublin, 2011, Tom 13 B, 167-174.

18. **Loveykin V. S., Pochka K. I. 2015.** The analysis of unevenness of the movement of roller forming installation with the balanced drive. *MOTROL*. Commission of Motorization and Energetics in Agriculture, Lublin-Rzeszow, 2015, Vol. 17, No 3, 17-27.

19. **Loveykin V. S., Pochka K. I. 2016.** Analysis of dynamic equilibration by the drive of cars of roller formation. *MOTROL*. Commission of Motorization and Energetics in Agriculture, Lublin-Rzeszow, 2016, Vol. 18, No 3, 41-52.

20. **Loveykin V. S., Pochka K. I. 2015.** Dynamic optimization of the mode of reversal of roller forming installation. *Collection of scientific tinders «Mechanical engineering»*, Harkiv, Ukrainian engineering and pedagogical academy, 2015, No 15, 76-86.

21. **Loveykin V. S., Pochka K. I. 2015.** Optimization of the breakthrough mode of reversal of roller forming installation. *Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK*, Kyiv, 2015, No 212, part 1, 186-197.

22. **Loveykin V. S., Pochka K. I. 2015.** Optimization of the mode of reversal of roller forming installation on acceleration of the third order. *Bulletin of the Donbass state machine-building academy*: collection of scientific works, Kramatorsk, 2015, No 3 (36), 16-26.

23. **Loveykin V. S., Pochka K. I. 2017.** Synthesis of camshaft driving mechanism in roller molding installation with combined motion mode according to acceleration of third order. Science & Technique, Minsk, BNTU, 2017, No 16(3), 206-214. DOI:10.21122/2227-1031-2017-16-3-206-214.

24. **Loveykin V. S. 1990.** Calculations of the optimum modes of the movement of mechanisms and cars. Manual, Kyiv, UMK VO, 168.

25. **Lovejkin V. S., Pochka K. I., Chovnjuk Ju. V., Dikteruk M. G. 2014.** Patent of Ukraine for an invention № 105744. Installation for formation of products from concrete mixes. № a201309305 it is stated 25.07.2013; it is published 10.06.2014, Bulletin № 11.

РЕАЛИЗАЦИЯ ОПТИМАЛЬНОГО РЕЖИМА ПЕРЕДВИЖЕНИЯ РОЛИКОВОЙ ФОРМОВОЧНОЙ УСТАНОВКИ НА УСКОРЕНИЕ ЧЕТВЕРТОГО ПОРЯДКА

Аннотация. В целях увеличения надежности и долговечности ролика формируя установки оптимального режима движения вперед и назад в формующей тележки на разгон четвертого порядка рассчитывается. Кинематические характеристики формируя корзину при оптимальном режиме движения на ускорение четвертого порядка рассчитываются. Дизайн роликовые формовочные установки с приводом от высокого момента шагового двигателя, который построен на прокатных роликов, образующих тележку и обеспечивает оптимальный режим движения вперед и назад формующей тележки на разгон четвертого порядка. Использование в установке указанного приводного механизма приводит к улучшению качества поверхности обрабатываемой бетонной смеси, снижение динамических нагрузок в элементах приводного механизма, к исчезновению лишнего разрушительных нагрузок конструкция рамы и, соответственно, увеличить надежность и долговечность установки в целом. В результате проведенных исследований в целях увеличения надежности и долговечности роликовые формовочные установки оптимального режима движения вперед и назад в формующей тележки на разгон четвертого порядка рассчитывается.

Кинематические характеристики формируя корзину в оптимальный режим движения вперед и назад на ускорение четвертого порядка рассчитываются.

Дизайн роликовые формовочные установки с приводом от высокого момента шагового двигателя, который построен на прокатных роликов, образующих тележку с возможностью реализации оптимального режима движения вперед и назад на ускорение четвертого порядка предлагается.

Проектирование привода установки в виде кулачкового механизма и профиля кулачка для обеспечения оптимального режима движения вперед и назад при формировании корзины на ускорение четвертого порядка строится.

Результаты работы в дальнейшем могут быть использованы для уточнения и совершенствования существующих инженерных методов расчета привода механизмов машин формирования ролика как на дизайн/этапах проектирования, и в режимах реальной эксплуатации. Также результаты работы могут быть полезны при проектировании или усовершенствовании механизмов с возвратно-поступательное движение исполнительных элементов.

Ключевые слова: роликовые формовочные установки, режим движения, шаг двигателя, привод.

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Study of Process of Cooking High-Energy Feed Mixtures for Cattle

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Summary. Livestock production is largely dependent on the quality of nutrition, ie the quantitative and qualitative composition of feed ingredients, including feed mixtures prepared.

Scientifically proven and practically confirmed that feeds play a key role in the cost of milk as well as its quantity.

Today, the family farms and livestock enterprises where cattle is more than 100 head of dairy cattle, feed mixtures with a high percentage of homogeneity and mixing according to the recipe feed ration is prepared via mobile feed mixtures combined units.

To this end, the industry produces a wide dimensional number of machines with different capacity hopper.

Machines of this type simultaneously performing manufacturing operations dosage, grinding, mixing feed components and after making the feed mixture - transport and distribute the mixture animals.

For the process of mixing in the combined feed mixtures units use screw working bodies, the coils are set long-knives for grinding materials.

Studies have shown that high levels of mixing feed components provided on condition continued their movement cont 6-8 minutes.

One of the conditions concerning the quality of cooking feed mixture is providing value nadhvyntovoho space hopper unit.

Theoretical and practical studies using combined harvester in the preparation of the feed mixture showed that high-energy feed mixtures space depends on the speed of the feeder, hopper parameters and physical and mechanical properties of the feed material.

Key words: technological scheme, process of cooking, feed mixtures.

INTRODUCTION

At all stages of the development of agriculture, especially cattle breeding, feed production issue remained one of the urgent tasks. Feeding allows full sumishkamy [8, 9, 10, 11] to raise the daily milk yield of cows by 15-20%, 3% reduced costs for transport and 5-7% increased digestion of animal feed.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

As family farms and livestock feed business mix, according to the prescription diet [12, 13, 14] and with a high percentage of homogeneity of mixing, prepared via mobile combined unit. The industry produces a wide dimensional number machines with different capacity hopper, and subsequently the working bodies. Interaction of feed materials with different physical and mechanical properties of the working bodies of the unit leads to individual approach in the design and calculation of each dimension-type series of machines for livestock.

The issue of development combined kormopryhotuvalnyh units used in the preparation of high-energy feed mixtures that reduce the cost of livestock production and improve its quality, is a pressing issue today.

The main thesis studies all cooking feed mixture is the assertion that mixing occurs over time t, in active cooperation with the feed components work by car. Not optimized size of the hopper, auger and speed of work, requiring time-consuming to prepare high-quality feed mixes at full bunker and break the structure of feed components. Some scientists consider the process of mixing and movement of the feed mixture based on rheological model of Newtonian and non-Newtonian fluid so.

Study authors [7], most accurately describe the processes taking place in kormopryhotuvalnyh machines, and indicate how to avoid harmful effects on the quality of work feed mixture.

OBJECTIVE

The purpose of research - support the design parameters combined unit, which is used for making high-energy feed mixtures.

THE MAIN RESULTS OF THE RESEARCH

Cooking with feed combined mobile unit (ICCP) perform a certain sequence of operations. Hypothesis mixing feed components in the ICCP is that component of feed rations in turn loaded into a hopper mixer volume V, where the first component of its physical and mechanical properties (ubeat V0, mass m0) followed by mixed to form a homogeneous component that receives two distinct components properties and is regarded as mixing with further new component, which incorporates next.

This approach makes it possible to assert that the feed mixture preparation in a bunker MKPA considered as a process of preparing a two-component mixture Fig. 1.

As a result of mixing proportion of feed components should be evenly distributed throughout the space V mixer.

The process of mixing a transitional state, characterized by a density of each feed component to the state feed concentration component in the mixture (bunker) $\frac{m_0}{V_0}\frac{m_0}{V}$.

Mixing feed components is through screw, which provides food movement in the vertical and horizontal directions. To feed moving vertically, after climbing the last of the screw and evenly distributed horizontally, you need to boost provided by the feed screw is created, zatuhav at the upper edge of the bunker.

If incorrect ratio parameters when too ICCP High bunker and small screwwhen mixed feed can not climb to the edge of the bunker, resulting in the upper appears "dead zone" in which mixing takes place very slowly, with high content feed. In this case significantly reduced the homogeneity of the feed mixture. When handing out different animals are different in composition, unbalanced mixture reduces the overall performance of the herd. Where there is a high auger for feed ingredients rash over the edge of the bunker, leading to increased costs of animal feed.

To address these shortcomings, movement of the mixture in the hopper ICCP as slow axially symmetric flow viscoplastic fluid in a pipe whose radius r varies periodically along the tube, slightly deviating from some average value r_0. In order to simplify the problem (but still including all the features of rheological models Shvedova-Binhama) introduce the concept of false dynamic viscosity (Forage mixture).

In the bunker ICCP fluid flow velocity distribution Shvedova-Binhama the radius r is:

$$\begin{cases} W = \frac{\Delta p}{4l\cdot\mu_{пл}}\cdot(R^2-r^2) - \frac{\tau_0}{\mu_{пл}}\cdot(R-r), \\ \qquad r_я \le r \le r_0 = R; \\ W = W_я = const = \frac{\Delta p}{4l\cdot\mu_{пл}}\cdot(R-r_я)^2, \\ \qquad 0 \le r \le r_{я,} \end{cases} \tag{1}$$

where: p - pressure drop in the pipe, Pa - length pipe m - radius of the nucleus ("cork") in the pipe, m.$\Delta l r_я$.

Present (1) in another form[1, 2, 3]:

$$\begin{cases} W = \frac{\Delta p\cdot R^2}{4l\cdot\mu_{пл}}\cdot\left(1-\frac{r^2}{R^2}\right) - \frac{\tau_0}{\mu_{пл}}\cdot(R-r), \\ \qquad r_я \le r \le r_0 = R; \\ W_я = \frac{\Delta p\cdot R^2}{4l\cdot\mu_{пл}}\cdot\left(1-\frac{r_я}{R}\right)^2, \\ \qquad 0 \le r \le r_я. \end{cases} \tag{2}$$

We introduce the notation U_{max}= - $U\frac{\Delta p\cdot R^2}{4l\cdot\mu_{пл}}$ maximum velocity of fluid flow (in the pipe axis) in flow (viscous fluid in a cylindrical tube with constant cross sections) newtonian fluid.

Then we get:

$$\begin{cases} W = U\cdot\left(1-\frac{r^2}{R^2}\right) - \frac{\tau_0}{\mu_{пл}}\cdot(R-r), \\ \qquad r_я \le r \le r_0 = R; \\ W = U\cdot\left(1-\frac{r_я}{R}\right)^2, \\ \qquad 0 \le r \le r_я. \end{cases} \tag{3}$$

The value found from the condition:$r_я$

$$W/_r = r_я + 0. \qquad W/_r = r_я - 0. \tag{4}$$

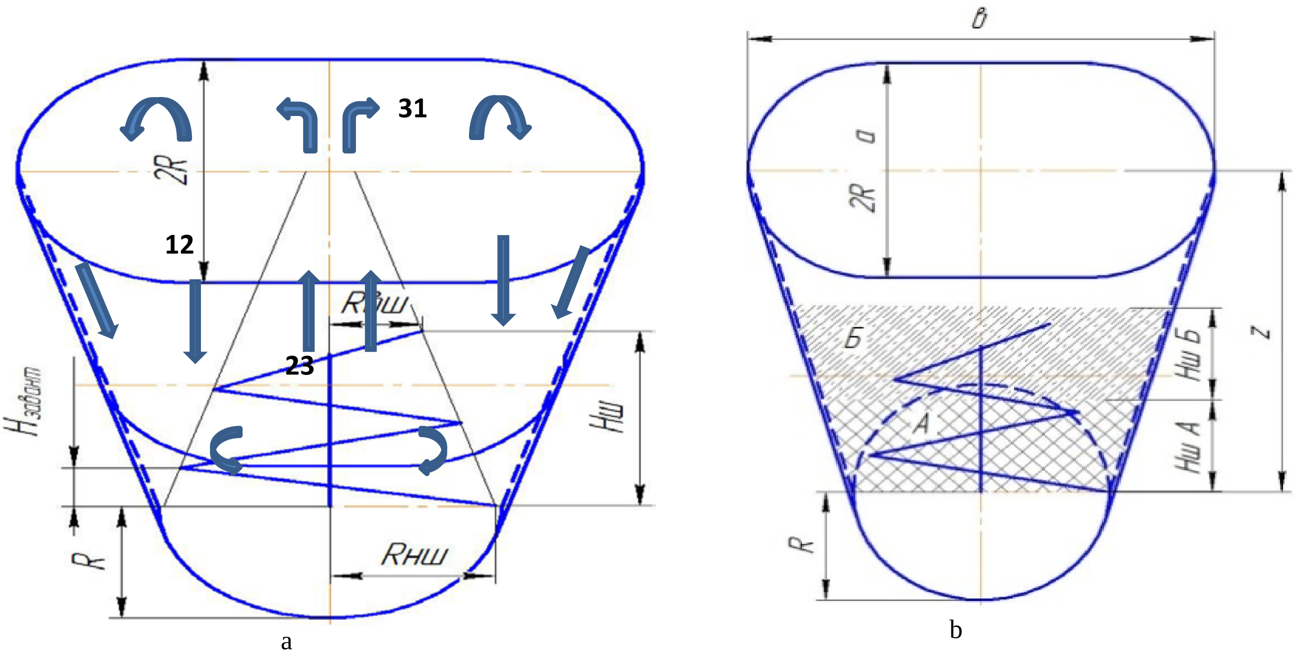

Fig. 1. Bunker mixer-distributors: a - scheme of circulation flow in the mixer-feed distributor, - a mixing layers.

After completing the transformation and solution in the final version, we get

$$\left(\frac{dw}{dr}\right)_S = \frac{4U}{3}\cdot\left[\frac{{\tau_0}^3\cdot R^2}{8\cdot {\mu_{пл}}^3\cdot U^3}-\frac{1}{R}\right]+\frac{\tau_0}{\mu_{пл}}\cdot\left[1-\frac{{\tau_0}^2\cdot R^2}{4\,{\mu_{пл}}^2\cdot U^2}\right], \qquad (5)$$

where: S - cross-section of the pipe.

Present (5) in a more compact form:

$$\left(\frac{dw}{dr}\right)_S = \frac{4U}{3R}\cdot\left[\frac{{\tau_0}^3\cdot R^3}{8{\mu_{пл}}^3\cdot U^3}-1\right]+\frac{\tau_0}{\mu_{пл}}\cdot\left[1-\frac{{\tau_0}^2\cdot R^2}{4\,{\mu_{пл}}^2\cdot U^2}\right]. \quad (6)$$

Substituting this particular expression (5) in the formula false dynamic viscosity Shvedova-Binhama then obtain:

$$\mu_{удав} = \mu_{пл} + \tau_0\cdot\left\{\left(\frac{dw}{dr}\right)_S\right\}^{-1}$$

$$\mu_{удав} = \mu_{пл} + \tau_0\cdot\left\{\frac{4U}{3R}\cdot\left[\frac{{\tau_0}^3\cdot R^3}{8{\mu_{пл}}^3\cdot U^3}-1\right]+\frac{\tau_0}{\mu_{пл}}\cdot\left[1-\frac{{\tau_0}^2\cdot R^2}{4\,{\mu_{пл}}^2\cdot U^2}\right]\right\}^{-1}. \quad (7)$$

Confine the pipe radius change the law:

r = δ, (8)$r_0 + \delta\cdot\sin(\alpha\ z),\ << r_0$

where: z - coordinate along the axis of the tube - constant parameters defined below, δ - the largest pipe radius deviation from the mean ()αr_0.

In operation, the screw creates a vibration frequency,

$$\omega = 2\pi\cdot f\ sec^{-1}.$$

where: $f -$ linear frequency vibrations Hz.

We apply the principles of physics and mathematical equations [4, 6] Navye-Stokes equations for viscous fluid (its course) with a - with a dynamic viscosity $\mu_{удав}$:

$$\mu \equiv \mu_{удав}. \qquad (9)$$

For viscous fluid flow occurring ratio:

$$\begin{cases} \varsigma_r = -p + 2\mu\cdot\frac{\partial u_r}{\partial r}, \\ \tau_{rz} = \mu\left(\frac{\partial u_r}{\partial z}+\frac{\partial u_z}{\partial r}\right), \\ \varsigma_z = -p + 2\mu\cdot\frac{\partial u_z}{\partial z}, \\ \tau_{r\theta} = 0, \\ \varsigma_\theta = -p + 2\mu\frac{Ur}{r}, \\ \tau_{z\theta} = 0, \end{cases} \qquad (10)$$

where: ς - stress tensor components in cylindrical coordinates (r, Θ, Z); p - pressure; and $\varsigma_r,\ \varsigma_z,\ \varsigma_\theta,\ \tau_{rz},\ \tau_{r\theta},\ \tau_{z\theta} U_r U_z$ - components of particle velocity fluid.

Considering fluid motion Forage mixture slow, do not take into account the inertial terms in the equations of motion, then:

$$\left\{\frac{\partial\varsigma_r}{\partial r}+\frac{\partial\tau_{rz}}{\partial z}+\frac{(\varsigma_r-\varsigma_\theta)}{r}=0,\quad \frac{\partial\tau_{rz}}{\partial r}+\frac{\partial\varsigma_z}{\partial z}+\frac{\tau_{rz}}{r}=0. \right. \quad (11)$$

We believe the massive power available (or rather, do not take them into account).

Substituting equation expression component of the stress tensor, we get:

$$\begin{cases} -\frac{\partial p}{\partial r}+2\mu\cdot\frac{\partial^2 U_r}{\partial r^2}+\mu\cdot\left(\frac{\partial^2 U_r}{\partial z^2}+\frac{\partial^2 U_z}{\partial r\partial z}\right)+ \\ +2\mu\cdot\left(\frac{1}{r}\cdot\frac{\partial U_r}{\partial r}-\frac{U_r}{r^2}\right)=0, \\ -\frac{\partial p}{\partial z}+2\mu\cdot\frac{\partial^2 U_z}{\partial z^2}+\mu\cdot\left(\frac{\partial^2 U_z}{\partial r^2}+\frac{\partial^2 U_r}{\partial r\partial z}\right)+ \\ +\mu\cdot\frac{1}{r}\cdot\left(\frac{\partial U_r}{\partial z}-\frac{\partial U_z}{\partial r}\right)=0. \end{cases} \qquad (12)$$

Add to the system (12) the continuity equation:

$$\frac{\partial U_r}{\partial r}+\frac{U_r}{r}\frac{\partial U_z}{\partial z}=0. \qquad (13)$$

Get the system of three equations with three unknown functions (p, , $U_r U_z$).

We take as a basis the continuity equation:

$$U_r = -\frac{1}{r}\cdot\frac{\partial\chi}{\partial z}, \qquad (14)$$
$$U_z = \frac{1}{r}\cdot\frac{\partial\chi}{\partial r}$$

where: χ (r, z) - a new unknown function.

After that, the first two equations (12), given to the following:

$$\begin{cases} \frac{1}{2\mu}\cdot\frac{\partial p}{\partial r} = -\frac{1}{2r}\cdot\left(\frac{\partial^3 x}{\partial z^3}+\frac{\partial^3 x}{\partial r^2\partial z}-\frac{1}{z}\cdot\frac{\partial^2 x}{\partial r\partial z}\right), \\ \frac{1}{2\mu}\cdot\frac{\partial p}{\partial z} = \frac{1}{2r}\cdot\left(\frac{\partial^3 x}{\partial r^3}+\frac{\partial^3 x}{\partial z^2\partial r}-\frac{1}{r}\cdot\frac{\partial^2 x}{\partial r^2}+\frac{1}{r^2}\cdot\frac{\partial x}{\partial r}\right). \end{cases} \qquad (15)$$

Excluding them, the function, we arrive at an equation:

$$\frac{\partial^4 x}{\partial r^4}-\frac{2}{r}\cdot\frac{\partial^3 x}{\partial r^3}+\cdot\frac{3}{r^2}\frac{\partial^2 x}{\partial r^2}-\frac{3}{r^3}\cdot\frac{\partial x}{\partial r}+2\cdot\left(\frac{\partial^4 x}{\partial r^2\partial z^2}-\frac{1}{r}\cdot\frac{\partial^3 x}{\partial z^2\partial r}\right)+\frac{\partial^4 x}{\partial z^4}=0, \quad (16)$$

which is one unknown function χ = χ (r, Z).

Based on the features of the problem, seek the solution (16) in the form of:

$$x = R_0(r)+\varphi(ar)\cdot\sin(az). \qquad (17)$$

where the function that determines the motion of a viscous fluid in a tube of constant radius cut (mainstream Forage mixture), and the second component allows correction in speeds the transition to the pipe cut variable (disturbance flow Forage mixture) $R_0(r) r_0 = R$.

To get the function equation $R_0(r)$:

$$R_0^{(IV)}-\frac{2}{r}\cdot R_0^{(III)}+\frac{3}{r^2}\cdot R_0^{(II)}-\frac{3}{r^3}\cdot(18) R_0^{(I)}=0$$

Total integral (18) is:

$$R_0 = A_0\cdot r^4+B_0\cdot r^2+C_0\cdot r^2\cdot lur++D_0. \qquad (19)$$

Speed defined this function expressed by the formula:

$$\begin{cases} U_r^0 = -\frac{1}{r}\cdot\frac{\partial R_0}{\partial z}=0, \\ U_z^0 = -\frac{1}{r}\cdot\frac{\partial R_0}{\partial z}=4A_0 r^2+2B_0+2C_0\cdot lnr+C_0. \end{cases} \qquad (20)$$

Since the speed on the axis of the tube r = 0 is limited, you need to take constant zero. The main flow Forage mixture at r = rate of feed mixture becomes zero.$C_0 r_0$

Under boundary conditions of viscous fluid motion, both components must be reduced to zero at the pipe wall, ie at$r = r_0+\delta\cdot\sin(az)$.

Bearing in mind the low speed main flow and neglecting small quantities much higher first arrive at the following boundary conditions of the problem:

$$0 = -\frac{2\cdot U\cdot\delta}{r_0}+\frac{a}{r_0}\cdot[\bar{A}\cdot\overline{U'}+\bar{C}\cdot(2\overline{U'}+\bar{x}\bar{U})], \qquad (21)$$
$$0 = \bar{A}\cdot\bar{U}+\bar{C}\cdot\bar{x}\cdot\overline{U'},\ \ \bar{x}=ar_0,\ \ \bar{U}(\bar{x})=\bar{U}(ar_0),$$
$$\overline{U'}(\bar{x})=\overline{U'}(ar_0).$$

Since the system (21) we get:

$$\bar{A} = \frac{2\bar{x}\cdot\overline{U'}\cdot U\cdot\delta}{a\cdot\left(2\bar{U}\cdot\overline{U'}+\bar{x}\cdot\overline{U^2}-\bar{x}\cdot\left(\overline{U'}\right)^2\right)},\ \bar{C} = \frac{2\overline{U'}\cdot U\cdot\delta}{a\cdot\left(2\bar{U}\cdot\overline{U'}+\bar{x}\cdot\overline{U^2}-\bar{x}\cdot\left(\overline{U'}\right)^2\right)}. \quad (22)$$

That is some constant. Denominator expressions in (22) is a significantly positive value. Indeed, if we use the above equation for the function, you can get $\bar{A}\bar{C}\bar{A}\bar{C}U$ [3]:

$$\frac{d}{dx}\left\{\frac{2U\cdot U'+x\cdot U^2-x\cdot(U')^2}{x}\right\}=2\cdot\frac{U^2}{x}, \qquad (23)$$

where

$$\frac{2U\cdot U'+x\cdot U^2-x\cdot(U')^2}{x}=2\cdot\int_0^x\frac{U^2}{x}\,dx+const. \qquad (24)$$

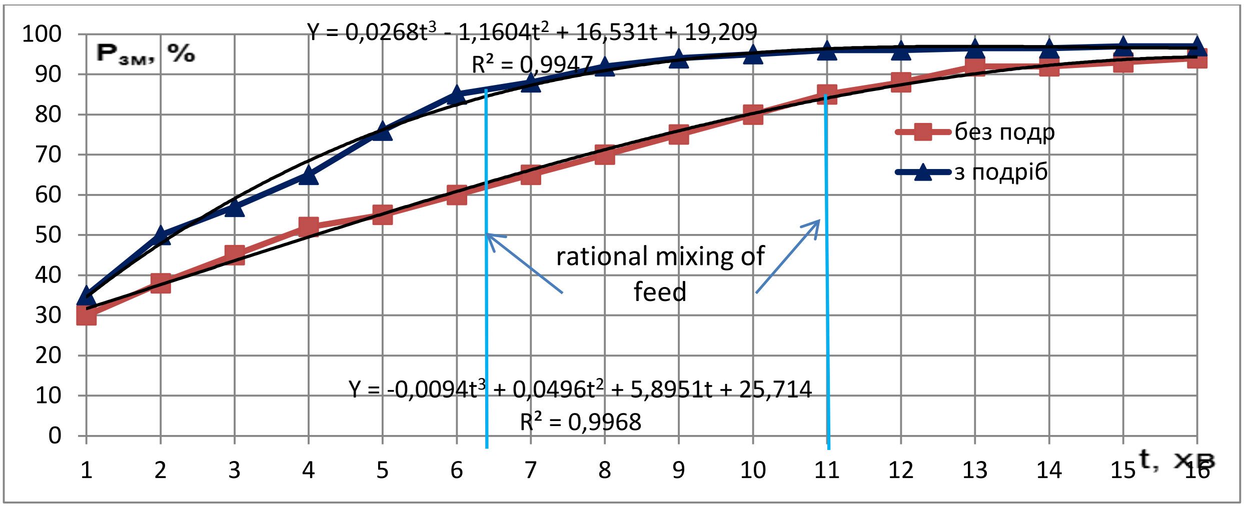

Fig. 2. Uniformity of mixing feed mixture depending on time and condition of feed with optimum parameters bunker

Permanent, located on the right side (24), equal to (12) to zero, as the expansion functions in steps of x begins with members of the second degree and, therefore, the left side of the equation becomes zero at x = 0. $U = -ixI_1(ix)$.

The function is positive when x> 0, respectively, integral, located on the right side of equation (24), also positive, because:$-i \cdot I_1(ix)$

$$2U \cdot U' + x \cdot U^2 - x \cdot (U')^2 > 0.$$

Note that a known ratio under the theory of Bessel functions [5]:

$$\int_0^x \frac{U^2}{x}\, dx = -\int_0^x x \cdot I_1^2(ix)dx = -\frac{x^2}{2} \cdot [I_1^2(ix) - -I_0(ix) \cdot I_2(ix)], \qquad (25)$$

$$U'(x) = \frac{d}{dx}[-ix \cdot I_1(ix)] = -i \cdot I_1(ix) + +x \cdot I_1{}'(ix) = x \cdot I_0(ix), \qquad (26)$$

where: $I_0(ix), I_2(ix)$ - Bessel functions of zero and second order of imaginary argument, respectively.

Consequently, (25) and (26), and constants can be calculated using tables Bessel functions of an imaginary argument $\bar{A}\bar{C}$ [5].

CONCLUSIONS

1. In the mixer portion with alternate loading feed ingredients should be considered process of making a multi-feed mixture, a two-component, which includes (a homogeneous mixture prior feeding components and subsequent component).

2. The effectiveness of the process of mixing feed components into a bunker ICCP is only possible with the right determination of the height of the wall and the hopper screw. If the wrong proportions options – too high bunker and small screwwhen mixed feed can not climb to the edge of the bunker and appears in the upper "dead zone" in this case significantly reduced the homogeneity of the feed mixture. Where there is a high auger for feed ingredients rash over the edge of the bunker, leading to increased cost of food.

3. To clarify the parameters, the ICCP movement of feed mixtures for the bunker Shvedova-rheological modeled Binhama which provides there are two components of movement of the feed mixture and one of them (for) depends on the parameters of vibration (rotational speed of the screw) allows to assert that vibration leads to an intensification of the movement of feed mixes and ingredients in most blends, there is an intensification of diffusion of components in both the longitudinal as well and in the transverse direction to the axis of the bunker. The results of numerical determination of height N_{sum} feed mixture $U_z\, U_r U_z$ over auger is 0.4-0.6 m.

REFERENCES

1. **Ishlinskii A. Yu. 1943.** On stability of viscoplastic flow of a strip and a round log. Applied mathematics and mechanics. Vol. 7. T. 2. 109-130.

2. **Ishlinskii A. Yu. 1943.** On stability of viscoplastic flow of round plates. Applied mathematics and mechanics. 1943. Vol. 7. T. 6. 405-412.

3. **Ishlinskii A. Yu. 1944.** The problem of slow viscous flow in a circular pipe of variable cross section. Applied mathematics and mechanics. Vol. 8. T. 5. 395-400.

4. **Romankov P. G. 1982.** Hydro-mechanical processes of chemical technology. Moscow. Chemistry. 288.

5. **Kuzmin, G. A. 1933.** Bessel functions. Moscow. Gostekhteorizdat. 152.

6. **Landau, L. D. 1965.** Theoretical physics. Volume VII. The theory of elasticity. Moscow. Science. 204.

7. **Aubin J., Naude I., Xuereb C. and Bertrand J., 2000.** Blending of Newtonian and Shear Thinning Fluids in a Tank Stirred with a Helical Screw Agitator', ChERD Trans IChemE, 78, A8, 1105-1114.

8. Modern means for the preparation and distribution of feed. http://www.propozitsiya.com.

9. **Podobed L. I. 2018.** To much milk is necessary to feed well. Electronic resource. http://podobed.org.

10. **Mackevich V. M. 2014.** Justification of the technological scheme of production of feed in farms. *Bulletin of Kharkov national technical University of*

agriculture named Peter Vasilenko. Kharkov. Vol. 144. 123-127.

11. **Egorov B. V. 2007.** Production technology of premixes. Kiev. Centre of educational literature. 288.
12. **Osaka N. I. 2011.** Technology of vegetable oils: a textbook. Kiev. Worth. 280.
13. **Sorokin V. M., 2013.** The analysis of the functional schemes of mixed fodder production in farms and perspective directions of their improvement. *Bulletin of Lviv National Agrarian University. Agroengineer studies*, No 12, vol. 1. 228-234.
14. **Sorokin V. M., 2012.** The choice of the parametric characteristics of the mixers feed additives in animal breeding farm. *Scientific Bulletin of national University of life and environmental Sciences of Ukraine. Series: electronics and energetics, agriculture*. Kiev. Vol. 144. part 2. 181 to 188.
15. **Rogovskii Ivan. 2014.** Stochastic models ensure the efficiency of agricultural machines. *MOTROL*. Lublin. 2014. Vol. 16. No 3. 296-302.
16. **Rogovskii Ivan. 2016.** Graph-modeling when the response and recovery of agricultural machinery. *MOTROL*. Lublin. Vol. 18. No 3. 155-164.
17. **Rogovskii Ivan. 2017.** Analytical provision of regular preventive maintenance of agricultural machinery and system implementation. *MOTROL*. Lublin. Vol. 19. No 3. P. 185-191.
18. **Rogovskii Ivan. 2017.** Choice of model class and method of modeling the resilience of agricultural machinery. *TEKA*. Lublin–Rzeszów. 2017. Vol. 17. No 3. 101-114.
19. **Loveykin V. S., Kovbasa V. P., Pochka K. I. 2010.** The dynamic analysis of roller forming installation with energetically balanced drive. *Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APC*, Kyiv, 2010, No 144, part 5, 338-344.
20. **Loveykin V. S., Pochka K. I. 2010.** Optimization of design data of roller forming installation with energetically balanced drive. *MOTROL*. Motorization and power industry in agriculture, Lublin, 2010, Tom 12 B, 9-18.
21. **Lovejkin V. S., Shumilov G. V. 2011.** Optimization of the mode of change of a departure of the tower crane behind single kinematic criteria. *MOTROL*. Motorization and power industry in agriculture, Lublin, 2011, Tom 13 B, 167-174.
22. **Loveykin V. S., Pochka K. I. 2015.** The analysis of unevenness of the movement of roller forming installation with the balanced drive. *MOTROL*. Commission of Motorization and Energetics in Agriculture, Lublin-Rzeszow, 2015, Vol. 17, No 3, 17-27.
23. **Loveykin V. S., Pochka K. I. 2016.** Analysis of dynamic equilibration by the drive of cars of roller formation. *MOTROL*. Commission of Motorization and Energetics in Agriculture, Lublin-Rzeszow, 2016, Vol. 18, No 3, 41-52.
24. **Loveykin V. S., Pochka K. I. 2015.** Optimization of the breakthrough mode of reversal of roller forming installation. *Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK*, Kyiv, 2015, No 212, part 1, 186-197.

ИССЛЕДОВАНИЕ ПРОЦЕССА ПРИГОТОВЛЕНИЯ ВЫСОКОЭНЕРГЕТИЧЕСКОЙ КОРМОВОЙ СМЕСИ ДЛЯ КРС

Васыль Хмелёвский

Аннотация. Производство продукции животноводства в значительной мере зависит от качества кормления, т.е. от количественного и качественного состава кормовых компонентов, из которых готовят кормовые смеси. Научно доказано и практически подтверждено, что корма играют ключевую роль в качестве и в стоимости молока, так и в его количестве. На сегодня, в семейных фермах и животноводческих предприятиях, где поголовье КРС составляет более 100 голов дойного стада, кормовую смесь с высоким процентом однородности смешения и в соответствии с рецепту кормового рациона, готовят с помощью мобильных комбинированных кормоприготовительная агрегатов. С этой целью промышленность выпускает широкий размерный ряд этих машин с различным объемом бункера. Машины такого типа одновременно выполняют технологические операции дозирования, измельчения, смешивания кормовых компонентов, а после приготовления кормовой смеси - транспортируют и раздают смесь животным. Для процесса смешивания в комбинированных кормоприготовительная агрегатах используют шнековые рабочие органы, на витках которых устанавливают ножи для измельчения длинноволокнистых материалов. Исследования показали, что высокий уровень смешивания кормовых компонентов обеспечивается при условии непрерывного их движения в течение 6-8 минут.

Одним из условий, по качеству приготовления кормовой смеси, является обеспечение соответствующей величины надгвинтового пространства в бункере агрегата.

Теоретические и практические исследования, проведенные с использованием комбинированного комбайна в процессе приготовления кормовой смеси, показали, что надгвинтовий пространство зависит от частоты вращения шнека, параметров бункера и физико-механических свойств кормового материала.

Ключевые слова: технологическая схема, надвинтовое пространство, кормовая смесь, кормоприготовительный агрегат.

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Activation of Cognitive Activity of Students in Conditions of Practical Training in Subjects Traffic Regulations and Freight Transportation

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Summary. Quantitative growth of the car park in our country and therefore increase road users increases the number of traffic accidents. Ukraine in the last five years registered 293 thousand. Traffic accidents, which killed nearly 35 thousand. And injured more than 286 thousand. People. The majority of road accidents committed the fault of drivers (77 per cent of the total). The mortality rate due to road accidents in Ukraine (102 persons per 1 million. Inhabitants) is much higher than in countries such as Switzerland (49 persons), Germany (62 persons). The main reason for this is the insufficient level of road safety; improper maintenance vehicle maintenance; poor discipline of road users; discrepancy state road network to the level of intensity of traffic; lack of implementation of new technologies and technical means of traffic management; low level of training of future drivers. The article deals with the problems of the educational process ZVORelated to improving the quality of practical training of students dytsyplin "Rules of the Road" and "Freight" and proposed characters their solutions by differentiating approach in the management of cognitive activity of students.

In particular the questions of formation of students in the practical training of special skills, required for the formation of new knowledge and skills to successfully master the content of the discipline.

The level of preparedness of students for the conscious mastery of knowledge is measured by the necessary supporting concepts, cognitive skills and memory readiness time to implement them.

Key words: cognitive activity, perception, exercise, motive, conceptual and logical thinking sphere, sphere shaped thinking, emotional sphere of thinking, practical tasks.

INTRODUCTION

Teaching "Rules of the Road" and "Freight" in agricultural engineering departments of the institution of higher education requires teacher special treatment to the student audience. The peculiarity of this is the account of unequal readiness of students to the perception of the material to be understanding. Some students know the bad traffic rules and especially the organization of cargo transportation since received training courses for drivers with experience and their use as while driving vehicles and as a pedestrian. This is one of the major factors that continue to help students during their studies. Some students have quite a rough idea of the rules of the road and freight traffic received and used for admission to higher education knowledge concerned only pedestrians. Experience of teaching "Rules of the Road" and "Freight" in the process of theoretical and practical training, including listed objective circumstances give grounds to apply individual approach to students during their studies.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Solving the problem of improving the quality of training highly skilled professionals dedicated to research and development of such prominent scientists [1-12]. Solving urgent practical training of students in higher education institutions involved of such prominent scientists [12-21].

OBJECTIVE

The purpose of the study is to identify the characteristics of the method in practical training for students during their study discipline "rules of the road" and "Freight" and it improvements specific to student perception Initial material.

THE MAIN RESULTS OF THE RESEARCH

To get a clearer picture of the feature perception of student discipline "rules of the road" and "Freight" the level previously acquired knowledge, we arbitrarily divided the students specialty "Transport technologies" of National University of Life and Environmental Sciences of Ukraine, which conducted surveillance into three subgroups:

1) Students who are partially aware of certain clauses of transportation and traffic rules and have the experience of their use mainly as an observer or a pedestrian.

2) Students who are learning the university had the opportunity to learn traffic rules and certain provisions of the rules of transportation courses for drivers or additional training courses within school training but they have no experience of their application as the driver of the vehicle, just as an observer or pedestrian.

3) Students are learning at the university had the opportunity to learn rules of the road for driver training courses, have the appropriate driving license vehicle and have experience with the Regulation as road users.

Preference while studying the level of previously acquired knowledge with students of the third subgroup who taught courses driver training and received certificates. Working with students is much easier because they have a basic knowledge freely operate in the Terms and certainly have no difficulty in drawing test or exam subjects. But training for students in this group are not mechanical repetition previously studied, and the ability to consolidate and extend the knowledge and skills to test the strength of previously obtained knowledge in communication with the teacher and on occasion less prepared to help their comrades learn discipline.

Difficulties arise in the study subjects the students of the first two groups. These difficulties in each subgroup are different in character display.

Students belonging to the first subgroup, which are partly familiar with the peculiarities of transportation and with specific traffic rules constitute approximately 60%, in some cases up to 70% of the course. These students are familiar with the traffic rules, rules of freight within the school or training because of their curiosity. Difficulties in the early stages of training students in this subgroup associated with lack of experience or lack of perception of educational information. That difficulty in cognitive activity is associated with insufficient preconditioning student.

Previous level prepare students for responsible study material is determined mainly personal experience. And experience cognitive activity is characterized by certain knowledge and skills needed to create new knowledge and skills [3].

According to scientists the level of preparedness for responsible student mastery of knowledge is measured by the necessary supporting concepts, cognitive skills and memory readiness time to implement them. It should be noted [1, 2, 3, 4, 5, 6, 7, 8, 12] in which scientists examined some cognitive skills and abilities that contribute to mastering new educational information. However, special research, to identify the necessary cognitive skills, which should have for students learning the rules of traffic and freight traffic in the practical training is almost done. Thus, the objective of our research is to identify the essential cognitive skills,

We believe that the presence of certain cognitive skills is a prerequisite for successful mastering knowledge of the Rules:

1. Availability of skills training to perceive flat figures as spatial images of sections of roads and intersections.

To form the students' abilities to perceive Flat educational figures as spatial images of sections of roads and intersections advisable in the initial period of learning the rules of the road apply methods of comparing figures on educational posters in textbooks and testing tasks in tickets to specific sections of roads and intersections in the street and road network settlement. To this end, we offer the students exercise using the conversation:

- the poster shows the picture of the road having two lanes in one direction; Give an example of such a road section that is located in our neighborhood;

- draw a section of road on the board you call and show the figure of its main elements;

- position in Figure vehicles as shown on the poster.

2. Availability of skills to represent the trajectory of the vehicle on posters and drawings in a test in the paper.

We offer the ability to shape the students to imagine the trajectory of the vehicle on the figures in a test in tickets and posters by executing them at workshops exercise during a conversation using models. Models appear at workshops, special boards, which show sections of roads and by magnets mounted vehicle.

For example, in the study of the content of the SDA in the "Starting up and change its direction," the students the following questions:

- place on the roadway road quad vehicles moving adjacent lanes in the same direction as shown on the poster;

- demonstrate the trajectory of the vehicle in case of rebuilding one of them to an adjacent lane, which moves another vehicle as shown on the poster;

- demonstrate without using the poster, the trajectory of the vehicle in case of simultaneous rebuilding.

During the conversation we adjust students' answers, and if necessary, give additional explanations, using visual aids.

The presence of certain cognitive skills is a prerequisite for successful mastering of knowledge of the subject "Freight", namely:

1. The ability to visualize objects shuttle routes between supply and consumption, using his flat schematic image (Fig. 1).

Fig. 1. Scheme pendulum routes.

This ability is formed by using these techniques. Students are encouraged to first introduce this route on a map similar to that shown in Fig. 3. Then they offered: to find the starting point of the route - click download, find the end point of the route - the point of discharge count localities through which this route, to determine its distance and average technical speed. After students have completed these tasks, it is proposed to route simplified model of scale, which allows you to place the scheme at the model and outline arrow mark direction of travel of the vehicle. After you move on to more complex tasks, similar to the model route to build two pendulum routes, where the starting point is the same, and the final points will be different. This model will be similar to a simplified flat images pendulum routes (Fig. 1). After performing compound exercises described in the ability of students formed №1, after which they correctly represent shuttle routes and any number of configurations, using their flat circuit models.

2. The ability to perceive flat figures circuit rozviznyh routes (Fig. 2) in the form of spatial image areas of roads, road conditions and points of loading and unloading.

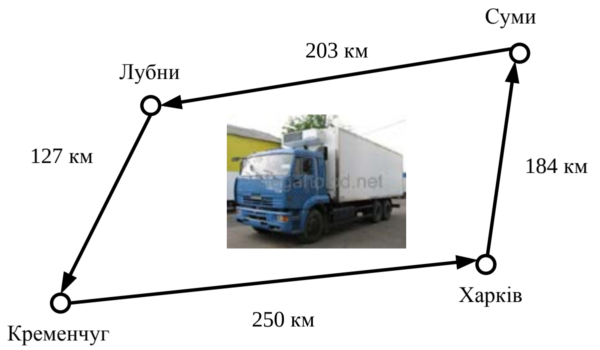

Fig. 2. Scheme route.

This ability is necessary to form after formed № 1. It is necessary to have students perform a set of sequential tasks: to find all the items on the map, through which route; determine the distance between these points to build the scale model simplified route. After performing this type of sequential tasks students formed the cognitive ability to think on a flat image Route (Fig. 2) is not geometric shapes – rectangle that resembles a parallelogram, namely route and its characteristic parameters.

3. The ability to provide rational roads among many other ways, using the flat image maps (Fig. 3) to develop optimal routes based transport technologies, types of connections and their technical resources.

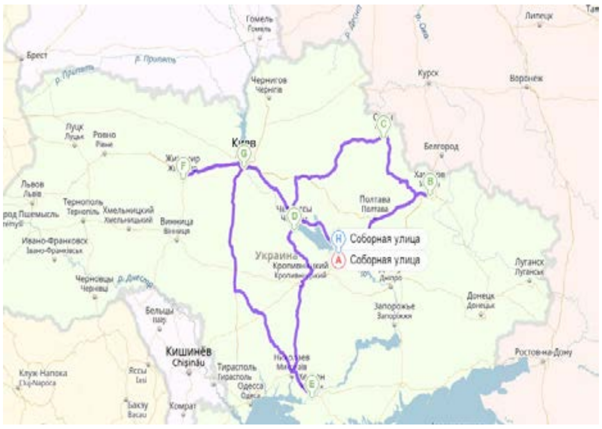

Fig. 3. Placement consumers on a map of Ukraine.

To form the ability to number 3, students are invited to perform the set of tasks that contribute to the creation of cognitive skills.

- identify on the map (Fig. 3) all items of consumption of the enterprise within a radius of 250 km from it;
- to determine the shortest possible connections between these points;
- translate the map in "Satellite" and determine the most convenient means of communication with selected;
- transfer mode map "Street View" and carefully consider road conditions selected to route roads. Particular attention is paid to their width, regulations of traffic and quality of road surface to determine the maximum permissible speed on technology each selected section of highway;
- transfer mode map "plugs" and determine whether it can be created congestion on road sections selected for route guidance, traffic and if there are, then determine what time it happens. If traffic jams occur regularly, you should choose instead the problem, another stretch of road.

After running such a complex sequential tasks, the students formed a cognitive skill number 3, which would allow them, using a flat map image on a computer monitor, fully present railways in kind and assemble them all the necessary characteristics for efficient selection when creating roads route for transportation.

4. Ability technical differentiation and possession of technical terminology.

This ability is the basis for the emergence and development of technical thinking in students and is based on understanding and skillful use of basic technical terms of discipline "Freight" and carrying out the necessary calculations for determining the results of modern methods of transport. Discipline involves possession of the following main terms: "zero mileage", "traffic volume", "turnover", "theoretical and operational performance", "equivalent distance transport by the criterion of productivity", "equivalent distance traffic on the criterion of cost", "steel and variables operating costs", "direct operating costs for transportation", "theoretical, technical and operational speed traffic" [10, 11]. To consolidate and proficiency in these terms students are asked to answer the following questions: the difference between the time spent in the car attire from the time of his stay on the route? In answering this question is revealed and reliably imprinted in the minds of students the essence of the concept of "zero mileage." Similar questions are developed to the disclosure of the remaining terms and thus formed cognitive abilities number 4.

Returning to the research learning of students. Compared with students first subgroup, for very different manifestation of the difficulties found in the second subgroup of students who study at the university to have the opportunity to learn traffic rules and regulations specific provisions on freight rates or additional driver training courses within school training. During the perception of educational material are significantly different from the first subgroup representatives, because they already have some knowledge and is relatively easy to orient in the educational material.

However, the behavior of students is significantly different from the rest of the second subgroup at workshops, they absently listening to the teacher, distracted, sometimes prevent perceive other educational information. Difficulties arise when protection reports and practical laboratory work when the teacher raised the issue of student response contains many blunders. Thus, difficulty in learning, resulting in the second subgroup of students, based on its mistaken notion of their knowledge and skills, reluctance to work with a group in class, use textbooks and reference books. To direct the cognitive activity of students in mastering the required active educational information, the teacher should promptly reinstate the driving force of the learning process. To do this, we create a situation which will allow the student to identify the actual level of knowledge. It is realized during a conversation with the teacher or students in the performance of complex practical problems that will allow without intervention teacher to assess their knowledge. Practical tasks, for example, when studying the topic "Traffic. Prohibitory signs "discipline" rules of the road "give this character:

- Give the exact name of road signs pointed pointer.
- What are the conditions for use of road signs?
- Provide a list of vehicles that are not subject to this road mark.
- Give an example of the use of the mark in real road conditions.
- Give the correct answer to the test.

Consider some of the aspects that affect cognitive activity of students in these subgroups workshops. We know that any human activity is not only characterized by meaningful goals but motivated. Objective this is something to which she directed that it should be a direct result. Motive is what makes human desire for this and not for any other purpose. These terms are those motives that cause people purposeful activity. For students these subgroups motives or motives for learning new knowledge is needed. But the question arises: why the need for students of first and third subgroups is mastery of knowledge and motivation for students this second subgroup lost motivation?

Because of pleasure or displeasure human needs there are certain emotions. Scientists, psychologists say that in terms of cognitive humans are three main areas of mental activity: conceptual and logical; shaped; emotional [9].

Conceptual and logical thinking sphere allows the student to perceive and understand the laws, the laws, concrete and abstract concepts that reflect the existing processes, events, items and other objects under study. With such positive properties of conceptual and logical thinking areas it relies on subjective burden in basic training. To the student was able to thoroughly understand the course material and well acquire knowledge required by the time of his mental concepts and the logical sector. The work in this sphere of thinking in the process of mastering knowledge traced three interconnected stages. The first stage - laying the foundations of concepts, their initial understanding and remembering that requires frequent repetition of educational information. The second stage - versatile play and understanding of the basics concepts addition of new information and skills formation connect these concepts with knowledge of new information. The third phase - the emergence of new problems, hypotheses and search for their solution. This stage of the creative application of knowledge. Creative thinking is based on direct and indirect sensory perception of information about events, processes, objects. Emotional sphere of thought itself does not perform work on understanding the information. However, it can significantly affect the operations of both fields of thought. So emotional sphere in the learning process is not used as an independent cognitive power. Creative thinking is based on direct and indirect sensory perception of information about events, processes, objects. Emotional sphere of thought itself does not perform work on understanding the information. However, it can significantly affect the operations of both fields of thought. So emotional sphere in the learning process is not used as an independent cognitive power. Creative thinking is based on direct and indirect sensory perception of information about events, processes, objects. Emotional sphere of thought itself does not perform work on understanding the information. However, it can significantly affect the operations of both fields of thought. So emotional sphere in the learning process is not used as an independent cognitive power.

Consider a second subgroup of students in terms of defining motivation to learn. As noted above, this subgroup students familiar with traffic rules and regulations specific provisions cargo at a certain level and the need for new knowledge they have. But new experiences passed. The student has studied the content of the Rules and put into practice some of the provisions. Therefore, the need for new knowledge is not motivation to learn, this need is satisfied. The experience unmet needs at the emotional sphere of thought has gone and therefore motivation, the desire for action on the subject of study happens. In addition, the emotional sphere of thinking does not tolerate repetitions. While teaching in the classroom and laboratory practical training material, which partially knowledgeable students of the second subgroup, takes effect is emotional sphere and inhibitory processes in the learning of students, disconnected from the emotions of conceptual and logical thinking and imaginative scope. In order to neutralize the negative effect of the emotional sphere and connect students to the learning of our proposed practical tasks that deplete students in setting the level of their knowledge. Practical tasks reveal those aspects of the object of knowledge that students are still unknown and thus reduced the motivation of new knowledge.

Students first subgroup need new knowledge zberihlasya. The experience unmet needs include motivation, the desire for action to possess the object of knowledge. Emotional sphere thinking of students in this group connects to the learning of conceptual and logical thinking and imaginative scope. To the student was able to thoroughly understand the course material and well acquire knowledge required by the time of his mental concepts and logical thinking areas. In the first stage of conceptual and logical areas there is passive perception of student learning material - they listen to a lecture or teacher explanations on practical and laboratory classes, working with textbooks, teaching aids. But passive repetition does not allow knowledge to provide active properties. Passive repetition necessarily varies active when the student plays their knowledge during oral answers. It exercises as practical problems of repetition is active, allowing the student to reproduce and organize the knowledge to fix them in memory, showing the ability to apply theoretical knowledge to practical action.

In the third subgroup of students best prepared perceived educational information on discipline "rules of the road" and "Freight" knowledge generated in the first stage of conceptual and logical thinking areas. The advantage levels of knowledge to representatives of the first and second subgroups appears sufficiently rapid transition of conceptual and logical thinking areas from the first to the second stage, the stage play and productive use of knowledge in different conditions. Volume and content of educational information on practical and laboratory studies of interest associated with the restoration motivation knowledge, experiences need arises, or rather the experience of dissatisfaction. The experience connects unmet needs emotional sphere of thinking, which in turn positively affects the logical and conceptual-shaped areas.

CONCLUSIONS

1. Exercises and tasks that we offer to use during practical and laboratory classes are intended to stimulate cognitive activity of students in the study subjects "Rules of the Road" and "Freight". As shown by our study, these exercises and tasks can definitely be called a means of cognitive activity of students. They should be an integral part of the main complex methods that directs students in mastering academic technical information focuses on some of the students with low pre-acquired, knowledge, stimulating them to active learning activities.

2. Needs further study the processes of formation of students cognitive skills from other disciplines specialty "Transport technologies".

REFERENCES

1. **Arkhangelsk P. S. 1974.** Lectures on the theory of education in high school. Moscow. High school. 384.

2. **Vergasov V. M. 1985.** Activation of cognitive activity of students in higher education. Kiev. High school. 176.

3. **Demin A. I. 1976.** The development of cognitive activity of students. Kiev. High school. 90.

4. **Danilova G. A., Skadina M. N. 1975.** Didactics of high school. Some problems of modern didactics. Moscow. Education. 303.

5. **Lerner I. J. 1982.** The development of students thinking in history teaching. Moscow. Education. 191.

6. **Schukina G. S. 1966.** Pedagogy. A course of lectures. Moscow. Education. 648.

7. **Slastenin V. A., Isaev S. F., Mishchenko A. S., Shiyanov E. N. 1997.** Pedagogy. Moscow. School-Press. 512.

8. **Shamova T. S. 1975.** The formation of cognitive independence of students. The formation of cognitive independence of students in learning systems leading knowledge and ways of working. Moscow. Research Institute schools. 5-19.

9. **Luzan P. G., Demin A. I., Ryabets V. I. 1998.** The formation activity of students: monograph. Kiev. High school. 192.

10. **Frishev S. G., Dokunin V. F. 2010.** Transport processes in agriculture. Kiev. High school. 415.

11. **Frishev S. G., Koszupisa S. I. 2011.** The basics of road freight transport. Kiev. High school. 290.

12. **Shchukin G. S. 1979.** Activation of cognitive activity of students in the learning process. Moscow. Education. 160.

13. **Rogovskii Ivan. 2014.** Stochastic models ensure the efficiency of agricultural machines. *MOTROL*. Lublin. 2014. Vol. 16. No 3. 296-302.

14. **Rogovskii Ivan. 2016.** Graph-modeling when the response and recovery of agricultural machinery. *MOTROL*. Lublin. Vol. 18. No 3. 155-164.

15. **Rogovskii Ivan. 2017.** Analytical provision of regular preventive maintenance of agricultural machinery and system implementation. *MOTROL*. Lublin. Vol. 19. No 3. P. 185-191.

16. **Rogovskii Ivan. 2017.** Choice of model class and method of modeling the resilience of agricultural machinery. *TEKA*. Lublin–Rzeszów. 2017. Vol. 17. No 3. 101-114.

17. **Loveykin V. S., Kovbasa V. P., Pochka K. I. 2010.** The dynamic analysis of roller forming installation with energetically balanced drive. *Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APC*, Kyiv, 2010, No 144, part 5, 338-344.

18. **Loveykin V. S., Pochka K. I. 2010.** Optimization of design data of roller forming installation with energetically balanced drive. *MOTROL*. Motorization and power industry in agriculture, Lublin, 2010, Tom 12 B, 9-18.

19. **Lovejkin V. S., Shumilov G. V. 2011.** Optimization of the mode of change of a departure of the tower crane behind single kinematic criteria. *MOTROL*. Motorization and power industry in agriculture, Lublin, 2011, Tom 13 B, 167-174.

20. **Loveykin V. S., Pochka K. I. 2015.** The analysis of unevenness of the movement of roller forming installation with the balanced drive. *MOTROL*. Commission of Motorization and Energetics in Agriculture, Lublin-Rzeszow, 2015, Vol. 17, No 3, 17-27.

21. **Loveykin V. S., Pochka K. I. 2016.** Analysis of dynamic equilibration by the drive of cars of roller formation. *MOTROL*. Commission of Motorization and Energetics in Agriculture, Lublin-Rzeszow, 2016, Vol. 18, No 3, 41-52.

АКТИВИЗАЦИЯ ПОЗНАВАТЕЛЬНОЙ ДЕЯТЕЛЬНОСТИ СТУДЕНТОВ В УСЛОВИЯ ПРАКТИЧЕСКОЙ ПОДГОТОВКИ ПО ДИСЦИПЛИНАМ “ПРАВИЛА ДОРОЖНОГО ДВИЖЕНИЯ” И “ГРУЗОВИЕ ПЕРЕВОЗКИ”

Аннотация. Количественный рост автомобильного парка в нашей стране и как следствие увеличение участников дорожного движения приводит к росту числа дорожно-транспортных происшествий. В Украине за последние пять лет зарегистрировано 293 тыс. дорожно-транспортных происшествий, в которых погибло почти 35 тыс. и травмировано более 286 тыс. человек. Подавляющее большинство дорожно-транспортных происшествий совершено по вине водителей транспортных средств (77 процентов общего количества). Уровень смертности в результате дорожно-транспортных происшествий в Украине (102 человека на 1 млн. жителей) значительно превышает показатели таких стран, как Швейцария (49 человек), Германия (62 человека). Основными причинами такого положения является недостаточный уровень обеспечения безопасности дорожного движения; ненадлежащее обеспечение технического обслуживания транспортных средств; низкий уровень дисциплины участников дорожного движения; несоответствие состояния улично-дорожной сети уровню интенсивности транспортного движения; недостаточность внедрения новейших технологий и технических средств организации дорожного движения; невысокий уровень подготовки будущих водителей. В статье рассматриваются проблемы учебного процесса УВО, связанные с повышением качества практической подготовки студентов по дисциплинам "Правила дорожного движения" и «Грузовые перевозки» и предложены действующие пути их решения за счет дифференциации подходов в управлении познавательной деятельностью студентов.

В частности рассматриваются вопросы формирования у студентов в процессе практической подготовки специальных умений и навыков, необходимых для формирования новых знаний и умений, чтобы успешно овладеть содержанием учебной дисциплины.

Уровень подготовленности студента к сознательному овладению знаниями определяется благодаря наличию необходимых опорных понятий, познавательных умений и навыков и готовности памяти вовремя реализовать их.

Ключевые слова: познавательная деятельность, восприятие, упражнения, мотив, понятийно-логическая сфера мышления, образная сфера мышления, эмоциональная сфера мышления, практические занятия.

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Use Moded Bar of Variable Cross Section in Vibration Analysis of Telescopic Boom System of Truck-Mounted Cranes

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Summary. The discrete - continual model of the rod of variable section for the analysis of oscillations of telescopic rotor systems of cranes is substantiated.

As methods for solving the basic equations (for bending type oscillations), the methods of Ritz and Budnov-Galerkin using the Relay formula are used to calculate the proper frequency of oscillations of the considered system using a model with lumped parameters (discrete models) and taking into account the distributed properties of the systems being studied.

The approaches used for the thorough analysis of the continual (distributed) properties of telescopic boom systems of mobile cranes and the analysis of variations of oscillations (longitudinal, twisting and bent) of telescopic boom systems of autocranes taking into account the circumstances of mass distribution along the arrow (rod) with a variable section of the rod along its length.

Approximate methods of analysis and improvement of methods for calculating various types of oscillations that arise in the rods of a variable section are presented, within the framework of consideration of telescopic boom systems of cranes as having discrete - continual properties.

Equations are constructed using the Bubnov-Galerkin method in the problems of longitudinal or steep oscillations of telescopic rotor systems of cranes.

Key words: model, rod, variable section, analysis, oscillations, telescopic boom system, truck cranes.

INTRODUCTION

To analyze the kinds of oscillations (longitudinal, twisting and bending) telescopic boom cranes systems should take into account the fact that the weight is distributed along the arrows (core) and core section is variable along its length.

In this case, instead of, for example, the classical equation of longitudinal vibrations (when constant-section rod) must come from one of the following equations:

$$c^2 \cdot \frac{\partial}{\partial x}\left(S \cdot \frac{\partial u}{\partial x}\right) = S \cdot \left(\frac{\partial^2 u}{\partial t^2}\right), \quad (1)$$

where: c - velocity of longitudinal vibrations propagating in the core, S - area of its cross section $S = S(x)$ $u = u(x, t)$ - Longitudinal movement of arbitrary cross-section of the rod, x - longitudinal coordinate (along the core axis), t - time.

Equation core twisting oscillations should be considered as:

$$c_1^2 \cdot \frac{\partial}{\partial x}\left(I \cdot \frac{\partial \varphi}{\partial x}\right) = I \cdot \frac{\partial^2 \varphi}{\partial t^2}, \quad (2)$$

where: c_1 - speed twisting waves propagating in the core, I - polar moment of inertia of the rod, $I = I(x)$, $\varphi = \varphi(x, t)$ - angle cross-section of the rod relative to its axis (x in any section of the rod).

Equation transverse (bending) oscillations of the rod should be seen in the following form:

$$\frac{\partial^2}{\partial x^2}\left(EI \cdot \frac{\partial^2 y}{\partial x^2}\right) = -m \frac{\partial^2 y}{\partial t^2}, \quad (3)$$

where: EI - bending stiffness of the rod, EI = EI (x), m - weight rod, y (x, t) - arbitrary displacement rod section (x) in the direction perpendicular to its axis.

It should be noted that the equations (1)-(3) using similar substitutions could lead to ordinary differential equations for the function X (x):

$$(S \cdot X')' + \frac{p^2}{c^2} \cdot S \cdot X = 0; \; (I \cdot X')' + \frac{p^2}{c_1^2} \cdot I \cdot X = 0; \quad (4)$$

$$(E \cdot I \cdot X'')'' - mp^2 \cdot X = 0,$$

bar near where function means differentiation with respect to spatial coordinates x, and the other equation for the function T (t).

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Issued above equation (1) - (4) are variable factors dependent on x. Solution in closed form is available only in certain cases where the variable S (x), I (x), J (x) by special dependency and, in general, is the transition to approximate methods (where J (x) - point inertia in the core section x, and E - in the above (3) is elastic modulus (Young's) core material). Some of these approximate methods are set forth below in connection with the need to analyze and improve methods for calculating the different types of vibrations that occur in the core variable section within review telescopic jib cranes as such systems with discrete - continuum properties.

Basic models of telescopic boom cranes investigated in [1-21]. However, the authors of these works use models with lumped parameters (ie discrete model) and do not include distributed properties of the systems. The authors of this study, it is advisable to use approaches developed in [8] for a comprehensive analysis is continual (distributed) properties telescopic jib cranes systems.

OBJECTIVE

The purpose of the work is the justification of approximate methods for the analysis of different kinds of vibrations arising in telescopic boom cranes systems that take into account their discrete - continuum properties.

To achieve these objectives in this study will be part on the work [8].

THE MAIN RESULTS OF THE RESEARCH

Below are justified and some methods of approximate solutions of bending vibration rods constant and variable section that allow variables to investigate fluctuations telescopic jib cranes systems.

1. Vereshchagin method (for permanent core section).

Composition and solve the differential equation of free oscillations console (model telescopic boom cranes system that is in operation (the unfolded throughout dovzhnynu state). We use the approach of [9]. We believe that the ends (free) console is a load, which has finite moment of inertia (Fig. 1 a), in addition, neglect beam weight compared to the weight of cargo. Fig. 1 introduced the following notation: l - the length of the console, EI - its bending stiffness, m - weight cargo, ϱ - its radius of inertia.

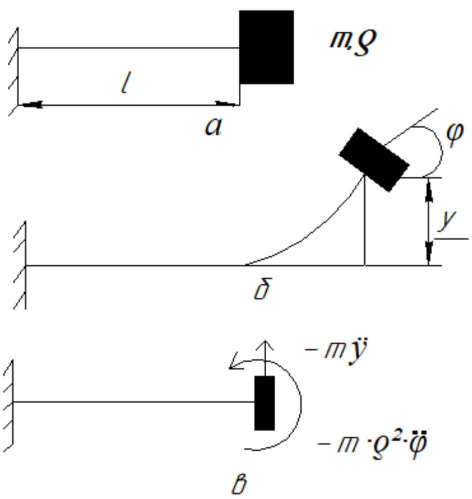

Fig. 1. Diagram console by Vereshchagin.

The proposed system has two degrees of freedom of movement, and generalized coordinates for convenient and appropriate to choose a console deflection and rotation angle φ end console (Figure 1b).

For the purposes of differential equations of motion and use the reverse method, consider bending lagless skeleton, which is shown in Fig. 1.

External forces are inertia load -m · ϱ2·. then:$\ddot{\varphi}$

$$y = \cdot \delta 11\text{-}m\varrho 2 \cdot, \varphi = - m \cdot\cdot \delta 12\text{-} m\varrho 2 \cdot\cdot . - \ddot{m} \cdot y\ddot{\varphi} \cdot \delta_{12}\ddot{y}\ddot{\varphi}\delta_{22} \quad (5)$$

This point was over a function of mean differentiation over time t.

Factors influence δ11, δ12, δ21, δ22 available methods of strength of materials, for example, using the formula Vereshchagin. In this case, they are expressed as follows:

$$\delta_{11} = \frac{l^3}{3EI}, \delta_{12} = \frac{l^2}{2EI}, \delta_{22} = \frac{l}{EI}. \quad (6)$$

Thus the differential equations of motion take the form:

$$\begin{Bmatrix} m \cdot \ddot{y} \cdot \frac{l^3}{3EI} + m\varrho^2 \cdot \ddot{\varphi} \cdot \frac{l^2}{2EI} + y = 0; \\ m \cdot \ddot{y} \cdot \frac{l^2}{2EI} + m\varrho^2 \cdot \ddot{\varphi} \cdot \frac{l}{EI} + \varphi = 0; \end{Bmatrix} \quad (7)$$

Partial solution (7) provided (stability criterion) Sylvester equilibrium for the considered system (consider this criterion is met) can be written as:

$$q_j = \cdot \sin(kt + \alpha), j = (1, 2).A_j \quad (8)$$

These expressions described monoharmonic oscillatory mode with frequency k, the total for all coordinates (ie y and φ). (Note that when the Sylvester criterion system which is derived from the equilibrium, provides free oscillations) q_j.

Substituting (8) in the differential equation (7), we obtain a homogeneous system:

$$\begin{Bmatrix} \left(\frac{ml^3}{3EI} \cdot k^2 - 1\right) \cdot m\varrho^2 \cdot \frac{l^2}{2EI} \cdot k^2 \cdot A_2 = 0; \\ \frac{ml^2}{2EI} \cdot k^2 \cdot A_1 + \left(\frac{m\varrho^2 \cdot l}{EI} \cdot k^2 - 1\right) \cdot A_2 = 0. \end{Bmatrix} \quad (9)$$

Equating to zero the determinant of the system (9), we obtain the following frequency equation:

$$\frac{m^2\varrho^2 l^4}{12 \cdot (EI)^2} \cdot k^4 - \left(\frac{m\varrho^2 l}{EI} + \frac{ml^3}{3EI}\right) \cdot k^2 + 1 = 0. \quad (10)$$

Its roots have the following form:

$$k_{1,2}^2 = \frac{1}{2} \cdot \frac{\left(\frac{m\varrho^2 l}{EI} + \frac{ml^3}{3EI}\right)}{\left[\frac{m^2\varrho^2 l^4}{12 \cdot (EI)^2}\right]} \pm \left\{\frac{1}{4} \cdot \frac{\left(\frac{m\varrho^2 l}{EI} + \frac{ml^3}{3EI}\right)^2}{\left[\frac{m^2\varrho^2 l^4}{12 \cdot (EI)^2}\right]^2} - \left[\frac{m^2\varrho^2 l^4}{12 \cdot (EI)^2}\right]^{-1}\right\}^{\frac{1}{2}}. \quad (11)$$

ϱ << 1 have from (11):

$$k_1^2 \approx \frac{3EI}{ml^3}\left(1 - \frac{q\varrho^2}{4l^2}\right); \; k_2^2 \approx \frac{qEI}{ml^3} \cdot \left(1 + \frac{ul^2}{q\varrho^2}\right). \quad (12)$$

To find their own forms of oscillations of the system will create relationship (A1 / A2) from the first equation of (9):

$$\frac{A_1}{A_2} = \frac{\left(1 - \frac{ml^3}{3EI} \cdot k^2\right)}{\left(m\varrho^2 \cdot \frac{l^2}{2EI} \cdot k^2\right)}. \quad (13)$$

Substituting here each of the found values and higher (by formulas (11) or (12) $k_1^2 k_2^2$ have:

$$x_{21} = \approx ; \approx - \frac{A_{21}}{A_{11}} \frac{3}{2l} x_{22} = \frac{A_{22}}{A12} \frac{2l}{3\varrho^2}. \quad (14)$$

These value (14) characterizing their two farms (Fig. 2, b).

As shown in Figure 2, the first own farm has a relatively low load angle and the second form - relatively small deflection end of the console.

Find the data traffic law system if its equilibrium is disturbed is applied to the center of gravity of the cargo instant momentum $\tilde{s}$.

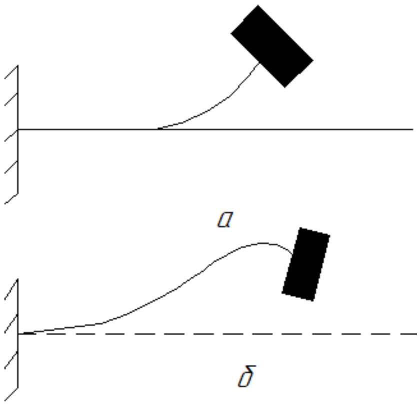

Fig. 2. Proper form fluctuations Console.

In this case, the initial conditions must be formulated as follows:

$$y\ (0) = 0,\ (0) =,\ \varphi\ (0) = 0 = 0.\dot{y}\,\frac{\tilde{s}}{m}\,\dot{\varphi}. \quad (15)$$

General solution now looks like:

$$\begin{cases} y = A_{11} \cdot sin(k_1 \cdot t + \alpha_1) + A_{12} \cdot sin(k_2 t + \alpha_2) \\ \varphi = A_{21} \cdot sin(k_1 t + \alpha_1) + A_{22} \cdot sin(k_2 t + \alpha_2) \end{cases} \quad (16)$$

Substituting here from (16) found the ratio of amplitudes (14), we find:

$$\begin{cases} y = A_{11} \cdot sin(k_1 t + \alpha_1) + \\ +A_{12} \cdot sin(k_2\, t + \alpha_2), \\ \varphi = \frac{3}{2l} \cdot A_{11} \cdot sin(k_1 t + \alpha_1) - \\ -\frac{2l}{3\varrho^2} \cdot A_{12} \cdot sin(k_2\, t + \alpha_2)\,. \end{cases} \quad (17)$$

To determine the four unknowns use the above initial conditions (15) $A_{11}, A_{12}, \alpha_1, \alpha_2$:

$$\begin{cases} A_{11} \cdot sin\alpha_1 + A_{12} \cdot \\ sin\ \alpha_2 = 0;\ \frac{3}{2l} \cdot A_{11} \cdot sin\alpha_1 - \\ -\frac{2l}{3\varrho^2} \cdot A_{12} \cdot \sin\alpha_2 = 0; \\ A_{11} \cdot k_1 \cdot cos\alpha_1 + A_{12} \cdot k_2 \cdot cos\alpha_2 = \\ = \frac{\tilde{s}}{m};\ \frac{3}{2l} \cdot A_{11} \cdot k_1 \cdot cos\alpha_1 - \\ -\frac{2l}{3\varrho^2} \cdot A_{12} \cdot k_2 \cdot cos\alpha_2 = 0. \end{cases} \quad (18)$$

Hence we find:

$$A_{11} = \frac{\tilde{s} \cdot l^2}{\sqrt{3mlEI}}, A_{12} = \frac{q\tilde{s} \cdot \varrho^2}{8l \cdot \sqrt{mlEI}}, \alpha_1 = 0;\ \alpha_2 = 0. \quad (19)$$

Accordingly, the motion is described by the equations:

$$\begin{cases} y(t) = \frac{\tilde{s} \cdot l^2}{\sqrt{mlEI}} \cdot \left[\frac{1}{\sqrt{3}} \cdot sink_1 t + \frac{9}{8} \cdot \frac{\varrho^3}{l^3} \cdot sink_2 t\right]; \\ \varphi\ (t) = \frac{\tilde{S} \cdot l}{\sqrt{mlEI}} \cdot \left[\frac{\sqrt{3}}{2} \cdot sin\, k_1 t - \frac{3}{4} \cdot \frac{\varrho}{l} \cdot sin\, k_2\, t\right]. \end{cases} \quad (20)$$

2. Ritz method.

Wonder several functions, (x), ..., (x), each of which meets the geometric boundary conditions of the problem and form function f (x)$f_1(x) f_2 f_n$ as the sum of:

$$f\,(x) = ... + \cdot.\overline{c_1} \cdot f_1 + \overline{c_2} \cdot f_2 + \bar{c}_n f_n \quad (21)$$

Substituting the function (21) in Rayleigh formula:

$$p^2 = \frac{\int_0^l EI \cdot (f")^2 dx}{\left[\int_0^l mf^2 dx\right]}, \quad (22)$$

then the result will depend on the particular choice of ratios $\overline{c_1}, \overline{c_2}, \dots, \overline{c_n}$.

Ritz method allows the use of a simple idea: coefficients $\overline{c_1}, \overline{c_2}, \dots, \overline{c_n}$.

Must be chosen so that the calculation formula (22) would give the least importance to. Theorem Rayleigh follows that such a choice would be the best (if this system function) $p^2\ f_i$.

Minimum conditions have the form p^2:

$$\frac{\partial}{c_i}\left[\frac{\int_0^l EI \cdot (f")^2 dx}{\int_0^l mf^2 dx}\right] = 0\ (i = 1, 2, \dots, n), \quad (23)$$

ie:

$$\left[\frac{\partial}{\partial \overline{c_i}} \int_0^l EI\ (f")^2\ dx\right] \cdot \left[\int_0^l mf^2\, dx\right] - \left[\frac{\partial}{\partial \overline{c_i}} \int_0^l mf^2 dx\right] \cdot \left[\int_0^l EI \cdot (f")^2 dx\right]. \quad (24)$$

Divide equation (24) integral to and including the formula (22)$\int_0^l mf^2\, dx$ have:

$$\frac{\partial}{\partial \overline{c_i}} \int_0^l [EI \cdot (f")^2 - p^2 \cdot mf^2]\, dx = 0, i = 1, 2, \dots, n. \quad (25)$$

Equation (25) is relatively homogeneous and linear, ..., and their number is equal to the number of members of the expression (21). Equating to zero the determinant composed of coefficients at, ..., will have a frequency equation. This equation not only gives a good approximation for naymenschoyi frequency, but also identifies (but less accurate) value higher frequencies. It can be found as much frequency as components made in expression (21) $\overline{c_1}\overline{c_2}\overline{c_1}\overline{c_2}$.

Ritz method as Rayleigh method allows to solve the problem in the case of discontinuous functions and EI m, when these functions are different analytical expressions for different parts of the beam length / console.

Define by Ritz lowest natural frequency of transverse vibrations console variable section, which has a thickness equal to the conventional one.

Height varies linearly (Fig. 3):

$$h_x = x\cdot;\ \mathrm{I} = \frac{\mathrm{h}}{\mathrm{l}} h^3 \cdot \frac{x^3}{(12l^3)}; m = \varrho h \cdot \frac{x}{l}. \quad (26)$$

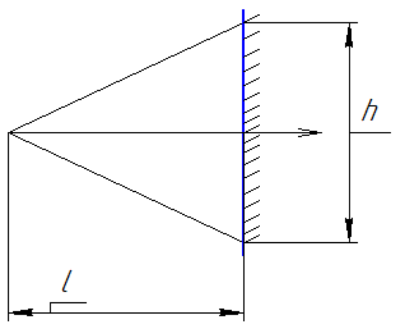

Fig. 3. Diagram console (26).

For the approach of looking for solution of using:

$$f\,(x) = \overline{c_1} \cdot \left(1 - \frac{x}{l}\right)^2 + \overline{c_2} \cdot x \cdot \frac{\left(1 - \frac{x}{l}\right)^2}{l}. \quad (27)$$

Each member of this example satisfies the boundary conditions of the problem:

$$f_1 = 0, f_2 = 0, f_1' = 0, f_2' = 0,\ x = 0. \quad (28)$$

If limited to one member, then get Rayleigh method (error of about 3%):

$$p = 1,582h \cdot \frac{\sqrt{\frac{E}{\varrho}}}{l^2}. \quad (29)$$

To get a better approximation, we take two terms of the expansion. Substituting them into expression (25), then we will have integral values:

$$h^3 \cdot \frac{\left[(\overline{c_1}-2\overline{c_2})^2+24\cdot\overline{c_2}\cdot\frac{(\overline{c_1}-2\overline{c_2})}{5}+6\cdot\overline{c_2^2}\right]}{(12l^3)} - p^2 \cdot \varrho hl \cdot \neq + 0. \frac{(\frac{\overline{c_1^2}}{30}+\frac{2\overline{c_1c_2}}{105}+\frac{\overline{c_2^2}}{280})}{E} \quad (30)$$

Differentiating the expression (30) on the first then on, we will have: $\overline{c}_1, \overline{c}_2$

$$\begin{cases} \left[\frac{Eh^2}{(12\varrho l^4)}-\frac{p^2}{30}\right]\cdot\overline{c_1} + \left[\frac{Eh^2}{(20\varrho l^4)}-\frac{p^2}{105}\right]\cdot\overline{c_2} = 0, \\ \left[\frac{Eh^2}{(12\varrho l^4)}-\frac{p^2}{105}\right]\cdot\overline{c_1} + \left[\frac{Eh^2}{(20\varrho l^4)}-\frac{p^2}{280}\right]\cdot\overline{c_2} = 0. \end{cases} \quad (31)$$

Equating to zero the determinant composed of coefficients of these equations (31), we obtain the equation frequency. Its roots:

$$p_1 = 1,536h \cdot; \frac{\sqrt{\frac{E}{\varrho}}}{l^2} p_2 = 4,994h \cdot \frac{\sqrt{\frac{E}{\varrho}}}{l^2}. \quad (32)$$

Find the exact value differs by only 0,1% p_1.

3. Bubnov - Galerkin.

In the simplest version of the method according to equation (3) should be in place X (x) approximately expose selected expression f (x), which has one uncertain parameter and then form the equation:

$$\int_0^l [(E \cdot I \cdot f) - mp^2 \cdot f] f dx = 0. \quad (33)$$

This equation expresses the vanishing of a possible work being done by force of elasticity and inertia of moving f (x).

If we take f (x) as (21) and examine each of the components (x), as a possible move then instead of (33) will have a ratio that expresses the vanishing of the possible: f_i

$$\int_0^l [(EI \cdot f")" - mp^2 \cdot f] \cdot f_i \cdot dx = 0, i = 1,2 \ldots \quad (34)$$

Such equations can be written as many constituents have adopted the expression (21). Each of equations (34) and has a uniform uncertain size, ... in the first degree $\overline{c_1}\overline{c_2}$.

Equating to zero the determinant of the system (34), will have a frequency equation.

Bubnov - Galerkin has one feature, which refers to the boundary conditions. If the function (x) satisfy only geometric boundary conditions (as stated above, the following functions can be used in solving the problem Ritz method), then it can lead to significant errors in applying the Bubnov - Galerkin. If the selection of features not consider power boundary conditions (for example, to ignore the conditions and at the free end beams / console or on the rocker bearing condition), then it will implicitly acknowledged the existence of the ends of the beam boundary conditions, which in reality is not. This occurs $f_i f_i(x) f_i'' = 0 f_i''' = 0\ f_i'' = 0$.

Error because the expression (34) will come nonexistent work effort. To compensate for the errors should subtract the left side of the expression (34) "extra" work of boundary conditions (collectively Bubnov - Galerkin). Usually do another take over functions previously not only geometric, but also force boundary conditions. With this feature by selecting Ritz and Galerkin give the same results.

Define Bubnov - Galerkin lowest incidence of transverse vibrations console discussed above in the preceding paragraph.

Accepted forms as fluctuations Console expression:

$$f(x) = \overline{c}_1 \cdot \left(1-\frac{x}{l}\right)^2 + \overline{c_2} \cdot x \cdot \frac{\left(1-\frac{x}{l}\right)}{l}, \quad (35)$$

Satisfies a geometric conditions at the right end, and so force conditions on the left.

Differentiating f (x) twice, multiply by EI = E $\cdot$ differentiating twice and again, we will have $h^3 \frac{x^3}{(12l^3)}$:

$$(EI \cdot f'')'' = E \cdot . h^3 \frac{\left[(\overline{c_1}-2\overline{c_2})\cdot x+6\overline{c_2}\cdot\frac{x^2}{l}\right]}{l^5} \quad (36)$$

Substituting this formula in (34), we find:

$$\int_0^l \left\{\frac{Eh^3}{l^5}\cdot\left[(\overline{c_1}-2\overline{c_2})\cdot x+\frac{6\,\overline{c}_2\cdot x^2}{l}\right]-\frac{\varrho hp^2}{l}\cdot\left[\overline{c_1}\cdot x\cdot\left(1-\left(\frac{x}{l}\right)^2\right)+\overline{c_2}\cdot\frac{x}{l}\cdot(1-\frac{x}{l})^2\right]\right\}\cdot\left(1-\frac{x}{l}\right)^2 dx = = 0, \quad (37)$$

$$\int_0^l \left\{\frac{Eh^3}{l^5}\left[(\overline{c_1}-2\overline{c_2})\cdot x+\frac{6\overline{c_2}\,x^2}{l}\right]-\frac{\varrho hp^2}{l}\cdot\left[\overline{c_1}\cdot x\cdot\left(1-\frac{x}{l}\right)^2+\overline{c_2}\cdot\frac{x}{l}\cdot(1-\frac{x}{l})^2\right]\right\}\cdot\cdot\frac{x}{l}(1-\frac{x}{l})^2 dx = 0. \quad (38)$$

Hence, too, will have the same equations as in the previous example using Ritz method.

Similarly consist equation method Bubnov - Galerkin in problems of torque fluctuations or longitudinal telescopic jib cranes systems.

CONCLUSIONS

1. A model of the core variable section to analyze different types:

- fluctuations (longitudinal bending, twisting) telescopic jib cranes of analytical methods (Rayleigh Vereshchagin, Ritz, Bubnov - Galerkin) that can determine the natural frequencies of said oscillation,

- and their spatial form (vibrations) that implement such own free fluctuation system.

2. Obtained in the results can be used to further refine and improve existing engineering calculation methods:

- different types of vibrations telescopic jib cranes analytical methods both at the stage of their design / construction,

- and in the mode of real operation using discrete - continuum model core variable section.

REFERENCES

1. **Komarov M. S. 1969.** Dynamics of lifting machines. Moscow. Engineering. 206.

2. **Kazak, S. A. 1968.** Dynamics of bridge cranes. Moscow. Engineering. 331.

3. **Gokhberg M. M. 1969.** Metal constructions of lifting – transport machines. Moscow. Engineering. 520.

4. **Lobov N. A. 1987.** Dynamics of load-lifting cranes. Moscow. Engineering. 160.

5. **Gaydamaka V. F. 1989.** Lifting – transport machines. Kiev. High school. 328.

6. **Loveikin V. S. 2004.** Modeling of dynamics of mechanisms of hoisting machines. Nikolaev. RVV NGAU. 286.

7. S**cheffler M., Dresig H., Kurt F. 1981.** Lifting – transport cranes. Moscow. Engineering. 287.

8. **Panovko J. G. 1990.** Fundamentals of applied theory of vibrations and shock. Leningrad. Polytechnic. 272.

9. **Panovko J. G. 1991.** Introduction to the theory of mechanical vibrations. Moscow. Science. 256.

10. **Loveykin V. S., Garnec V. M., Pochka K. I. 2004.** Patent of Ukraine for an invention № 67091A. Installation for formation of products from concrete mixes, № u2003076371 it is stated 08.07.2003; it is published 15.06.2004, Bulletin №6.

11. **Loveykin V. S., Pochka K. I. 2004.** The dynamic analysis of roller forming installation with the rekuperativ drive. Dynamics, durability and reliability of farm vehicles: *Works of the First International scientific and technical conference (DSR AM-I)*, on October 4-7, 2004, Ternopil (Ukraine), 507-514.

12. **Loveykin V. S., Pochka K. I. 2005.** The analysis of unevenness of the movement of roller forming installation with the rekuperative drive. *Scientific and technical and production magazine «Hoisting-and-transport equipment*», 2005, No 4, 19-33.

13. **Loveykin V. S., Pochka K. I., Palamarchuk D. A. 2004.** Optimization of design data of the driving mechanism of roller forming installation with the rekuperative drive. *Scientific and technical magazine «Technology of construction»*, Kyiv, 2004, No 15, 40-48.

14. **Loveykin V. S., Pochka K. I. 2010.** The analysis of unevenness of the movement of roller forming installation with energetically balanced drive. V*ibrations in the equipment and technologies*, 2010, No 4 (60), 20-29.

15. **Loveykin V. S., Pochka K. I. 2010.** Optimization of design data of roller forming installation with energetically balanced drive. *MOTROL*. Motorization and power industry in agriculture, Lublin, 2010, Tom 12 B, 9-18.

16. **Loveykin V. S., Pochka K. I. 2004.** The analysis of the movement of roller forming installation with the balanced drive. *Bulletin of the Kharkiv national automobile and road university*, 2004, No 27, 95-101.

17. **Loveykin V. S., Pochka K. I. 2005.** The power analysis of roller forming installation with the balanced drive. S*cientific bulletin of National agricultural university*, 2005, No 80, 346-356.

18. **Loveykin V. S. 1989.** Assessment of the movement of mechanisms and cars. *Hoisting-and-transport equipment*, Kyiv, Tehnika, 16-18 (in Russian).

19. **Lovejkin V. S., Shumilov G. V. 2011.** Optimization of the mode of change of a departure of the tower crane behind single kinematic criteria. *MOTROL*. Motorization and power industry in agriculture, Lublin, 2011, Tom 13 B, 167-174.

20. **Loveykin V. S., Pochka K. I. 2015.** The analysis of unevenness of the movement of roller forming installation with the balanced drive. *MOTROL*. Commission of Motorization and Energetics in Agriculture, Lublin-Rzeszow, 2015, Vol. 17, No 3, 17-27.

21. **Loveykin V. S., Pochka K. I. 2016.** Analysis of dynamic equilibration by the drive of cars of roller formation. *MOTROL*. Commission of Motorization and Energetics in Agriculture, Lublin-Rzeszow, 2016, Vol. 18, No 3, 41-52.

ИСПОЛЬЗОВАНИЕ МОДЕДІ СТЕРЖНЯ ПЕРЕМЕННОГО СЕЧЕНИЯ В АНАЛИЗЕ КОЛЕБАНИЙ ТЕЛЕСКОПИЧЕСКИХ СТРЕЛОВЫХ СИСТЕМ АВТОКРАНОВ

Аннотация. Обоснована дискретно-континуальная модель стержня переменного сечения для анализа колебаний телескопических стреловых систем автокранов.

В качестве методов решения основных уравнений (для изгибных типа колебаний) использованы методы Ритца и Буднова - Галеркина с применением формулы Рэлея для вычисления собственной частоты колебаний рассматриваемой системы с использованием модели с сосредоточенными параметрами (тоесть дискретные модели) и учетом распределенных свойств исследуемых систем.

Использованы подходы, для всестороннего анализа континуальных (распределенных) свойств телескопических стреловых систем автокранов и осуществлен анализ разновидностей колебаний (продольных, крутильных и изгибных) телескопических стреловых систем автокранов с учетом обстоятельства распределения массы вдоль стрелы (стержня) с переменным сечением стержня по его длине.

Изложенные приближенные способы анализа и совершенствования методов расчета различных видов колебаний, которые возникают в стержнях переменного сечения, в рамках рассмотрения телескопических стреловых систем автокранов как имеющих дискретно-континуальные свойства.

Составленные уравнения по методу Бубнова - Галеркина в задачах о продольные или крутящие колебания телескопических стреловых систем автокранов.

Ключевые слова: модель, стержень, переменное сечение, анализ, колебания, телескопическая стреловая система, автокраны.

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Justification of Choice of Heating System for Pigsty

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Summary. The article analyzes the types of heating systems for heating the pig farm.

The specific weight of heat supply processes and microclimate provision in the total expenditures of fuel and energy resources in the premises for keeping pigs is given.

The necessary temperature regime for sows, piglets weeks from birth and pigs for fattening was determined.

The factors that have a significant influence on the selection of the system of heating and ventilation of the pig farm are determined.

The shortcomings and advantages of systems using open energy sources when burning gas or other fuels and systems using a water heat carrier are given.

The advantages and disadvantages of infra-red heating, fan convectors, "dark radiators", "aquasolar", "warm" floor, heating of pigsties with a solid concrete floor with plastic or metal pipes laid in it, along which the coolant circulates, are analyzed.

Equipment for water heating in premises with weaned piglets is considered: delta pipes, twin tubes, butterfly pipes - with two, three or four plates.

Key words: pigsty, microclimate, heat supply, heating system, ventilation system, advantages and disadvantages, infrared heating, coolant.

INTRODUCTION

Modern pig farms today are more like working intensively industry. Pigsty equipped with sophisticated technological systems preparation and distribution of feed, automatic climate control and ventilation. In small areas there are thousands of animals. As in nature there is a natural balance for improved performance paid a price. Selection of increased production figures bahatoplidnosti, but also significantly reduced the resistance of animals to adverse external factors [1-3].

Perfectly matched parameters of air temperature and constant air exchange rules dotrymuvani optimal climate should compensate for these adverse changes in the biological properties of animals [4-21]. The importance of investment in safe and efficient working automatic ventilation system demonstrates the following: the pig can live without food - two weeks without water - 2 days without air - 2 minutes. To achieve high efficiency pig must provide them with optimal climatic conditions. One important component is to support the heat-humidity air Pigsty parameters [4, 5].

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

The role of microclimate and its impact on the performance of pigs covered in scientific studies [3, 6, 7], which states that extreme conditions adversely affect their body. Some studies indicate that keeping the average temperature in the mother liquor at 15,4ºS, lower relative humidity leads to an increase in serum pigs like gamma globulin and indicators bactericidal activity. In keeping pigs at 8...13ºS a reduction of live weight to weaning, increased frequency of disease, reduced bactericidal, complementary and lizotsymna activity. Adversely affect the physiological state and the high temperature and humidity. However, minor daily fluctuations in temperature (under optimal values of other climatic parameters) do not affect the health of piglets and their stress reactivity, as noted by M. Black, O. Dudnik and D. Bulba [8]. Creating optimized temperature and humidity conditions of pigs [9] promotes better growth, reduce morbidity, reduce costs and increase feed to improve the economic efficiency of pork production.

OBJECTIVE

The aim of this work study is the choice of piggery heating.

THE MAIN RESULTS OF THE RESEARCH

For industrial pork production in terms of farms and complexes characterized by high concentration of livestock production facilities, resulting in dramatically increased air content of the metabolic products of animals (harmful gases, water vapor), dust and bacterial contamination of air, resulting affects the physiological state and productivity of animals.

Create an optimal microclimate in the premises for swine only on condition of rational use of heating and ventilation systems based on highly efficient technical means.

Table 1. Proportion processes in total costs of energy resources%

Processes	The consumption of pig farms and complexes	
	electricity	fuel
Heat and providing microclimate	40...65	60...90
Preparation and distribution of fodder	12...28	5...35
Cleaning and preparation of manure for use	8...15	2...3

At the same time, we know that providing the necessary microclimate is one of the most energy intensive processes, along with the preparation and the distribution of feed, manure cleaning and preparation for use (Table. 1).

Special heating systems require farm where pigs are raised, because the breeding of these animals in the first place is to achieve the required weight, which also conducted intensive fattening. Keeping pigs in the wrong temperature conditions lead to unfavorable consequences, because the cold will have to increase the quantity of food, and when the air is too hot in animals reduced appetite and weight loss begins. Therefore, it is important to follow the necessary treatment that is keeping temperatures:

• sow - about 16-20 ° C;

• piglets weeks of age - 28-30 ° C. Further reduction of 2 degrees per week;

• growing pigs feel best at 14-20 ° C.

In order to perform proper heating pig, select this type of heating system that would meet all necessary requirements. The optimum temperature for pigs is such, where they spend a large amount of energy to maintain their body temperature. The process of weaning piglets from sows is very painful for them, they have to quickly adapt to the new environment, near absence of the mother. At the same time respond to such stress changes around them pigs are quite different. Usually piglets begin to behave nervously, disputes among animals in new groups may have different diseases - all of which reflected negatively on their development and subsequent weight gain. Therefore, weaning piglets from sows should be conducted as careful with them except for the extra stress or any anya discomfort. It is important to create a piglet rearing on the first day following conditions to be self-adjusting to life was as simple as possible. It must be remembered that the variety of new situations for themselves they face and create the most favorable conditions of piglets in the group regardless of the size of the group.

In the first couple of weeks after the transfer of rearing pigs on the temperature in their places of rest should stay approximately the department was as farrowing. Particular attention should be paid to the absence of a draft, to which pigs are very sensitive and even distribution of heat throughout the unit.

Especially in cold areas pigs not spend much energy on the development and weight gain, and on their heating. In areas with a hot climate decreases appetite in animals and there are signs of heat stress. Numerous practical observations have confirmed that a significant deviation of ambient temperature from the optimum leads to a marked decrease in performance of pigs (15-30%) and fodder overrun by 25-50%. Modern automatic heating systems of pig farms can maintain the temperature regime at a given level without human intervention. It is important to determine what advantages and disadvantages of having different systems and methods, and which is best suited for a particular pig farm.

Heating systems for pigpens. To create the optimum temperature microclimate necessary to provide a quality heating and ventilation pig. The use of certain methods is largely dependent on natural conditions of the region, flooring, location of rooms and of course the age of the pigs. However, remember that that would not system was chosen heating have to be synchronized with the ventilation system. Both systems should operate smoothly, this is what will ensure maximum efficiency microclimate created without unnecessary expenses.

The heating system should only heat to compensate the losses that may occur due to insufficient tightness walls, door openings and the introduction of fresh cool air from the ventilation system. Typically, an established violation of ventilation and heating occurs in cases where ventilation is at too high a level against the background of normal operation of the heating system; regulation of the temperature increase due to the heating and ventilation equipment operation are set in ranges with a difference of less than 5 °C; and non-compliance with the ratio between the maximum and minimum range regulation of heating and ventilation systems, accepted as 1:20. These violations do not allow this system to perform its basic function in maintaining maximum temperatures in summer and winter with minimal collateral animals fresh air. The choice of heating system, in addition to the configuration of the room, providing a significant impact in the household presence of various energy sources used equipment and manpower availability.

For space heating in pig farms for rearing pigs in the global market offers a number of different heating systems. Although now often organize piggery heating by direct combustion of gas or liquid fuel, general section of heating systems can be characterized by two types.

The first ones include heating, releasing energy source which is located directly in the room, which should be heated. They just include systems operating on gas or other fuels that make selection of heat energy occurs in the processing of pigs. The second type of system include the deployment of energy sources outside the pig. In this case, the energy carrier usually the water which brings heat to the system elements to locations animals.

Comparing the two groups of heating necessary to mention their significant advantages and disadvantages. Thus, the key disadvantage of using open sources of energy by burning gas or other fuels is the allocation of the air in the room by-products of combustion. If you use this gas is carbon dioxide and steam, and the application of oil to gas is added soot. It is clear that to maintain animal health, these gases must as soon as possible removed from the premises, which means more ventilation intensity with a corresponding decrease in heating efficiency, resulting in that part of the heated air immediately goes to the ventilation and lost.

These aspects clearly indicate the great advantages of the second type using a water medium heat. Thanks to them in a room where pigs are kept, no additional forms of harmful gases and therefore it does not require complex control devices microclimate. But the use of equipment, pumping water requires management high cost of installation and adjustment settings, greater attention to uniform heat distribution in compliance with the relevant conditions of the installation of the heating system and the allocation of a separate room in which to place the heat exchange between the main energy source of heating equipment and water. Also, in systems of the second type unlike the first heat passes through a water pipe system much longer path through its transportation losses can significantly increase.

An important factor in choosing the right heating system for pig serves fuel used. In this regard it should be noted that the need to expand the livestock buildings greatest opportunities to increase coverage area heating allows the use of oil, which can rise to new premises at a distance of 30 m. If the distance is greater still need to build additional heating which, in turn, requires additional space that meets all the requirements pozhezhostiykosti with good ventilation for fuel storage. Compared with the use of any carrier gas eliminates the need to install them in separate rooms. This compact gas heaters can easily be installed in the central aisles.

Infrared gas radiator long enough period considered basic equipment for heating in sections rearing. This is due to their reasonable price and ease of installation and reinstall if necessary. In addition, it is very important for young pigs, they do not create drafts that could affect the health of animals. Infrared emitters are indeed very well suited for heating recreation areas piglets. This contributes to targeted feeding radiation in the form of a wave that just hitting the surface of the skin of the animal turns into a tangible warmth. Typically, the installation of infrared emitters held near the feeders, which can significantly increase the number of approaches to food. When using this equipment for general heating, it is advisable to direct the heat wave to another carrier,

In many cases the most energy efficient type of heating is an infrared (Fig. 1). In traditional heating first heats the air, then heat comes to biological objects. Warm air naturally goes to the ceiling, creating convection currents that move the dust in the room, and in the cold season - to the floor. As a result, most of the heat is spent on heating useless to the consumer space. Thermal energy from infrared heaters is not absorbed by air, so all the heat from the radiator with almost no losses reaching biological objects. This warm air is not concentrated almost to the ceiling, making these devices effective in problem solving energy-efficient heating rooms with high ceilings. The use of infrared heating provides a 40% energy saving. Importantly, infrared heating - this is the only method that allows a local heating zone workplace or in the room. With infrared heating is possible to maintain different temperatures in different parts of the room and partially reduce the energy to work traditional heating systems in some areas of the room. For example, if the jobs are at a considerable remove from one another, the room in general should not have the same temperature [10-12].

Fig. 1. Infrared heating in Pig.

Even in terms of comfort different work situations involve different temperatures. Infrared heaters provide accelerated in comparison with traditional systems, warm room. The transfer of heat from infrared heaters object is no inertia, so there is no need for preheating or permanent office space. Emitter does not dry the air without burning oxygen raises dust and no noise. The infrared heater unlike traditional way of heating, which must first warm air reduces the temperature difference zones in floors and ceilings as heat rays heat the surface, falling, thus it is possible to maintain the temperature in the room below normal. IR does not use air as a heat carrier and therefore provides optimal temperature balance in all areas. Infrared heating acts directly on biological objects, so when temporary loss of heat in the room caused by, for example, open doors, infrared heaters quickly restore the desired temperature [13] .

Typically, the IR emitters system very easy to use and its cleaning and inspection is conducted no more frequently than once a month. Still not completely forget about the shortcomings of this technology. Not to mention the air pollution combustion, gas emitters significantly increase the space dust, which increases the cost of maintenance equipment. In addition, an important drawback acts difficulty regulating their work, namely the inability to set parameters for automatic start setting heating after a full shutdown.

Accordingly, if the working Pig climate control system, gas emitters must always be in operation at least a minimal mode. This causes additional financial costs. In the worst case, to align the temperature conditions may need to involve more and ventilation system, further increasing unwanted heat loss.

The advantages of infrared heaters is the possibility of a uniform distribution of heat radiation and power control unit from 10 to 100%. Moreover, the lack of air filter allows water to wash the unit if necessary, outside and inside. Two-emitting surface in the shape of cones usually provide very good heating and are like two teploobihrivachi one. Fan coil can operate completely independently of the movement of heat flow. At the core of their work is also burning gas, but to spread the heat they need additional supercharger air. It is important to monitor the need for heating to avoid overheating.

An important feature of this system is that the heated air is not in the machine and in the central aisle, which is much less dust. As a result, the equipment is much less clogged and deteriorate. Usually blower heaters are not used for rearing as a current of air blown into the room, creating excessive air movement that piglets flukes harmful. A huge advantage of using such a system can be achieved by sending warm air in a separate section through the feed passage at an angle. The result will be reached undulating movement reached its air and more even distribution of the section.

Significant progress to prevent accumulation of warm air from the ceiling and his loss of ventilation is achieved by using so-called "dark emitters." In such systems, the air is also heated by burning gas passes through a thick tube (two inches), which are welded plates that give warmth to the space. As a result, the heat goes directly to the pig and the best heats it. The best effect is achieved even heat distribution width section to 6 m, large areas is necessary to establish additional emitters. At last it is also possible to use gas guns that are usually not recommended for small sections through venting to atmosphere of combustion products and the formation of additional drafts. Among the advantages of air guns include relatively low energy consumption, ease of use and maintenance, easy cleaning and maximum heat efficiency. In addition, the use of teploharmati multyhazovoyi wiring allows the heater to work as methane and propane or butane.

As water heating equipment in the premises of weaned piglets often use delta pipes, twin-pipe truby-"butterfly" - with two, three or four plates, respectively - 2.5-inch heating pipes, radiators heating elements in the floor .

The basic material from which made Delta pipe, tube and twin-tube butterfly is aluminum with heat dissipation of 150 to 200 watts. The main disadvantage of aluminum as a material for heating in the location of animals, is its high susceptibility to corrosion, especially in the presence of ammonia. For the installation of this equipment usually choose a place in the perforated channel feed passage during or at the height of 60 ... 80 cm in the middle section along the wall. As a result, there may be various problems. When placing were selected place under the perforated channel or feed passage, heated air immediately ventilation channel, rising up, and partially lost. If warm air to exit adequate insulating plate, it becomes possible to avoid unwanted heat loss. Twin tubes, unlike other have less horizontal surfaces simplifies cleaning them no matter where in the room they are installed. Due to a rather slow current of water in the system, water heating makes it relatively easy to adjust the desired temperature, but if the length of the pipe will be more than 12 m, to achieve the desired heat transfer at the end of the system fail because of the large heat loss by way of its passage. After 2.5 inch larger diameter pipe is passed through a unit of time more heated water

An important advantage of this type of pipes is their high resistance to external conditions, compared with aluminum. This allows you to build up heating directly in the area of animal placement at a height of about 20 cm from the floor. Typically, 2.5-inch pipes cheaper than other types of pipes, but with their installation should significantly greater financial investment. Flat radiators or heaters should be fixed at a height of about 80 cm from the floor.

For optimal heat distribution in stalls must use long radiators. This will prevent the normal lifting of warm air near the ceiling and the formation there of a thermal layer in which the temperature can sometimes be 10 ° C higher than at the location of piglets. In addition, short and tall radiators in any case will contribute to local heating, not heat distribution throughout the volume.

As one of the options for water heating market are also so-called "akvasolyary" performing quality zonal heating of piglets after weaning they relate to energy saving technologies.

The most effective teplosystemoyu, which has been successfully applied to heat just a room with weaners are "warm" floor (Fig. 2). In turn, the system is almost never used by itself, because its heat is not enough to effectively heat the entire volume. However, as an additional source of heat, especially at the initial stage of rearing, floor heating is very important. Underfloor heating is often used together with infrared heaters. This floor heating can be both electric and water. The biggest drawback is its pollution. Most exposed to this system of open top tubes with triangular profile below the slot floors. In the slot floor with triangular steel profile heating efficiency is increased through better heat conductivity and its more equitable distribution. Dung pigs significantly pollute the system heating, and increased evaporation of ammonia and other harmful gases at high temperatures significantly degrade air quality. Enabling faster ventilation raises polluted air in the warm zone placement pigs than it creates only more discomfort. Use closed heating system is also associated with a greater risk of contamination. Therefore, the longitudinal walls are hardly used. Enabling faster ventilation raises polluted air in the warm zone placement pigs than it creates only more discomfort. Use closed heating system is also associated with a greater risk of contamination. Therefore, the longitudinal walls are hardly used. Enabling faster ventilation raises polluted air in the warm zone placement pigs than it creates only more discomfort. Use closed heating system is also associated with a greater risk of contamination. Therefore, the longitudinal walls are hardly used.

Fig. 2. Application of "warm" floor combined with infrared heaters.

Heating with solid pigpens concreted floor is done by laying it in plastic or metal pipes, which will circulate coolant.

Heating pipes are characterized by maximum efficiency of heat, minimal power consumption and no need maintenance. This type of heating is often used for heating rooms and corridors of weaned piglets. The only difficulty it may cause conversion or repair of embedded pipes.

It is important to calculate the heating area that the size of the area for heating is determined depending on the number of pigs in stalls. One should bear in mind that during the first week after weaning piglets each required to have its own warm place. Accordingly, when the content in one group at stall 100 heads, floor heating area must be at least 12...15 m^2.

CONCLUSIONS

1. Not always the cheapest option will fully justify the expectations of a fairly large investment. Even more difficult situation will look teplosystemamy that require significant financial costs and alterations in the Pig.

2. Inconsistency their requirements management or failure to set functions with incorrect calculation of the need for heating or unnecessarily high cost of operation, virtually not allow something significantly change.

3. Thus, an integrated approach to the needs of the pig objective assessment of its capabilities will help make the right decisions, and gap analyzes of various systems - to prevent the occurrence of side effects in the use of expensive equipment.

REFERENCES

1. **Boltyanskaya N. I. 2012.** The development of the pig industry and the competitiveness of its products. *MOTROL*: Motoryzacja i Energetyka Rolnictwa, Vol. 14. No3b. 164-175.

2. **Sklar A. G., Boltyanskaya N. I. 2012.** Mechanization of technological processes in animal CTW. Melitopol. Kolor Print. 720.

3. **Bugaevskiy V., Ostapenko A., Danilchuk N. 2009.** The influence of climate on the efficiency of growing pigs. Agrarian. No 12. 12-13.

4. **Boltyanskaya N. I. 2017.** The dependence of the competitiveness of the pig industry from it-chnology parameters of productivity of the animals. *Bulletin of Kharkov national University-University of agriculture after Petro Vasilenko*. Kharkov. Vol. 18. 81-89.

5. **Avilov A., Denisov, A. 2011.** The influence of microclimate in pigsties on the health and productivity of animals. Pig. No 2. 26-27.

6. **Kuznetsov A. F. 2004.** Air environment and its influence on the animal organism. IP and acclimatization in animal husbandry. Saint-Petersburg. 21-27.

7. **Black M. V. 2002.** The effect of air on the health and productivity of animals. Handbook of technology and management in animal husbandry. Kharkov. Epad. 143-147.

8. **Black N. V., Dudnik A. A., Bulba D. V. 2000.** The influence of microclimate on the resistance and prevention of stress in pigs. *Problems of Zooengineering and veterinary medicine*. Kharkov. RVV HZVI. No 6 (30). 74-77.

9. **Shadrin A. M., 1972.** The influence of microclimate in the premises of a pig breeding complex on the physiological characteristics and productivity of pigs: the dissertation of the candidate of veterinary Sciences. Moscow. 16.

10. **Boltyanskaya N. I. 2016.** The creation of optimal microclimate parameters in the conditions of growing shortage of energy in the pig industry. *Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK*. Kiev. Vol. 254. 284-296.

11. **Boltyanskaya N. I. 2016.** Indicators of an estimation of efficiency of application of resourcesbut-Gauci technologies in animal husbandry. *Bulletin of Sumy national agrarian University. A series of "Mechanization and automation of production processes"*. Amount. Vol. 10/3 (31). 118-121.

12. **Boltyanskaya N. I. 2016.** The system of factors of effective application resurser-Gauci technologies in dairy cattle in the enterprise. *Scientific Bulletin Tauride state agrotechnological University. Electronic scientific specialized edition*. Melitopol. Vol. 6. Vol. 1. 55-64.

13. **Boltyanskaya N. I., Boltyanskaya O. V. 2012. 2013.** The introduction of infrared heating as a method of solving the problem of the effective heating on pig breeding farms. *Labor Tavria State Agrotechnological University*. Melitopol. Vol. 13. T. 6. 166-171.

14. **Rogovskii Ivan. 2014.** Stochastic models ensure the efficiency of agricultural machines. *MOTROL*. Lublin. 2014. Vol. 16. No 3. 296-302.

15. **Rogovskii Ivan. 2016.** Graph-modeling when the response and recovery of agricultural machinery. *MOTROL*. Lublin. Vol. 18. No 3. 155-164.

16. **Rogovskii Ivan. 2017.** Analytical provision of regular preventive maintenance of agricultural machinery and system implementation. *MOTROL*. Lublin. Vol. 19. No 3. P. 185-191.

17. **Rogovskii Ivan. 2017.** Choice of model class and method of modeling the resilience of agricultural machinery. *TEKA*. Lublin–Rzeszów. 2017. Vol. 17. No 3. 101-114.

18. **Loveykin V. S., Kovbasa V. P., Pochka K. I. 2010.** The dynamic analysis of roller forming installation with energetically balanced drive. *Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APC*, Kyiv, 2010, No 144, part 5, 338-344.

19. **Loveykin V. S., Pochka K. I. 2010.** Optimization of design data of roller forming installation with energetically balanced drive. *MOTROL*. Motorization and power industry in agriculture, Lublin, 2010, Tom 12 B, 9-18.

20. **Lovejkin V. S., Shumilov G. V. 2011.** Optimization of the mode of change of a departure of the tower crane behind single kinematic criteria. *MOTROL*. Motorization and power industry in agriculture, Lublin, 2011, Tom 13 B, 167-174.

21. **Loveykin V. S., Pochka K. I. 2016.** Analysis of dynamic equilibration by the drive of cars of roller formation. *MOTROL*. Commission of Motorization and Energetics in Agriculture, Lublin-Rzeszow, 2016, Vol. 18, No 3, 41-52.

ОБОСНОВАНИЕ ВЫБОРА СИСТЕМЫ ОТОПЛЕНИЯ СВИНАРНИКОВ

Аннотация. В статье проанализированы виды отопительных систем, для осуществления обогрева свинофермы.

Приведен удельный вес процессов теплоснабжения и обеспечения микроклимата в совокупных расходах топливно-энергетических ресурсов в помещениях для содержания свиней.

Определен необходимый температурный режим для свиноматок, поросят недели от рождения и свиней на откорме.

Определены факторы, оказывающие существенное влияние на выбор системы отопления и вентиляции свинофермы.

Приведены недостатки и преимущества систем с использованием открытых источников энергии при сжигании газа или другого топлива и систем с использованием водяного носителя тепла.

Проанализированы преимущества и недостатки инфракрасного отопления, вентиляторных конвекторов, «темных излучателей», «аквасоляриев», «теплого» пола, отопления свинарников со сплошной бетонированным полом с заложенными в него пластиковых или металлических труб, по которым циркулирует теплоноситель.

Рассмотрены оборудование для водяного отопления в помещениях с отлученными поросятами: дельта трубы, твин трубы, трубы- «бабочки» - с двумя, тремя или четырьмя пластинками

Ключевые слова: свинарник, микроклимат, теплоснабжения, система отопления, система вентиляции, преимущества и недостатки, инфракрасное отопление, теплоноситель.

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Discrete-Continual Model to Analyze and Optimize (Minimize) Dynamic Loads in Elastic Elements/Ropes for Lifting Equipment

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Summary. The discrete-continuum model for analysis and its optimization (minimization) of dynamic loads in elastic elements (ropes) of load-lifting machines is substantiated.

The influence of distributed and lumped parameters of elastic elements on the magnitude of the dynamic loads in them on the sections of transition processes (descent, inhibition, reversal of motion) is determined.

The proposed criterion of the quality of movement of the lifting mechanism of the crane, which minimizes the coefficient of dynamism in the ropes, as well as the laws of the movement of cargo, in which these criteria of optimization of dynamic loads and elastic elements are implemented, are established.

For determination of dynamic loads in an elastic element, for example, in a rope a two-mass model of a discrete type (with lumped parameters) is used, with the help of possible reactions in the motion of the drive mechanism with the drum at the descent, the reaction of motion with constant acceleration is used which minimizes the value of the driving moment drive, linear motion reaction acceleration, which minimizes the dynamic component of the drive power, reaction of motion with change of acceleration of the third order, the reaction of motion with the change of acceleration in its curve of the fifth order.

Key words: continuity, model, analysis, optimization, minimization, dynamics, loads, elastic elements, ropes, hoisting machines, cranes.

INTRODUCTION

The performance and reliability of hoisting machines, precision and performance of different types of jobs: unloading, loading, transport and other - essentially depends on the dynamic loads in elastic elements of flexible working, drive and hardware. The values of these loads depends on the area of movement of lifting machinery or its mechanism. The most dynamic stresses occur in areas transients (downhill braking movement).

One way to reduce these pressures on the drive elements are resilient cranes lifting mechanisms is necessary choices for their movements in areas transients.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

In [1] showed that during braking during downhill dynamic load factor in elastic elements of crane mechanisms reaches 2.5 or more. In [1-4] the effect of various reactions to dynamic traffic load in elastic elements of lifting equipment for example lifting mechanism. To determine the dynamic loads in the elastic element, for example, used a rope dvomasova discrete model type (with lumped parameters) diagram is presented below in Fig. 1.

At the same time as possible reactions in motion with a drum drive mechanism at the site of descent used the following 4 [3, 4]: 1) reaction motion with constant acceleration, which minimizes the value of the driving time of the drive, 2) reaction movement with linear acceleration change, which minimizes dynamic component power drive, 3) reaction to the change of motion acceleration third order, 4) reaction to the change of motion acceleration curve in his fifth order. It is the last two reactions give a smooth change of motion acceleration curved drum mechanism that would reduce the fluctuations of dynamic loads in the spring elements, but does not minimize them as a dynamic factor.

In [4] The effect of movement in response to the change and maximum values of dynamic loads in the rope when lifting load at startup, but does not include properties rope spread as elastic element lifting mechanism of the crane.

The impact of distributed properties of cables, according to the authors of this study can be defined using the approaches set out in [5-21].

OBJECTIVE

The purpose of the work is justification discrete-continuum model of lifting mechanism of a crane, which allows for distributed properties of the spring element (rope) and allows the absence to the selected quality criteria of the system to minimize the dynamic loads on the rope, to determine optimal in this sense, the laws of motion of the cargo and the drive mechanism of the drum and to identify their oscillation frequency rope that define its resonances, subject to the availability of goods enshrined in it.

THE MAIN RESULTS OF THE RESEARCH

The dynamic model of valve lift mechanism as a system with lumped parameters and its analysis.

The diagram of the dynamic model (discrete type) lifting mechanism (Fig. 1) made the following notation [4]: m, m1-built lifting channel to the masses under load and drive mechanism of the drum, x, x1 - generalized coordinates of mass m, m1, (F2, F1 - cargo weight (F2 = m1 · g, g - acceleration due to gravity) and the driving force of the drive construction to cargo rope, C - tightening rope.

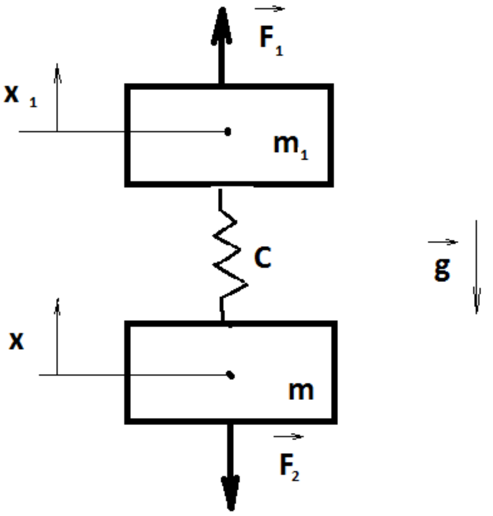

Fig. 1. The dynamic model of the crane lifting mechanism as systems with lumped parameters (discrete model type).

In the first approximation P = E S/e, where e - modulus material tightrope, S-area of its cross section, l - rope length).

The model equations of motion lifting mechanism have the form (4):

$$\begin{cases} m1 \cdot x = F1 - \ddot{C} \cdot (x1 - x) \\ m \cdot \ddot{x} = (x1 - x) - F2 \end{cases} \quad (1)$$

Which easily through simple changes to reduce to a single equation for X (E) fourth order.

Given the fact that the driving force of the drive drum is determined: F1 = F2 + (m + m1) · a (t) = mg + (m + m1)·a (t), going from (1) have:

$$X^{(IV)} + k^2 \cdot x = \ddot{=}\, k^2 \cdot a(t) \text{where } k = \sqrt{(\frac{1}{m} + \frac{1}{m1}) \cdot C}. \quad (2)$$

C - frequency natural vibrations of the discrete dynamic model of lifting mechanism, t - time, a = a (t) - function acceleration of a motion mode drive mechanism with a drum, depending on the time (t).

Solution (2) depends on the type of right that is determined by the mode of movement of the drive mechanism. Symbols Number mode 1, 2, 3, 4 above in the analysis of publications. For specific regime and (t) has the following form:

a) First rezhym-

$$a = vy / tn = coust, \quad (3)$$

b) a second rezhym-

$$a = \frac{2vy}{tn} \cdot (1 - \frac{t}{tn}), \quad (4)$$

c) The third mode-

$$a = 12 \cdot \frac{vy \cdot t}{tn^2} (1 - \frac{t}{tn})^2, \quad (5)$$

d) The fourth mode-

$$a = 60 \cdot \frac{vy \cdot t^2}{tn^3} \cdot (1 - \frac{t}{tn})^3. \quad (6)$$

Note that in the expressions (3)-(6) Vy - speed steady movement of cargo during its recovery, tn - length start (acceleration) of cargo.

Further that the point system was in the time of relative peace, that is:

$$x\frac{(t)}{t=0} = 0, x1, , 1 = 0 \qquad \frac{(t)}{t=0} = 0\dot{x}\frac{(t)}{t=0} = 0\dot{x}\frac{(t)}{t=0} \quad (7)$$

Therefore, equation (2) should roz'yazuvaty under the following initial conditions:

$$x\frac{(t)}{t=0} = 0, \dot{x}\frac{(t)}{t=0} = 0\ddot{x}\frac{(t)}{t=0} = -g, \dddot{x}\frac{(t)}{t=0} = 0. \quad (8)$$

Total (2) is:

$$X (t) = (A1 + A2 \cdot t) + B1 \cdot \sin (kt) + B2 \cdot \cos (kt) + \\ + x\ part. (T), \quad (9)$$

where the constants A1,2, V1,2 define the conditions (8) when a particular solution found (2) x part. (T). We will further deal with the movement of goods, which minimizes dynamic factor.

In the twisting element lifting mechanism, ie the rope, the section of its start when tYe [0, tn]:

$$\frac{1}{tn}\int_0^{tn}\{k \text{ дин.}(t)\}^{\;2} dt \to min \quad (10)$$

From the second equation of (1) efforts to rope are defined as follows:

$$F = C \cdot (x1\text{-}x) = m\ddot{x} + Mg. \quad (11)$$

Quality criteria of motion (10), based on (11) determines the performance of the following conditions necessary for its implementation (Euler-Poisson):

$$x^{(IV)} = 0. \quad (12)$$

Then we have:

$$\begin{cases} x^{(IV)} + k^2 \cdot x = k^2 \ddot{\cdot}\, a(t), \\ x^{(IV)} = n \end{cases} <=> \ddot{x}a\ (t). \quad (13)$$

So, to find x (G) for optimal cargo movement at the site start (in the sense of the criterion (10) should solve (13) with zero initial conditions:

$$X\frac{(t)}{t=0} = 0, \qquad \dot{x}\frac{(t)}{t=0} = 0. \quad (14)$$

According to relations (3)-(6) have.

For the first mode:

$$X (t) =, \frac{vy}{tn} . (\frac{t^2}{2}). \quad (15)$$

For the second mode:

$$X (t) =, \frac{2vy}{tn} . \left\{\frac{t^2}{2} - \frac{t^3}{6tn}\right\}. \quad (16)$$

For the third mode:

$$X (t) = \frac{12vy}{tn} . \left\{\frac{t^3}{6tn} - \frac{t^4}{6t^2n} + \frac{t^5}{20t^3n}\right\}. \quad (17)$$

For the fourth mode:

$$X (t) = \frac{60vy}{tn} . \left\{\frac{t^4}{12t^2n} - \frac{3}{20} . \frac{t^5}{t^3n} + \frac{t^6}{10.t^4n} - \frac{t^7}{42 \cdot t^5n}\right\}. \quad (18)$$

For dynamic coefficient k din. (+) (for each of the corners modes) are:

$$k\ din. (t) = +\frac{a(t)}{g}. \quad (19)$$

For the first mode of movement of the drum drive mechanism are:

$$K\ din. (T) = 1 + \frac{vy}{g.tn} = coust > 1. \quad (20)$$

For the second mode of motion of the drum drive mechanism are:

$$K\ din.\ (T) = 1 + \frac{2vy}{g \cdot tn} \cdot \left(1 - \frac{t}{tn}\right) = 1 + \frac{2vy}{g \cdot tn} - \frac{2vy.t}{gt^2n}. \quad (21)$$

Maximum values of *Dean K (t)* becomes the starting point, at t = 0:

$$Dean\ K\ (t)\ /\ max = k\ dyn\ (t)\ /t_{=0} = 1 + \frac{2vy}{g \cdot tn}. \quad (22)$$

For the third motion mode drive mechanism with a drum ends

$$Kdyn.\ (T) = 1 + \frac{12vy}{gtn}\left(\frac{t}{tn} - 2 \cdot \frac{t^2}{t^2n} + \frac{t^3}{t^3n}\right). \quad (23)$$

Maximum values of k dyn (t) becomes y at time t = tn / 3:

$$kdyn\ (t)\ /\ max = k\ dyn\ (t)\ /t =_{\frac{tn}{3}} = 1 + \frac{64vy}{9 \cdot g \cdot tn}. \quad (24)$$

For the fourth motion mode drive mechanism with a drum ends:

$$kdyn\ (t) = 1 + .\frac{60 \cdot vy}{gtn} \cdot \left(\frac{t^2}{t^2n}\right) \cdot \left(1 - \frac{t}{tn}\right)^3. \quad (25)$$

Maximum values of k dyn (t) becomes y at time t =:$\frac{2}{5}tn$:

$$\frac{k_{дин^4}(t)}{max} = \frac{k_{дин^4}(\epsilon)}{t_{\frac{2}{5tn}}} = 1 + \frac{1296 \cdot vy}{625 \cdot g \cdot tn}. \quad (26)$$

The following Table 1 shows the min and max values:

$$k_{дин^{(i)}}(\epsilon),\ \ and = (1.4)$$

$$for\ g = 9{,}81m\ /\ v_y = \frac{0{,}5м}{c}, t_n = 2{,}0c, c^2$$

Table 1. The value of min and max$k_{дин^{(i)}}(t)$, i = (1,4).

and	$k_{дин^{(i)}/min}$	$k_{дин^{(i)}/max}$
1	*1,025*	*1,025*
2	*1,000*	*1,025*
3	*1,000*	*1,181*
4	*1,000*	*1,053*

Note the following: 1) the minimum value for i = (2,4) becomes time t = tn, ie at the end of the period of start-up, 2) for i = (1,4) is not the case optimal cargo movement (oscillating) character (in contrast to the results obtained y.$k_{дин^{(i)}}(\epsilon) k_{дин^{(i)}}(t)$[4]).

Incidentally, at time t = 0 (early start):

$$k_{дин^{(t)}}\ for\ i = (3{,}4)\ k_{дин^{(\epsilon)}} = 1.$$

Thus, the motion mode drive mechanism of the drum, which ensure smooth movement and cargo, and also ideal value at the beginning (t = 0) and the late start (t = tn). This third and fourth modes (law a (t) respectively).

Given (13), we have:

$$x_1(t) \ddot{=} a(t). \quad (27)$$

Since x1 (t) are also zero-point conditions:

$$X1\ (t)\ /{,}t_{=0} = 0\, \frac{\dot{x1(t)}}{t_{=0}} = 0 (28)$$

Then the optimum law of motion x1 (t) coincide with corresponding to x (t) (15) (16) (17) (18).

The dynamic model of valve lift mechanism as a system of separated parameters and its frequency. Rope with no movement in the lifting mechanism.

Using the approach to work (6), determine the natural frequencies of the rod (model flexible rope) under the following boundary conditions:

When z = 0.

When z = l, where l-length of rope (at the time point lifting).

$$mX\ (z) = ES = E \cdot S,\cdot p^2 \cdots \frac{dX}{dz}\frac{dx}{dz}.$$

where: z - coordinate pozdovzhenya (along the axis of the straight rope), p - rope natural frequency (at rest), x (z) - own modes of rope that performs longitudinal vibrations.

Custom modes of x (z) has the following form:

$$X\ (z) = \cdot\ sin\ (+ \cdot\ cos\ (), A_1 \frac{pz}{v}) A_2 \frac{pz}{v}. \quad (29)$$

Where v - velocity of longitudinal waves in the rope,

$$V = \sqrt{\frac{E}{p}},$$

where: p - density material rope.

With conditions at z = 0, we have X (z) / = 0, so:$z_{z=0}$ $A_2 = 0$. The condition at z = l we have:

$$m \cdot p^2 \cdot \left(\frac{pl}{v}\right) = E \cdot cos. \cdot S \cdot \frac{p}{v}\left(\frac{pl}{v}\right). \quad (30)$$

Thus, the frequency equation taking into account the expression = E / p, is v^2:

$$\frac{p \cdot l}{v} \cdot tg\left(\frac{p \cdot l}{v}\right) = \frac{p \cdot S \cdot l}{m}. \quad (31)$$

So part of the equation (31) is a ratio of weight to the rope core end load (m). The value of the first root of equation (l/v) depending on the ratio = pS · l/m following (see. Table 2) $p_1\alpha$:

Table 2. depending on$\left(\frac{p_1 \cdot l}{v}\right)$ $\alpha = \frac{p \cdot S \cdot l}{m}$

α	0.10	0.30	0.50	0.70	0.90
$p_1 \cdot l/v$	0.32	0.52	0.65	0.75	0.82
α	1.00	2.00	4.00	10,00	
$p_1 \cdot l/v$	0.86	1.08	1.27	1.42	

Calculate the natural frequency of oscillation system $p_1$for different values rope length l by the following values: v = Sm / c, E = 2 · Pa, S = 25,· $10^3 10^{II} 10^{-4}м^2$.

$P = 8 \cdot 10^3 \frac{кг}{м^3}$ (steel rope), m kg. Table 3 presents the value and importance of l-frequency, which corresponds to a model system with lumped parameters and is defined, in this case, the expression $10^3 p_1 \Omega$:

$$\Omega = \sqrt{\frac{1}{m} + \frac{ES}{l}}\,. \quad (32)$$

Table 3. Value p_1 and depending on l yΩ.

L, m	5	15	25	35	45
p_1, c^{-1}	320.0	173.0	130.0	107.1	91.1
Ω, c^{-1}	316.0	182.6	141.4	119.5	105.4
L, m	50	100	200	500	
p_1, c^{-1}	86.0	54.0	31.8	14.2	
Ω, c^{-1}	100.0	70.7	50.0	31.6	

The table shows that the value of Ω significantly exceed p_1 especially for large rope length.

Natural frequencies rope for this case are determined by the following transcendental equation must solve using PC:

$$\left\{mm_1 \cdot p^4 - E^2 \cdot S^2 \cdot \frac{p^2}{v^2}\right\} \cdot sin\left(\frac{pl}{v}\right) + \left\{ES \cdot \frac{p^3}{v} \cdot (mm_1\right\} cos\left(\frac{pl}{v}\right) = 0. \quad (33)$$

The coefficient of dynamic rope lifting mechanism is determined by the formula given above for load securing points (z = l) In the case of optimum start system set modes and traffic load over the drum (also the best in terms of quality criteria of the system at the site launch).

CONCLUSIONS

1. Reasonable physical-mechanical model of lifting mechanism of a crane at the site of its descent, dyskretno-continual system parameters.
2. Modes of traffic load and drive mechanism with a drum that satisfy the quality criteria of the system that minimizes the coefficient of dynamic ropes on the site starting mechanism.
3. Obtained in the results can subsequently be used to analyze, refine, improve engineering methods for calculating mechanism lifting cranes on their site start considering discrete-continuum all the features of the latter, as well as to determine the characteristic natural vibration frequencies (long) ropes (with order to prevent their unwanted resonance vibrations) as the engine design (design of such systems and the real operation.

REFERENCES

1. **Komarov M. S. 1969.** Dynamics of lifting machines. Moscow. Engineering. 206.

2. **Kazak, S. A. 1968.** Dynamics of bridge cranes. Moscow. Engineering. 331.

3. **Gokhberg M. M. 1969.** Metal constructions of lifting – transport machines. Moscow. Engineering. 520.

4. **Lobov N. A. 1987.** Dynamics of load-lifting cranes. Moscow. Engineering. 160.

5. **Gaydamaka V. F. 1989.** Lifting – transport machines. Kiev. High school. 328.

6. **Loveikin V. S. 2004.** Modeling of dynamics of mechanisms of hoisting machines. Nikolaev. RVV NGAU. 286.

7. S**cheffler M., Dresig H., Kurt F. 1981.** Lifting – transport cranes. Moscow. Engineering. 287.

8. **Panovko J. G. 1990.** Fundamentals of applied theory of vibrations and shock. Leningrad. Polytechnic. 272.

9. **Panovko J. G. 1991.** Introduction to the theory of mechanical vibrations. Moscow. Science. 256.

10. **Loveykin V. S., Garnec V. M., Pochka K. I. 2004.** Patent of Ukraine for an invention № 67091A. Installation for formation of products from concrete mixes, № u2003076371 it is stated 08.07.2003, it is published 15.06.2004, Bulletin №6.

11. **Loveykin V. S., Pochka K. I. 2004.** The dynamic analysis of roller forming installation with the rekuperativ drive. Dynamics, durability and reliability of farm vehicles: *Works of the First International scientific and technical conference (DSR AM-I),* on October 4-7, 2004, Ternopil (Ukraine), 507-514.

12. **Loveykin V. S., Pochka K. I. 2005.** The analysis of unevenness of the movement of roller forming installation with the rekuperative drive. *Scientific and technical and production magazine «Hoisting-and-transport equipment*», 2005, No 4, 19-33.

13. **Loveykin V. S., Pochka K. I., Palamarchuk D. A. 2004.** Optimization of design data of the driving mechanism of roller forming installation with the rekuperative drive. *Scientific and technical magazine «Technology of construction»*, Kyiv, 2004, No 15, 40-48.

14. **Loveykin V. S., Pochka K. I. 2010.** The analysis of unevenness of the movement of roller forming installation with energetically balanced drive. V*ibrations in the equipment and technologies*, 2010, No 4 (60), 20-29.

15. **Loveykin V. S., Pochka K. I. 2010.** Optimization of design data of roller forming installation with energetically balanced drive. *MOTROL*. Motorization and power industry in agriculture, Lublin, 2010, Tom 12 B, 9-18.

16. **Loveykin V. S., Pochka K. I. 2004.** The analysis of the movement of roller forming installation with the balanced drive. *Bulletin of the Kharkiv national automobile and road university*, 2004, No 27, 95-101.

17. **Loveykin V. S., Pochka K. I. 2005.** The power analysis of roller forming installation with the balanced drive. S*cientific bulletin of National agricultural university*, 2005, No 80, 346-356.

18. **Loveykin V. S. 1989.** Assessment of the movement of mechanisms and cars. *Hoisting-and-transport equipment*, Kyiv, Tehnika, 16-18 (in Russian).

19. **Lovejkin V. S., Shumilov G. V. 2011.** Optimization of the mode of change of a departure of the tower crane behind single kinematic criteria. *MOTROL*. Motorization and power industry in agriculture, Lublin, 2011, Tom 13 B, 167-174.

20. **Loveykin V. S., Pochka K. I. 2015.** The analysis of unevenness of the movement of roller forming installation with the balanced drive. *MOTROL*. Commission of Motorization and Energetics in Agriculture, Lublin-Rzeszow, 2015, Vol. 17, No 3, 17-27.

21. **Loveykin V. S., Pochka K. I. 2016.** Analysis of dynamic equilibration by the drive of cars of roller formation. *MOTROL*. Commission of Motorization and Energetics in Agriculture, Lublin-Rzeszow, 2016, Vol. 18, No 3, 41-52.

ДИСКРЕТНО-КОНТИНУАЛЬНІ МОДЕЛИ В АНАЛИЗЕ И ОПТИМИЗАЦИИ (МИНИМИЗАЦИИ) ДИНАМИЧЕСКИХ НАГРУЗОК В УПРУГИХ ЭЛЕМЕНТАХ / КАНАТАХ ГРУЗОПОДЪЕМНЫХ МАШИН

Аннотация. Обоснована дискретно-континуальная модель для анализа и его оптимизации (минимизации) динамических нагрузок в упругих элементах (канатах) грузоподъемных машин.

Выяснен влияние распределенных и сосредоточенных параметров упругих элементов на величину динамических нагрузок в них на участках переходных процессов (спуск, торможение, реверсирование движения).

Предложенный критерий качества движения грузоподъемного механизма крана, по которой минимизируется коэффициент динамичности в канатах, а также установлены законы движения груза, при которых реализуется указаны критерии оптимизации динамических нагрузок и упругих элементах.

Для определения динамических нагрузок в упругом элементе, например, в канате использована двухмассовых модель дискретного типа (с сосредоточенными параметрами), при этом в качестве возможных реакций в движения приводного механизма с барабаном на участке спуска использованы реакции движения с постоянным ускорением, который минимизирует величину движущего момента привода, реакции движения линейной изменением ускорения, минимизирует динамическую составляющую мощности привода, реакции движения с изменением ускорения третьего порядка, реакции движения с изменением ускорения в его кривой пятого порядка.

Ключевые слова: дискретность, континуальность, модель, анализ, оптимизация, минимизация, динамика, нагрузки, упругие элементы, канаты, грузоподъёмные машины, краны.

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Justification of Capacity of Pellets Granulation Line at Private Enterprise "Malyn Furniture Factory"

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Summary. Furniture manufacturing is linked with the deep round timber processing and characterized by the creation of the significant amount of wood waste, precisely, more than 70% of the beginning amount of round wood. According to this fact, during a long period of time, high attention have been paid to the technologies of processing these waste in order to increase companies' profits. Therefore, by conducting a literature review, it is known that waste of wood processing can be used to produce building materials, namely, wood chip board, wood fiber board, medium density fibreboard. Additionally, saw dust, chips and other similar waste are used as a substrate for growing of plants or as fuel for boilers.

Private enterprise "Malyn furniture factory" produces timber, glulam, furniture boards, sofas, case furniture, tables, chairs, molding and veneered interior doors. In order to manufacture this assortment of goods, the factory processes 1500 m³ of round timber each month. As a result, it is generated 165 t. of half beams and 90 t. of sawdust each month during the primary wood processing. These types of wood waste have high humidity and ash-making impurities (bark, sand, etc.), and cannot be used to produce pellets, currently. Therefore, their usage is limited by the direct burning in the boilers to obtain thermal energy for facilities heating and timber drying. During the production of semi fabrications out of timber with humidity of 8-10%, it is generated 150 t. of the offcuts, 84 t. of wood wool and 32 t. of sawdust. All these waste have necessary quality and humidity to be used for pellets manufacturing. Lastly, during the final stage of furniture production, it is created 19 t. of offcuts and approximately 52 t. of wood wool and sawdust. Offcuts that were obtained after furniture boards processing consist of glue and cannot be used to produce pellets. On another hand, wood wool and sawdust have acceptable quality.

The overall amount of wood waste that have necessary quality and humidity to be used in pellets manufacturing at PE "Malyn furniture factory" is 318 t. per month. Based on the 8-hour working day and two-shift schedule, the calculated productivity of the pellets' granulation line that uses only wood waste generated on each production stage with the necessary quality is 964 kg/h. Currently, PE "Malyn furniture factory" uses Italian granulation line P-System P-500 with the capacity of 400 kg/h to produce pellets. As a result, the company generates more raw materials for pellets' production than can recycle with existing granulation line. Therefore, the head department of PE "Malyn furniture factory" is planning to increase the amount of produced pellets by installing new and more productive granulation line.

Key words: Malyn furniture factory, wood waste, pellets, calculated productivity.

INTRODUCTION

The technological process of wood harvesting and its processing is linked with the generation of a significant amount of wood waste. Harvesting, delivery, and processing of wood are technological processes that characterized by the loss of a portion of the wood that cannot be used to produce final wooden goods. For instance, during the harvesting and delivery of round wood, approximately 20% of the beginning amount of round timber is waste, namely, branches, stumps, and roots. Moreover, around 20% of delivered wood cannot be used due to the insufficient quality. Accordingly, timber manufacturing generates 35-42% of wood waste whereas furniture manufacturing generates up to 70% of wood waste from the beginning amount of round timber.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Waste of wood processing can be used to produce building materials, namely, wood chip board, wood fiber board, medium density fibreboard. Bigger offcuts are used to produce smaller goods, precisely, wooden boxes, stands, etc. Wood wool and grained chips are used in the manufacturing of hard granulated fuel.

To start with, in the work [1] described the usage of wood waste in the manufacture of MDF (Medium Density Fibreboard). In [2] presented the study of polymer matrix composite reinforced with powdered remnants MDF received as waste furniture. The production of fiberboard from the waste products of Brazilian Oak (Tauari) furniture is described in [3]. As a connecting element, polyurethane adhesive with castor oil was used up to 16%. The density of such boards was 1000 kg/m^3. The production of wood waste wood fibers collected in the Japanese furniture industry containing Pometia pinnata, Pseudotsuga menziesii and Cryptomeria japonica with different particle forms was described in [4]. The compression was carried out at a temperature of 180° C and an initial pressure of 3 MPa. The pressing time is 5 minutes. The density of the fiberboard was 720 kg/m^3. The study of the characteristics of these plates showed that the caravan fiberboard has somewhat worse properties than other fiberboard. Improvement of these characteristics can be achieved by mixing caraway waste with higher quality wood particles such as Cryptomeria japonica or Pseudotsuga menziesii. The new composite plastic with wood from wood waste and dedicated high-density polyethylene [5]. It has been found that larger particles of wood fiber exhibit better mechanical properties.

In [6] it is indicated that in the production of rattan furniture, about 50% of the material is lost. In order to reduce the material loss, it was suggested that the waste be processed into a barrier-free board with no connective materials with properties similar to those of Hibiscus cannabinus, coconut husk, and sugar cane boards using hot pressing. The villages were dried and then subjected to hot compression at a pressure of 147,5 kPa. In the article [7] it is noted that the Wilhelm Klauditz Institute developed a multi-stage chemical-thermo-mechanical process that allows the production of particles and fibers from old furniture and industrial residues. With this process, it is possible to produce boards of elongated particles and fibers with the same or even higher properties than the original product, without the addition of fresh particles or fibers. There are two industrial plants in operation: the largest of them has an annual capacity of about 30000 tons of dry extracted particles.

In [8], a study was made on the use of wicker furniture from rattan wastes as a material for the production of cement slab. Three-layer plates with a density of 1050 kg/m^3 and 1200 kg/m^3 and a thickness of 6 mm were made. In the production of plates, the ratio of mixing Portland cement and rattan waste was used as 2,5:1,0, 2,75:1,0, 3,0:1,0, 3,25:1,0. The paper [9] describes experimental studies on the use of clayey earthwood and wood chips in combination with classical connecting elements (cement and lime). New building materials (for terrestrial terraced houses) using clay and chips were made. The proposed material has the same mechanical characteristics as bricks of burnt clay.

In [10], wood waste, including wastes from furniture production, was investigated for the production of wood chips as a filling of pipes and filling of mounds. It is established that woodcock is suitable as a non-structural material for filling the masonry, but not as a material for filling pipes. In [11], it was proposed to compost the wood bark obtained after the cracking of the branches of trees that are going to produce furniture. Composted wood bark with its high air content and good drainage properties is widely used for growing plants in containers.

The [12] describes studies of 31 furniture industry enterprises in the province of Gumushan, Turkey. Surveys were conducted using personal interviews. It was found that in the manufacture of furniture, MDF and, at a lesser extent, wood particle board, were used, and when cutting, two major types of waste were produced in the form of fine dust and fractional fragments of these slabs. Of the waste recovered, 96,9% was used for heating homes and workplaces, where they burned under incomplete combustion. Work [13] describes the use of waste products for the production of furniture for the production of electricity in Malaysia. In [14], the method of obtaining energy by means of joint gasification of coal and wastes of furniture production is described. Mixtures of bituminous coal from the Pittsburgh pool № 8 and and the waste products of the furniture industry (sawdust) were jointly gasified in a gasifier with a fluidized bed. The results of gasification of the mixture of coal and sawdust showed slight differences in operations in comparison with work only on coal. At the same time, the transport properties of the mixture of coal and sawdust were significantly improved compared to coal. The paper [15] describes the co-incineration of furniture production processes with solid household wastes for energy production. Part of the furniture waste was subjected to torreasing using a rotary chamber reactor. The burning of wood waste, including furniture, in the furnace with boiling sham-rum, is investigated in [16]. The paper [17] describes the possibility of obtaining high-quality generating gas from wood, including from wastes from furniture production.

The production of fuel briquettes from the waste products of the furniture industry in the form of chips and larger particles in various proportions with the addition of kraft-lignin is described in [18]. Briquettes were made using temperatures of 60°C, 75°C and 90°C. The pressing and cooling time was 5 minutes, and the pressing pressure was $68{,}9 \cdot 10^5$ N/m^2. The presence of 20% kraft-lignin has the advantage of increasing the resistance and durability of briquettes.

At the same time, there are restrictions on the use of waste from furniture production due to the geographic location of the furniture factories producing these wastes and the enterprises that process them. In [19], an internet-geographical information system (or Internet GIS) was developed to support decision-making in analyzing geospatial data for collecting and transporting wood waste in the furniture industry based on minimum costs.

OBJECTIVE

The objective of our research is the justification of capacity of the granulation line that recycles wood waste of furniture manufacturing at PE “Malyn furniture factory”.

THE MAIN RESULTS OF THE RESEARCH

Private enterprise “Malyn furniture factory” is the manufactory that equipped with modern machinery and produces a wide assortment of goods, precisely, sawn timber, glulam, furniture boards, sofas, case furniture, tables, chairs, molding and veneered interior doors. In order to recycle generated wood waste, pellets granulation line was installed. All production technology of PE "Malyn furniture factory" is divided into separate stages:

1. *Harvesting.* The enterprise has forest harvesting department. The proper technical equipment allows the enterprise to carry out work on the harvesting of round timber in the amount of 1500 m^3 per month.

1

2

3

Fig. 1. Primary wood processing: 1 – sawmill department, 2 – offcuts in packs, 3 – sawdust in the tank next to the boiler-house.

1

2

Fig. 2. Use of primary wood waste to obtain heating energy: 1 – waste before loading to the boiler, 2 – burning waste in the boiler.

2. *Primary wood processing.* In the sawmill department No 1 (Fig. 1, 1), the primary processing of wood is carried out. As the output, edged and unedged sawn timber are produced and two types of waste are generated, namely, offcuts (Fig. 1, 2) and sawdust (Fig. 1, 3). The sawn timber is packed in packs, and sawdust and offcuts are accumulated in the tank next to the boiler-house of the enterprise. This waste is used as fuel (Fig. 2) for heat generation, precisely, for the heating of industrial premises and to provide the required temperature regime inside the drying chambers.

3. *Drying of timber.* Sawn and packed sawn timber are moved to drying chambers with the help of a forklift truck (Fig. 3, 1). This equipment of the Italian company INSORLAN was installed at the factory in 2009. The drying process is carried out for 7-50 days depending on the size and type of wood and its initial moisture content. The entire drying process is automated. Control is carried out

using processors and appropriate software (Figures 3, 2). For the production of furniture and doors, the humidity of wood should be within 8-10% after drying.

4. Manufacture of semi fabrications. After the drying process, the sawn timber enters the department No. 2, where further processing and manufacturing of semi fabrications takes place. The wood undergoes the following technological operations: board cropping (Fig. 4, 1), timber cutting with the help of the SurerCut optimizer (Fig. 4, 2) in order to remove knots, resin pockets, cracks, etc. During these operations, the significant amount of dried offcuts (Fig. 4, 3) are generated, which are raw materials for the production of pellets.

After the calibration on a four-sided machine, previously made semi fabrications are transported to a finger joint line where they are glued together in glulam of preset length (Fig. 5). This operation is performed on the latest equipment of the Italian company Spanevello.

The final processing of the semi fabrications is the profiling of the glulam on the four-sided machine (see Fig. 4, 2) in order to obtain calibrated semi fabrications with the required sizes (up to 0.1 mm). After that, the semi fabrications are placed on pallets, packed and shipped to the production warehouse. After the cutting and calibration operations, wood dust is generated (Fig. 6), which is used for the pellets production.

5. Manufacturing of finished products. Several production departments, which produce finished products, are organized at the private enterprise "Malyn furniture factory". Depending on the type of product, semi fabrications are transported to the different departments. During the production of the furniture boards and furniture out of them, the corresponding glulam is glued into boards on the special press machine for transverse gluing. After that, boards are calibrated to the necessary thickness and cut to the required sizes on the Italian panel-sizing machine Sicar BOOM-3200 (Fig. 7). As a result, generated offcuts consist of glue and, therefore, are not suitable for the pellets production, but can be used to generate energy by burning in a boiler.

1

2

Fig. 3. Drying of timber: 1 – drying chamber with timber and waste of wood processing, 2 – monitor of the control processor of the drying chamber.

1

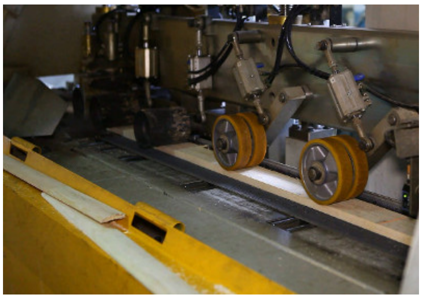

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Fig. 4. Manufacture of semi fabrications: 1 – board trimming, 2 – timber cutting with the SuperCut optimizer, 3 – offcuts.

Fig. 5. Production of the finger joined glulam: 1 – machinery with shaper knives, 2 – cut semi fabrications before finger-joining, 3 – press machine of finger joint line, 4 – glulam.

Fig. 6. Wood wool on the four-sided machine after profiling of the glulam.

Before painting and assembling of the finished products, the necessary holes are drilled in the parts on the drill machine Alhra21.

The waste of this operation are chips that used for the production of pellets (Fig. 8).

The process of veneered doors production takes place in the department No 5. Depending on model of door, the semi fabrications are assembled in frames, covered in MDF (Fig. 9, 1) on a special press machine (Fig. 9, 2), calibrated to the preset thickness (Fig. 9, 3) and cut.

1 2 3

Fig. 7. Production of the furniture boards: 1 – press machine for transverse gluing, 2 – panel-sizing machine SICAR BOOM-3200, 3 – formatted furniture boards.

1 2 3

Fig. 8. Drilling of the holes on Alpha21 drilling machine: 1 – general view of the machine, 2 – the process of drilling holes, 3 – wood wool as the waste of operation

The generated waste are wood chips and offcuts, which are unsuitable for the pellets production due to the content of glue residues but are acceptable for obtaining thermal energy by burning in a boiler.

After that, the frames are covered by high-quality veneer on the SICAR hot plate presses and the Spanish shaving machine BARBERAN (Fig. 10).

Veneered door frames, door boxes, and trims undergo a stage of grinding and drilling of assembly holes. The complete set of door parts, according to the order, arrives at the painting department. The products are painted with the necessary color, packed and sent to the warehouse of the finished products.

The technological line of pellets production out of the wood processing and furniture production waste at PE "Malyn furniture factory".

As the private enterprise "Malyn furniture factory" produces pellets only out of own furniture production waste, the volume of its production is proportional to the volume of the main production. The average monthly volume of round wood processing (mainly pine) by the factory is 1500 m^3, or with a coefficient of full-strength 0,65 [20] – 2310 volumeters. As the density of pine is 500 kg/m^3 [21, p. 17], the factory processed 1500×500=750000 kg. or 750 t. of round wood monthly.

During the primary wood processing, it is generated 22% of the offcuts and 12% of sawdust out of the beginning volume of round wood [21, p. 29]. The output of the main products (boards and bars) is 100-22-12=66%, or 740×0,66=495 t./month. Consequently, during the processing of round timber on the sawmills, it is generated:

– Offcuts: 750×0,22=165 t./month,

– Sawdust: 750×0,12=90 t./month.

This waste has high humidity and the presence of non-combustible materials (bark, sand, etc.) and cannot currently be used to produce pellets.

Fig. 9. Covering of parts by veneer: 1 – wooden beams covered by MDF, 2 – press machine used to cover beams and frames by MDF, 3 – Grinding machine for wooden beams.

Fig. 10. Machinery used to cover wooden products by the veneer.

Their usage is limited by combustion in a boiler to obtain heating energy that is used for drying of timber in drying chambers and to provide the necessary temperature regimen in the production, domestic and administrative premises of the enterprise. In order to use this waste as the raw materials for the pellets production, they have to be dried and debarked. In the production of semi fabrications out of timber with a moisture content of 8-10%, the waste output are offcuts (30%), wood wool (17%), sawdust (6,5%) [22, p. 24]. Thus, during the manufacturing of semi fabrications, the next waste is generated:

– offcuts: 495×0,3=150 t./month,

– wood wool: 495×0,17=84 t./month,

– sawdust: 495×0,065=32 t./month

The production of semi fabrications generates 150+84+32=266 t. of waste and 495-266=229 t. of semi fabrications per month in total. All the waste obtained during the manufacturing of semi fabrications have the required quality and humidity for the pellets production.

During the production of finished products, the next amount of waste is generated, precisely, 8,2% of offcuts, 22,0% wood wool and 0,6% of sawdust [22, p. 24]. Consequently, the enterprise generates the next amount of waste at this production stage:

– offcuts: 230×0,082=19 t./month,

– wood wool and sawdust: 230×0,226=52 t./month

Offcuts that are obtained during the processing of the furniture boards, consists of admixtures of glue and cannot be used to manufacture pellets. On another hand, wood wool and sawdust (52 tons per month) that are generated after drilling holes in the furniture parts can be used for the production of pellets.

Consequently, the amount of waste currently suitable for the pellets production is 266+52=318 t./month. The rest of the waste cannot be used to manufacture pellets for various reasons and, therefore, burned in the boiler to obtain the thermal energy.

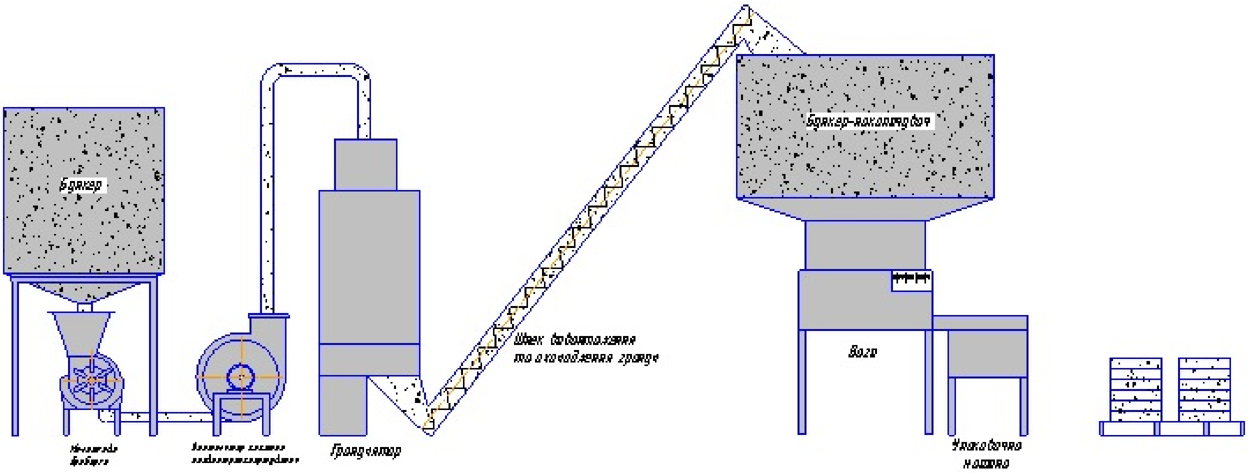

Fig. 11. Technological scheme of the pellets production line with additional crusher.

According to the two-shift work schedule of the pellets granulation department, 8 hours of working time per one shift (of which about 0,5 hours can be spent on preparatory works and daily maintenance of the granulation line, therefore, the net working time of the granulation line will be 8-0,5=7,5 hours), and 22 working days per month (in average), the calculated capacity of the granulation line is:

$$\frac{318}{22 \cdot 2 \cdot 7{,}5} = 0{,}964 \text{ t./hour.}$$

Currently, the Italian line with a productivity of 400 kg./hour is used for the production of wood pellets at the private enterprise "Malyn furniture factory" (Fig. 11). As a result, the factory generates more raw materials that are suitable for the pellets production than can be recycled with the existing granulation line. Therefore, the management of PE "Malyn furniture factory" plans to expand the production of granulated biofuel through the introduction of a new, more productive, pellets production line.

CONCLUSIONS

1. The estimated productivity of the pellets production line with the usage of only wood waste with acceptable quality, precisely, dried and debarked, at PE "Malyn furniture factory" is 964 kg./hour.

2. Currently, the Italian line with a productivity of 400 kg./hour is used for the production of wood pellets at the private enterprise "Malyn furniture factory".

3. Consequently, the factory generates more waste that is suitable for the pellets production than can be recycled with the existing granulation line.

4. Therefore, the management of PE "Malyn furniture factory" plans to expand the production of granulated biofuel through the introduction of a new, more productive, pellets production line.

REFERENCES

1. **Palanikumar K., Valarmathi T. 2016.** Experimental Investigation and Analysis on Thrust Force in Drilling of Wood Composite Medium Density Fiberboard Panels. Experimental Techniques. 40(1). 391-400. doi: 10.1007/s40799-016-0044-6.

2. **Gomes J. W., de Souza L. G. M., de Souza L. G. V. M., Santos N. R. 2015.** Production and Characterization of Polymeric Composite Materials Using MDF Waste in Powder and Poliester Terephthalic Resin. Materials Research-Ibero-American Journal of Materials.18. 25-29. doi: 10.1590/1516-1439.338014.

3. **Santos W. L. F., da Silva A. J. P., Cabral A. A., Mercury J. M. R. 2014.** Particleboard Manufactured from Tauari (Couratari oblongifolia) Wood Waste Using Castor Oil Based Polyurethane Resin. Materials Research-Ibero-American Journal of Materials.17(3). 657-663. doi: 10.1590/S1516-14392014005000013.

4. **Rofii M. N., Yumigeta S., Kojima Y., Suzuki, S. 2013.** Effect of furnish type and high-density raw material from mill residues on properties ofparticleboard panels. Journal of Wood Science. 59(5). 402-409. doi: 10.1007/s10086-013-1353-3.

5. **Valles-Rosales D. J., Mendez-Gonzalez L. C., Rodriguez-Picon L. A., del Valle-Carrasco A., Alodan, H. A. 2016.** Wood Chile Peppers Stalks-Plastic Composite Production. Maderas-Ciencia Y Tecnologia. 18(1). 179-190. doi: 10.4067/S0718-221X2016005000018.

6. **Zuraida A., Maisarah T., Wan-Shazlin-Maisarah W. M. Y. 2017.** Mechanical, Physical And Thermal Properties of Rattan Fibre-Based Binderless Board. Journal of Tropical Forest Science. 29(4). 485-492. doi: 10.26525/jtfs2017.29.4.485492.

7. **Michanicki A. 1996.** Recovery of fibers and particles from wood-based products. Use of Recycled Wood and Paper in Building Applications Conference, Madicom. Use of Recycled Wood And Paper in Building Applications. 115-119.

8. **Olorunnisola A. O., Adefisan O. O. 2002.** Trial production and testing of cement-bonded particleboard from rattan furniture waste. Wood And Fiber Science. 34(1). 116-124.

9. **Badea C., Dan S. 2016.** Unburned Clay Bound Building Materials for Masonry. Materiale Plastice. 53(4). 681-684.

10. **Imteaz M. A., Altheeb N., Arulrajah A., Horpibulsuk S., Ahsan A. 2017.** Environmental benefits and recycling options for wood chips from furniture industries. Proceedings of The Institution of Civil Engineers0Waste and Resource Management. 170(2). 85-91. doi: 10.1680/jwarm.17.00011.

11. **Carlile W. R. 2005.** The use of composted materials in growing media. International Symposium on Growing Media, Angers, France. Proceedings of The international Symposium on Growing Media. 779. 321-327. doi: 10.17660/ActaHortic.2008.779.39.

12. **Top Y. 2015.** Waste generation and utilisation in micro-sized furniture-manufacturing enterprises in Turkey. Waste Management. 35. 3-11. doi: 10.1016/j.wasman.2014.09.028.

13. **Ratnasingam J., Ramasamy G., Ioras F., Thanasegaran G. 2016.** Potential Co-Generation of Electrical Energy from Mill Waste: A Case Study of the Malaysian Furniture Manufacturing Industry. Bioresources. 11(2). 5064-5074.

14. **McLendon T. R., Lui A. P., Pineault R. L., Beer S. K., Richardson S. W. 2004.** High-pressure co-gasification of coal and biomass in a fluidized bed. Biomass & Bioenergy. 26(4). 377-388. doi: 10.1016/j.biombioe.2003.08.003.

15. **Kopczynski M., Lasek J. A., Iluk A., Zuwala J. 2017.** The co-combustion of hard coal with raw and torrefied biomasses (willow (Salix viminalis), olive oil residue and waste wood from furniture manufacturing). 4th International Conference on Contemporary Problems of Thermal Engineering (CPOTE), Katowice, Poland. Energy. 140(1). 1316-1325. doi: 10.1016/j.energy.2017.04.036.

16. **Redko A., Pivnenko Y. 2015.** Experimental and Theoretical Researches of Hydrodynamics of the Fluidized Bed of Wood Waste. Motrol. 17(6). 27-34.

17. **Tsyvenkova N., Golubenko A., Mulyar A., Los L., Romanyshyn A. 2016.** The Investigation of the Technical Specification of Gas Generator Purification System. Motrol. 18(1). 71-80.

18. **Gouvea A. D. G., Carvalho A. M. M. L., Silva C. M., Carneiro A. D. O., Trugilho P. F., de Freitas F. P., Valadares L. B., Gomes C. M., Costa E. B. 2017.** Stufy of The Addition of Lignin Extracted From Kraft Black Liquor in The Mechanical Prorrieties of Briquettes. Ciencia Florestal. 27(3). 1029-1036.

19. **Susanty A., Sari D.P., Budiawan W., Sriyanto Kurniawan H. 2016.** Improving green supply chain management in furniture industry through Internet based Geographical Information System for connecting the producer of wood waste with buyer. 7th International Conference on Ambient Systems, Networks and Technologies (ANT-2016) / 6th International Conference on Sustainable Energy Information Technology (SEIT-2016), Madrid, Spain. Procedia Computer Science. 83. 734-741. doi: 10.1016/j.procs.2016.04.161.

20. **Roundwood and sawn timber. 2007.** Method of measuring parameters. DSTU EN 1310:2005 from 1th January 2008. Kyiv: Derzhstandart Ukraine [in Ukrainian].

21. **Golovkov S. I., Koperin I. F., Naidenov B. F. 1984.** Energeticheskoe ispolzovanie drevesnyih othodov [Energy use of wood waste]. Moscow: Forest industry, 224.

22. **Collection of methods for calculating waste generation volumes. 2004.** St. Petersburg: СОЕНК, 77.

ОБОСНОВАНИЕ МОЩНОСТИ ПЕЛЛЕТ ЛИНИИ ГРАНУЛИРОВАНИЯ ЧАСТНОГО ПРЕДПРИЯТИЯ “МАЛИНСКАЯ МЕБЕЛЬНАЯ ФАБРИКА”

Аннотация. Производство мебели связано с глубокой круглой обработкой древесины и характеризуется созданием значительного количества древесных отходов, точнее, более 70% начало объем круглого леса. По данному факту, в течение длительного периода времени, большое внимание было уделено технологии переработки этих отходов в целях повышения ответственностью профсвоему. Поэтому, проводя обзор литературы, известно, что отходы переработки древесины могут быть использованы для производства строительных материалов, а именно ДСП, ДВП, МДФ. Кроме того, опилки, щепа и другие отходы используются в качестве субстрата для выращивания растений или в качестве топлива для котлов.

Частного предприятия “Малинская мебельная фабрика” производит брус, клееный брус, мебельные щиты, диваны, корпусная мебель, столы, стулья, литье и шпонированные межкомнатные двери. Для того, чтобы изготовить этот ассортимент товаров, завод перерабатывает 1500 м^3 круглого леса в месяц. В результате создается 165 Т половина лучей и 90 Т. увиделпыли каждый месяц во время первичной обработки древесины. Эти виды отходов древесины имеют высокую влажность и зольность-оформление примесей (кора, песок и т. д.), и не может быть использована для производства пеллет, в настоящее время. Поэтому их использование ограничивается прямого сжигания в котлах для получения тепловой энергии за услуги отопления и сушки древесины. Во время съемок полу измышления из древесины с влажностью 8-10%, она производится 150 тонн. из обрезков, 84 т. из древесной шерсти и 32 Т. опилок. Все эти отходы имеют необходимые качества и влажности, чтобы использоваться для производства пеллет. Наконец, на заключительном этапе производства мебели, он создан 19 тонн. из обрезков и примерно 52 т из древесной шерстью и опилками. Отходы, которые были получены после обработки мебельных щитов состоит из клея и может быть использован для производства пеллет. С другой стороны, древесная шерсть и опилки имеют приемлемое качество.

Общее количество древесных отходов, которые имеют необходимые качества и влажности для использования в гранулы производства на ЧП “Малинская мебельная фабрика” составляет 318 Т. в месяц. Основана на 8-часовой рабочий день и двухсменный график работы, расчетную производительность линии грануляции гранул, что используются только древесные отходы, образующиеся на каждой стадии производства с необходимым качеством является 964 кг/час. В настоящее время, ЧП “Малинская мебельная фабрика” использует итальянскую линию гранулирования П-системы С-500, с производительностью 400 кг/ч для производства топливных гранул. В результате, компания производит больше сырья для производства пеллет, чем может переработать существующие линии грануляции. Таким образом, начальник отдела ЧП “Малинская мебельная фабрика” планирует увеличить объем производства окатышей за счет установки новых, более продуктивных линий грануляции.

Ключевые слова: Малинская мебельная фабрика, древесные отходы, пеллеты, расчетную производительность.

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Technological Basis for Process Control of Production of Poultry Production

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Abstract. The article summarizes the existing domestic, European and North American methodological requirements to test set of machines for poultry.

Characterized that the method of comparing the values of indicators in the subject of complex regulatory requirements and with relevant indicators for complex analog.

It is also established that the results of mathematical processing of measurement data used for comparison with the required values of technical specifications with the state acceptance tests (technical terms, if state periodic testing) for a decision on the conformity of the test complex technical requirements to technical specifications). There are two possible cases.

Also, for comparison of parameters obtained in the prototype testing of complex equipment and complex analog calculate the significance of differences in means.

Recommendations from the results of testing complex take on the basis of results of comparison of values of indicators of the test of complex equipment technical requirements for supply, zootechnical requirements and values for complex analog.

Key words: methodology, requirement, test, complex, machine for poultry.

INTRODUCTION

Poultry is a company specialized intensive poultry meat or egg directly.

Poultry feed derived from feed mills, while products produced evenly and rhythmically throughout the year.

Consider the following methods of cultivation and poultry, sexual, cellular and combined.

In the floor keeping chickens kept pas poultry house floor with possible walking or not.

In keeping chickens are outdoors and find their own food, herbs, insects, mineral supplements and more.

With this increased maintenance labor costs and limited concentration of livestock.

Floor cultivation and breeding chickens is to use deep litter on the floor planchastiy or mesh, good ventilation, optimal light conditions.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

This increases the level of mechanization and automation of manufacturing processes, improves productivity, increases economic efficiency [1-5].

In keeping Cage chickens are placed in the cellular batteries consisting of several layers of cells [6, 7]. In each cell to accommodate 3-10 10-60 chickens or chicks [8-12]. Location chickens in small groups reduces stress in the formation of groups easier to observe them [13-15]. The relatively limited movement of chickens in cages leads to reduction of feed costs by 10-25% compared to the floor while keeping the same performance [16].

In keeping Cage increase the cost of the metal, but there is no need to litter in livestock increases 3-4 times per unit area [17-19].

Combined cultivation is that chickens to 1.5-2 months of age are kept in cages with heated and then transferred them to the floor in keeping light areas that are not heated. This method is used in small poultry farms [20].

OBJECTIVE

Purpose of research – to reveal the main methodological requirements to test a set of machines for poultry farming.

THE MAIN RESULTS OF THE RESEARCH

The process of egg production can consider poultry pas example of a complete cycle, ie from hatching eggs and meat to the diet of laying (Fig. 1).

The process of production of dietary egg starts in 1 shop breeder chickens, which provides full economy hatching eggs. Breeder located in housings 10 thousand heads, divided into 4-5 sections.

The shop incubation grade 3 eggs, disinfects and lay in bulk incubators for chickens according to a given rate of production. Streams 4 day-old chicks and 14 come from the workshops of incubation to 5 workshops cultivation and breeding heifer replacement deha breeder 17.

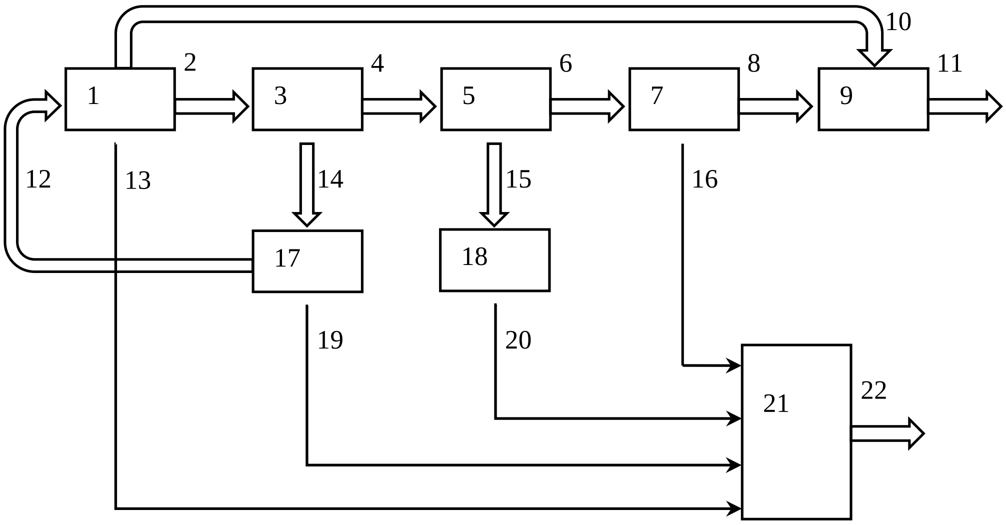

Fig. 1. Scheme of egg production process: 1 - shop of a parent herd, 2 - flow of incubation eggs, 3 - the shop of incubation, 4, 14 - streams of day-old chicks of industrial and pedigree herds, 5 - Growing shop, 6 - flow of young animals, 7 - industrial plant herd, 8, 10 - eggs flows, 9 - the shop for processing eggs, 11 - a stream of dietary eggs, 12 - the stream of repair young animals, 13, 16, 19, 20 - streams of discarded chickens in processing shops, 17 - Growing shop of young pigs of the parent flock, 15 - the flow of cockroaches, 18 - shop for fattening cocks, 21 - shop for processing chickens, 22 - sales of meat.

In plant breeding 5 day-old chicks are placed in a prepared disinfected the room and hold up to 140 days of age, depending on the method of keeping the floor, in cages or in combination.

Then the stream top 12 cockerels and chickens parental forms sent to the breeder, and 6 stream of young plant growing - for the acquisition of industrial herd of 7 to 180 days of age, they are at heifer replacement.

Rooster separated from the chickens in the daily or 30-day age and sent to the plant feeding 18 which are raised for meat subject to special diets.

Stream 20 cockerels egg breeds rent for slaughter at the age of 60-90 days, when they reach mass 700-1200 g.

Shop 7 industrial flock of chickens is the main element that gives dietary eggs.

Chickens are kept in cages without cockerels. Stream 8 eggs collected from the hens of industrial herd and unsuitable for incubation breeder 10 goes to the processing plant Egg 9, where they are sorted, cleaned, packed and sent for implementation.

Main production sector towards the egg - an egg diet (stream 11), and support - from chicken rejected (13, 19, 20, 16) chickens, roosters and vyhodovanyh cockerels.

The shop processing chickens spend 21 slaughter, processing carcasses, sorting, cooling and packaging for sale.

Industrial aviary egg direction control is a complex subject with many uncertain ties.

Analysis of facility management is complicated by the fact that the processes in the poultry house, providing reception planned number of eggs do not occur during continuous operation, due to the presence of a large number of random disturbances.

It should also be noted that the facility management total number of parameters to take into account when calculating the value management rather large. The composition of the flow of information can be found by expert assessments at three levels: engineer operator, foreman, chief specialist.

To ensure the validity of the results of examination recommended rank correlation method which allows to determine the relationship between the findings of the panel. For poultry egg direction, the flow of information can be presented three types of parameters: technical, technology, technical and economic.

Prospects of automation in poultry. We was designed microprocessor control and process control in the poultry house. Fragments of the system implemented on the farm "Kiev" and achieved high economic performance.

The principle of operation of the system shown in the block diagram (Fig. 2). Process control by means of microcontrollers UYS2721.

To improve the reliability of the control of the controller duplicated. When leaving one microcontroller system is blocked and process control equipment and takes over another controller.

This signal is formed in damage to unit coordination and implementation of parallel processors. When a mismatch control signal signal appears the damage coming on both processors.

The result is an automatic test both processors in which determine the one that failed. Allowing management of non-working CPU will then be available.

Management in this case, go to the processor, and display information through the block will be presented to the operator. Control signals from the processor enters the processor, and then depending on the type of control equipment enters the decryption unit, or digital-to-analog converter.

To control the ventilation control signal in the form of eight parallel code enters the digital-to-analog converter where converted to an analog signal into a voltage and hits the boards ventilation.

Managing other technological equipment decryption unit carried out by forming a control signal on it.

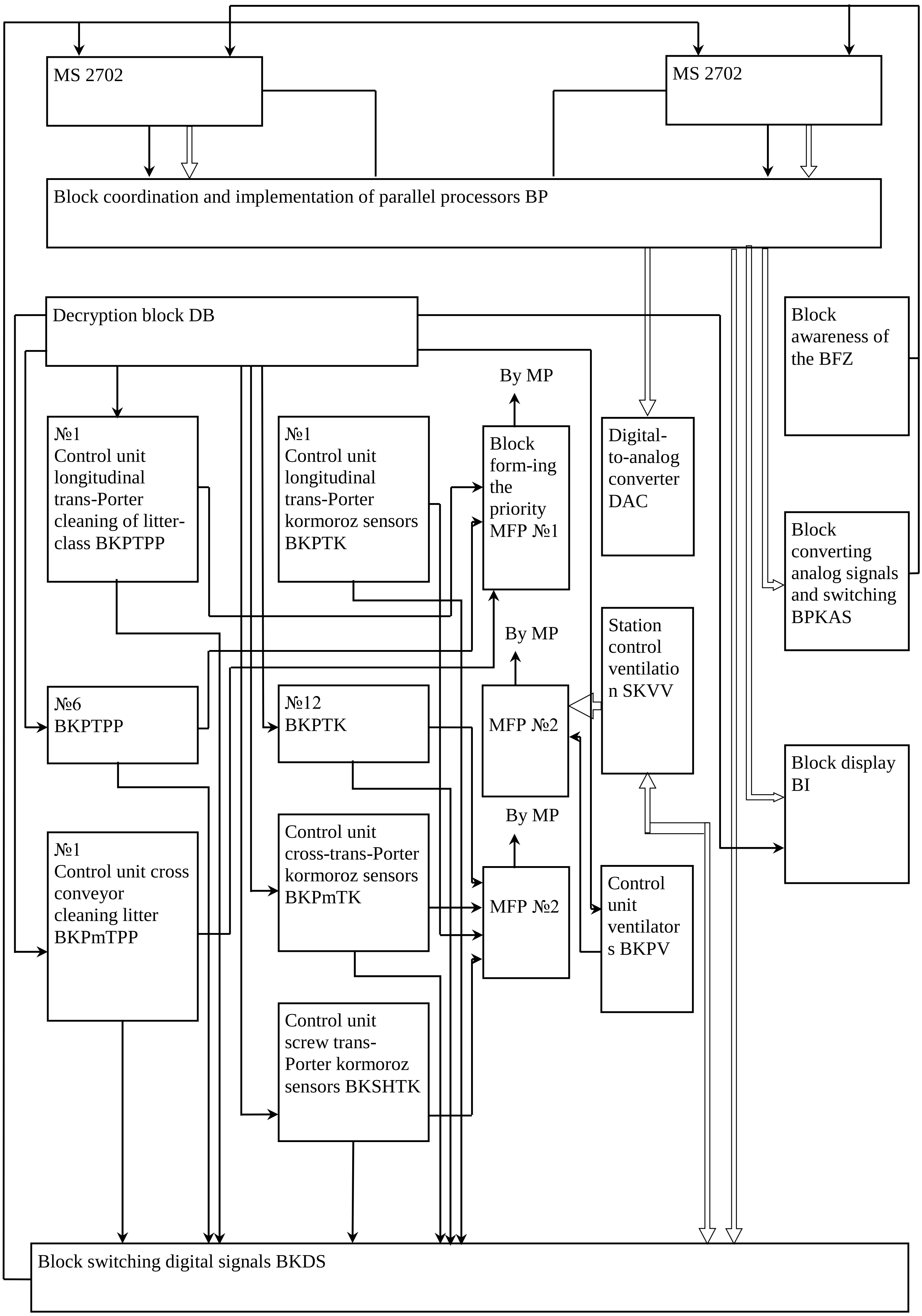

Fig. 2. Block diagram of the microprocessor system of monitoring and control of technological parameters in the poultry house.

Fig. 3. Exterior of water.

Fig. 4. Appearance feed flow type ECHO.

To control the process control unit used kormorozdachi longitudinal conveyor kormorozdachi LP ... L'12 control unit kormorozdachi cross conveyor, screw conveyor control unit kormorozdachi.

To control the process of removing litter from the block decryption signal supplied to the control unit longitudinal conveyor cleaning litter N1 ... N6, and the control unit transverse conveyor cleaning litter.

Forced ventilation to control signal from the decryption unit enters the control unit ventilators. At malfunction in the control circuit electrical equipment, the failure of electric motors, with output operating modes beyond the nominal power in the formation of a priority signal which generates an interrupt signal entering the microprocessor.

Information about the rejection and the current values (on request) process parameters is formed and displayed in the block display.

Request current values of microclimate organization formed in the block query. Converting analog signals and input them into the microprocessor is in unit conversion and switching of analog signals.

In this system, such converters used (Fig. 3-5): temperature measuring - sensor type TSM, for humidity - sensor type DV-1K, to measure the cost of feed - flow type ECHO, for measuring water consumption - flow type IP.

IT farm designed and put into operation the first stage of the automatic control system integrated poultry farms (Fig. 6). Hierarchical it has two levels: the automated production management system, it includes automated dispatch control system and two automated process control systems - automated process control systems and automated power management process poultry. Through an automated system supervisory control is centralized temperature control in poultry houses - the system "Chestnut - T" - and centralized control and management regime in light housings - "Chestnut - C".

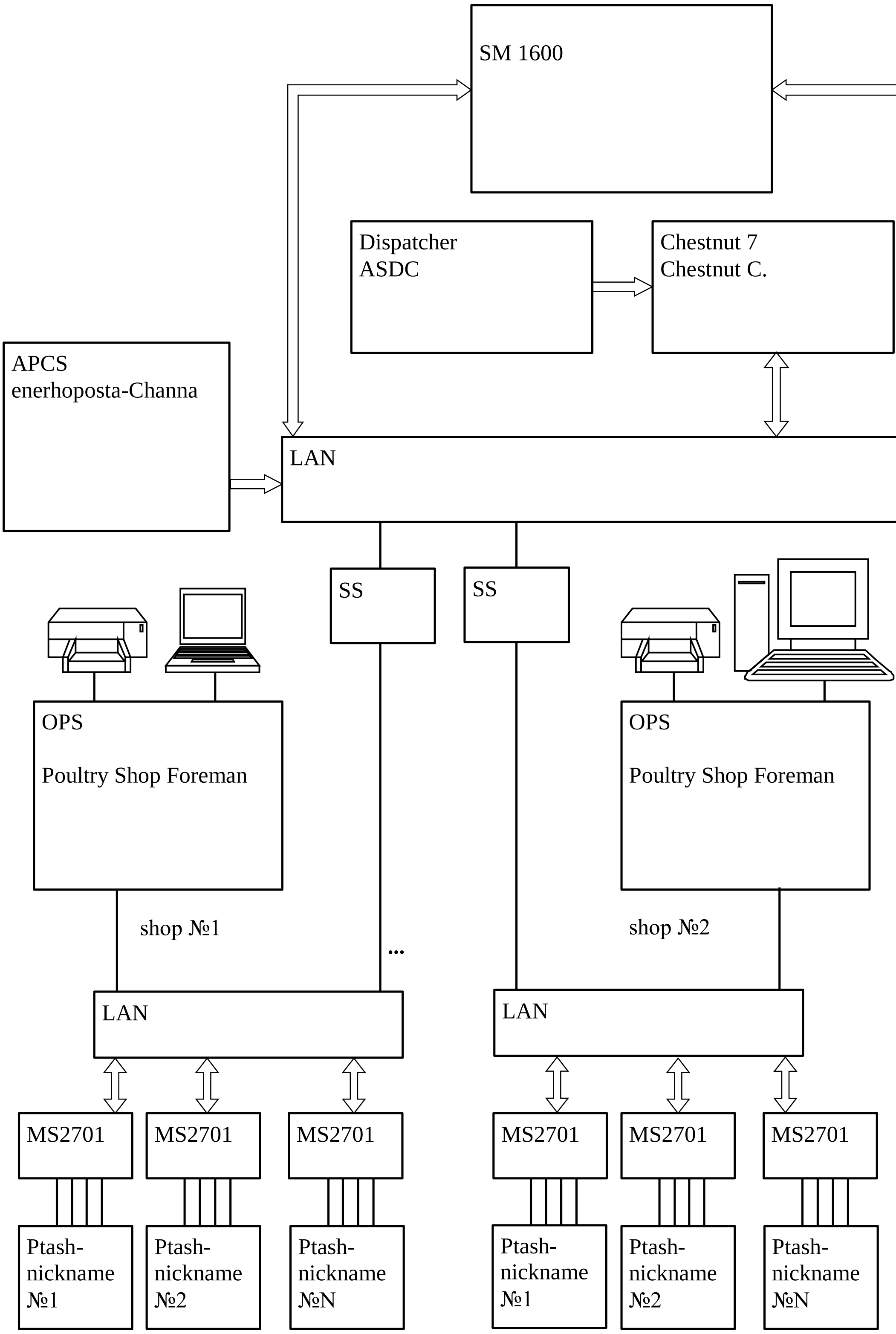

Fig. 6. Physical structure of the automated control system of technological processes at the poultry farm: ADCS - automated dispatch control system, DC - device of conjugation, OpD - operator's desk.

Fig. 7. Cell battery CBN for keeping chickens: 1 - drinking equipment, 2 - frame, 3 - cage, 4 - feeder, 5 - fodder breeder.

Table 1.

Settings		
technical	technological	feasibility
Failure: fan motor, Engine cellular batteries. Control operability of electrical equipment (motors protection). Diagnosis and forecasting of electric motors. Diagnosis and management circles of power networks (primary measuring transducers). Self control systems. Work tidal ventilation and exhaust systems. Work ventilators and water heaters.	Temperature: inner, external. The concentration of CO_2. Illumination during daylight hours. The growth of mass poultry. The velocity of the air. The temperature of the coolant, which is fed to the poultry house heating system. Number of coolant that passes through the circle opposite the shop and each poultry house (room) apart. The presence and quantity of fodder in the bunker. The concentration of NH3.	Egg production, egg / h. Gross production of eggs. Livestock poultry. The cost of feed: g / head, kg / 1000 pcs. eggs. Water consumption: g / head, kg / 1000 pcs. eggs. Culling chickens% of total stock, for slaughter, mortality. Figure culling in relation to cross biological characteristics. Dynamics of egg weight. Electricity consumption. Prediction yaytsenosnosti. Cost: USD. / 1000 pcs. eggs, UAH. / 1 kg of feed.

Table 2.

Parameters		
technical	technological	technical and economic
Fault: fan motors, cell battery motors. Control of the electrical capacity of electrical equipment (protection of electric motors). Diagnostics and forecasting of electric motors. Diagnostics of control circuits and power networks (primary measuring transducers). Self-diagnostics of the control system. Work of the tidal and exhaust ventilation systems. Work of inflow ventilation and water heaters.	Temperature: internal, exterior CO_2 concentration. Lighting during light day. Bird mass increase. Speed of air movement. Temperature of the coolant, which is supplied to the heating system of the poultry house. The amount of coolant that passes in the back of the shop and in each poultry house (hall) separately. Presence and quantity of mixed fodders in the bunker. Concentration NH_3.	Egg yolks, eggs per hour. Gross egg production. The bird's head. Feed expenditures: g / head, kg / 1000 pcs eggs Water consumption: g / gol, kg / 1000 pcs eggs Chicken excrement,%, total number: for slaughter, mortality. Chart plot in relation to the biological characteristics of the cross. The evolution of the mass of eggs. Electricity costs. Prediction of egg production. Costs: UAH / 1000 pcs. eggs, UAH / 1 kg of feed.

CONCLUSIONS

1. Automated process control system implemented at the poultry plant poultry, comprising 5 to 10 chicken houses. Technical support this level is made on the basis of microcomputer CM 1810. Composition of this information is presented in Table 1 and Table 2.

2. Directly in poultry houses are microcontrollers type MS2721 (MS2701) performing process control in the poultry house on a given program.

REFERENCES

1. **J. Liua M. Abdalbasit, A. Gasmallaa, P. Lia, R. Yang. 2016.** Enzyme-assisted extraction processing from oilseeds: Principle, processing and application. Innovative Food Science & Emerging Technologies. Vol. 35. 184-193.

2. **Th. A. McKeon, D. L. Brandon, X. He. 2016.** Improved method for extraction of castor seed for toxin determination. Biocatalysis and Agricultural Biotechnology. Vol. 5. 56-57.

3. **Novitsky A. V. 2015.** Assessment of the reliability of funds for the preparation and distribution of feed, depending on conditions and modes of operation. Scientific Bulletin of National University of life and environmental Sciences of Ukraine. Series: electronics and energetics, agriculture. Kiev. Vol. 212. 141-147.

4. **Modern methods for the preparation and distribution of feed. 2018.** Available at: http://www.propozitsiya.com.

5. **Verkhovna Rada of Ukraine. 1994.** The Law of Ukraine "On ensuring the sanitary and epidemic well-being of the population”, Vidomosti Verkhovnoi Rady Ukrainy. Vol. 27. 218.

6. **Ministry of Health Protection of Ukraine. 1996.** Order “On Approval of State Sanitary Rules and Norms”, available at: http://zakon2.rada.gov.ua/laws/show/z0488-96 (Accessed 16 Jan 2017).

7. **Lukin V. A. 2011.** New sanitary norms and rules: first impressions. Wireless Ukraine, vol. 7(1). 18-21, Available at: http://www.wireless.ua/templates/new_template/images/wu6.pdf (Accessed 16 Jan 2017).

8. conf.rd.asu.lt/index.php/rd/article/download/151/34.html.

9. **Rogovskii I. L. 2015.** Recovery Assembly units of agricultural machines. Bulletin of Kharkov National Technical University of Agriculture named Peter Vasilenko. Kharkov. Vol. 159. 224-232.

10. **Rogovskii I. L. 2015.** Methodologist technological operations recovery of agricultural machines with limited resources. Scientific Herald of National University of Life and Enviromental Science of Ukraine.

Series: Technique and energy of APK. Kyiv. Vol. 212. Part 1. 314-322.

11. **Rogovskii I. L., Melnyk V. I. 2016.** Model of parametric synthesis rehabilitation agricultural machines. Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK. Kyiv. Vol. 241. 387-395.

12. **Rogovskii I. L., Melnyk V. I. 2016.** Analyticity of spatial requirements for maintenance of agricultural machinery. Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK. Kyiv. Vol. 251. 400-407.

13. **Rogovskii I. L. 2016.** Analysis of model of recovery of agricultural machines and interpretation of results of numerical experiment. Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK. Kyiv. Vol. 254. 424-431.

14. **Voytyuk V. D., Rublyov V. I., Rogovskii I. L. 2016.** System guidelines for quality assurance of technical service of agricultural machinery. Kiev. NULESU. 360.

15. **Rebenko V. I., Rogovskii I. L. 2017.** Methodological requirements to test set of machines for poultry. Scientific Herald of National University of Life and Enviromental Science of Ukraine. Series: Technique and energy of APK. Kyiv. Vol. 275. 311-325.

16. **Rebenko V. I., Rogovskii I. L. 2018.** Basic methodological requirements to test set of machines for poultry. Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK. Kyiv. Vol. 282. 339-350.

17. **Rogovskii Ivan. 2014.** Stochastic models ensure the efficiency of agricultural machines. *MOTROL*. Lublin. 2014. Vol. 16. No 3. 296-302.

18. **Rogovskii Ivan. 2016.** Graph-modeling when the response and recovery of agricultural machinery. *MOTROL*. Lublin. Vol. 18. No 3. 155-164.

19. **Rogovskii Ivan. 2017.** Analytical provision of regular preventive maintenance of agricultural machinery and system implementation. *MOTROL*. Lublin. Vol. 19. No 3. P. 185-191.

20. **Rogovskii Ivan. 2017.** Choice of model class and method of modeling the resilience of agricultural machinery. *TEKA*. Lublin–Rzeszów. 2017. Vol. 17. No 3. 101-114.

ТЕХНОЛОГИЧЕСКИЕ ОСНОВЫ УПРАВЛЕНИЯ ПРОЦЕССОМ ПРОИЗВОДСТВА ПРОДУКЦИИ ПТИЦЕВОДСТВА

Аннотация. В статье обобщены существующие отечественные, европейские и североамериканские методические требования к испытаниям комплекса машин для содержания птицы. Охарактеризовано, что методика сравнения значений показателей по испытуемому комплексу с требованиями нормативной документации и с соответствующими показателями по комплексу-аналогу.

Также установлено, что результаты математической обработки данных измерений используют при сравнении их с требуемыми величинами технического задания при государственных приемочных испытаниях (технических условий при государственных периодических испытаниях) для принятия решения о соответствии испытываемого комплекса требованиям технического задания технических условий). При этом возможны два случая. Также для сравнения показателей, полученных при испытаниях опытного образца комплекса оборудования и комплекса-аналога подсчитывают значимость разницы средних показателей.

Рекомендации из результатов испытаний комплекса принимают на основании результатов сравнения значений показателей испытуемого комплекса оборудования требованиям технических условий на поставку, зоотехническим требованиям и значениями показателей по комплексу-аналога.

Ключевые слова: методика, требование, испытание, комплекс, машина для содержания птицы.

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Optimal Width of Reapers Combine Harvesters

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Summary. In the article a mathematical model of calculation of optimum width of the harvesting of a combine harvester is compiled. The following combines are used for the calculation: DON-1500 B, CLASS Lexion 480 and John Deer 9640 WTS. Dependences of changes in speed of combines and direct operating costs on harvesting from grain crop yields and harvesting width of a combine are determined.

The analysis and comparison of the main performance indicators of harvester combines with different trap widths shows almost invariable values of direct operating costs due to the slight effect of width on performance. It has been determined that for John Deer 9640 WTS the optimum will be a reaper with a width of 7.5 m for a yield of 4.5 t / ha. In this case, direct costs for this reaper will be 3750 UAH / ha.

Key words: grain harvester, optimization, reaper, capacity, capacity for threshing power, crop capacity.

INTRODUCTION

The current head of agribusiness at least sometimes worried about issues efficiency performance of industrial problems faced by the economy and how long it takes to manufacture each hryvnia invested in income earned and how it will be.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Therefore, to improve the performance of production faced with a choice of purchasing harvesting equipment [1]. When choosing how to use their own experience and the experience of neighboring farms or similar area [2-5]. However, today's market harvesting machines is broad enough [6-11]. And if the choice is somehow combine can understand the question selection Reaper sometimes solved only intuitively [12-16]. Each manufacturer (or seller) SH Technology will offer a reaper, but whether it is best for a particular farm and will remain on the conscience of the seller [17]. And it is working with the owner [18]. And something to fix after the acquisition is already difficult [19]. Therefore, the question of choosing the optimal width harvesters, as a matter of choice combine harvester is no less important [20].

OBJECTIVE

The aim of the study – develop a model of optimal choice Reaper width for combine harvesters, depending on yield management and low direct operating costs.

THE MAIN RESULTS OF THE RESEARCH

Investigations obtained, which is typical indicator for the efficiency of grain harvesting can take the criterion of efficiency loss. This criterion is the sum of explicit (combine harvesting costs) and implicit (technological losses of grain). These technological losses of grain can be divided into:

– headers direct losses,
– losses associated with nedomolotom and crushing grain,
– losses due to the excess of the timing of the harvest.

Affect the obvious loss is possible by the selection of brands combine harvesters. Regarding the latter implied losses, a loss again associated with providing cleaning technique (seasonal operating time on HCC) and Quality Technology (weediness) and regulations. Question loss grain reaper depends on the optimal width for a given recent productivity culture.

To improve efficiency loss criterion we attempt to find the optimum width depends Reaper yield of grain and direct operating costs per unit of work. In this case the main criterion chosen combine speed and minimum cost.

Variables adopted for the study objective function working width Reaper (B_p), namely:

$$B_p = f\left(V_p; G_k; N_p; W; k_{p.x.}\right).$$

Depending on the size combine harvesters in the aggregate change the following parameters:

– working speed V_p km / h,
– operating weight harvester G_k Kg,
– factor working strokes combine $k_{p.x.}$,
– power on rolling N_p kW,
– variable performance combine harvester.

To determine the working speed of the LC at different Reaper width using two analytical dependence [4]

$$V_p = \frac{3.6 \cdot \left(Ne_н \cdot \xi - N_p\right)}{\frac{B_p \cdot U(1+\delta_c)(N_{ПМ} + N_{ПП})}{10} + \frac{g \cdot G_K \cdot (f+i)}{\eta_{TP}}}.$$

$$V_p^{\max} = \frac{360 \cdot q_ф}{B_p \cdot U},$$

where: $Ne_н$ - nominal effective engine power, kW,

B_p - Reaper width, m,

U - grain yield, t / ha,

ξ - motor load factor, which can be seen as transfer efficiency from the motor to the drum,

$N_{ПМ}$ - power density for threshing grain weight of 1 kg per second (9.1 kW. s / kW),

$N_{ПП}$ - power density for crushing weight of 1 kg solomystoyi 1 s. (2.1 kVt.s / kWh),

f - rolling coefficient (0.12),

η_{TP} - efficiency Transmission (0.88),

δ_c - solomystist (1.5),

G_K - combine mass and weight of grain in bunker.

Equation (1) limits the speed of the engine power harvester $Ne_н$ and formula (2). Actual capacity threshing $q_ф$. In the calculations taken by the working speed less than the calculated dependencies 1 and 2.

Operating weight combine harvester determined by the formula:

$$G_K = G_0 + G_{ж} + G_з,$$

where: G_0 - weight combine harvesters without, kg,

$G_Ж$ - weight Reaper kg,

$G_З$ - mass of grain in bunker kg (calculations made continued simplification of grain bunker weight equal to the maximum possible capacity for bunker).

$$G_З = \frac{V_б \cdot \varphi \cdot \rho}{100},$$

where: $V_б$ - the bunker volume, m^3,

ρ - density of cargo (grain) kg / m^3,

φ - ratio of the volume of bunker $\varphi = 0.95$.

Costs capacity to combine movement determined from the dependence [6]:

$$N_{пер} = \frac{g \cdot G_K \cdot V_p}{3.6 \cdot \eta_{тр}} \cdot \left(\mathrm{f} + \frac{\mathrm{i}}{100}\right),$$

where: f - coefficient of rolling,

i - the slope of the fields% if i = 0

$$N_{пер} = \frac{g \cdot G_K \cdot V_p \cdot \mathrm{f}}{3.6 \cdot \eta_{тр}}.$$

Ratio calculated in working strokes combine:

$$k_{р.х.} = \left(1 + \frac{10^3 \cdot T_{пов} \cdot W_н}{6 \cdot L_Г \cdot B_p \cdot U}\right),$$

where: $T_{пов}$ - time for one turn, h,

$L_Г$ - the length of estrus, m. (per accepted average length 1000 m).

Variable performance self-propelled combine harvester, t / h determined by the formula:

$$W_{зм} = W_{год} \cdot \left(\frac{1}{\tau_{см}} + \frac{1}{k_{р.х.}} - 1\right)^{-1},$$

where: $W_{год}$ - hourly productivity per hour of normal time, t,

$\tau_{см}$ - regulatory utilization time changes.

Productivity per hour of normal time determined through a balance of engine power, namely:

$$W_{год} = \frac{Ne_н \cdot \xi - N_{пер}}{(N_{ПМ} + N_{ПП})} \text{ T / h}$$

Change losses of grain reaper (Hedera), depending on the speed of the harvester can be determined by empirical relationship established experimentally by us:

$$\Delta = -5 \times 10^{-4} + 0.067 \cdot V_p - 7.5 \cdot 10^{-3} \cdot V_p.$$

Power, which spends equipment at threshing grain is found from the formula (8):

$$N_{обм} = Ne_н \cdot \xi - N_{пер}.$$

For cost optimization criterion adopted total direct operating costs harvest losses complemented by high-speed cutter different modes:

$$C = C_1 + C_2 + C_3 + C_4 + C_{ж} \text{ UAH / ha}$$

where: C_1 - salaries of staff serving combine UAH / ha,

C_2 - the cost of spent fuel and lubricants, € / ha,

C_3 - deductions for depreciation combine UAH / ha,

C_4 - deductions for major, minor repairs and maintenance combine UAH / ha,

$C_{ж}$ - loss of income from shedding grain reaper, € / ha,

Remuneration attendants is given by:

$$C_1 = \frac{\sum n_i \cdot m_i}{W_{зм}} \text{ UAH / ha}$$

where: n_i - remuneration for a variable rate output machine operators (support staff), USD,

m_i - employees of certain qualifications,

The cost of fuel and lubricants determined:

$$C_2 = Ц_к Q_п \text{ UAH / ha}$$

where: $Ц_к$ - integrated the price of one kilogram of fuel, UAH / kg,

$Q_п$ - fuel consumption, kg / ha.

Fig. 1. Block diagram of calculating performance HCC Grains.

Table 1. Results of calculation optimization of HCC depending on the width Reaper.

Reaper width, m	Yield, t / ha	The calculated speed, km / h	Productivity-ness, ha / h	Direct exploitation-tion costs, € / ha
5	3	7.65	2.78	1294.76
	4	6.53	2.37	1306.76
	5	5.65	2.05	1612.53
	6	4.61	1.67	1883.05
	7	3.89	1.41	2153.23
	8	3.46	1.26	2493
	9	2.97	1.08	2765.68
6	3	6.68	2.89	1110.42
	4	5.43	2.35	1288.66
	5	4.69	2.03	1630.11
	6	3.83	1.66	1903.1
	7	3.24	1.4	2175.8
	8	2.88	1.25	2519.85
	9	2.47	1.07	2795.23
7	3	5.87	2.96	1059.35
	4	4.64	2.34	1259.61
	5	4.01	2.02	1593.52
	6	3.28	1.65	1860.39
	7	2.77	1.39	2126.95
	8	2.46	1.24	2463.22
	9	2.11	1.06	2732.38

Deductions for depreciation determined:

$$C_3 = \frac{(\text{Б}_к + \text{Б}_{жс})\cdot a}{100\cdot W_{зм}\cdot t_н}.$$

Deductions for capital, maintenance and technical osbluhovuvannya combine found a similar (13):

$$C_4 = \frac{(\text{Б}_к + \text{Б}_{жс})\cdot p_{TOP}}{100\cdot W_{зм}\cdot t_н},$$

where: $\text{Б}_к$ - book value of combine harvesters USD,

$\text{Б}_{жс}$ - Reaper carrying amount, USD,

a - standard deduction for depreciation,%,

p_{TOP} - standard deductions for maintenance and repairs,%,

$t_н$ - zonal annual burden on combine harvester, h.

The value of losses from crop losses on determined by the relationship:

$$C_{жс} = U\cdot\Delta\cdot Ц_з.$$

where: $Ц_з$ - the purchase price of a ton of grain, UAH / t.

The first block diagram (left) is based on gaining performance including bandwidth thresher, solomystist and productivity. Dependence on which determine the performance metric will look like:

$$W^{э}_{год} = \frac{3.6 q_н}{U(1+\delta_c)}.$$

The second part of the block diagram (right) also shows the calculation scheme performance determining HCC, but already the part of the technical and operational capabilities combine. This relationship allows for width, yield, TSP kinematics motion, etc:

$$W_Г = \frac{0.36\cdot B_p\left(Ne_н\cdot\xi - 2\cdot q_н\right)}{\frac{B_p\cdot U(1+\delta_c)(N_{ПМ}+N_{ПП})}{10} + \frac{g\cdot f\cdot G_T\cdot t}{\eta_{TP}}}.$$

This was chosen for further calculation and performance of the two, which is smaller. Fuel consumption and other indicators were considered unchanged. Modeling calculations carried out for three combine harvesters: DON-1500 B (Reaper of 5, 6 and 7 pm), CLAAS Lexion 480 (5.4, 6, 7 pm) and the John Deere 9640 WTS (5,4, 6, 7.5 and 9 m). The results obtained by calculations optimization DON-1500B harvester presented in Table 1 and Fig. 2-4.

For ease of analysis were constructed changes depending on the speed of the combine yield for different widths Reaper (Fig. 2-4).

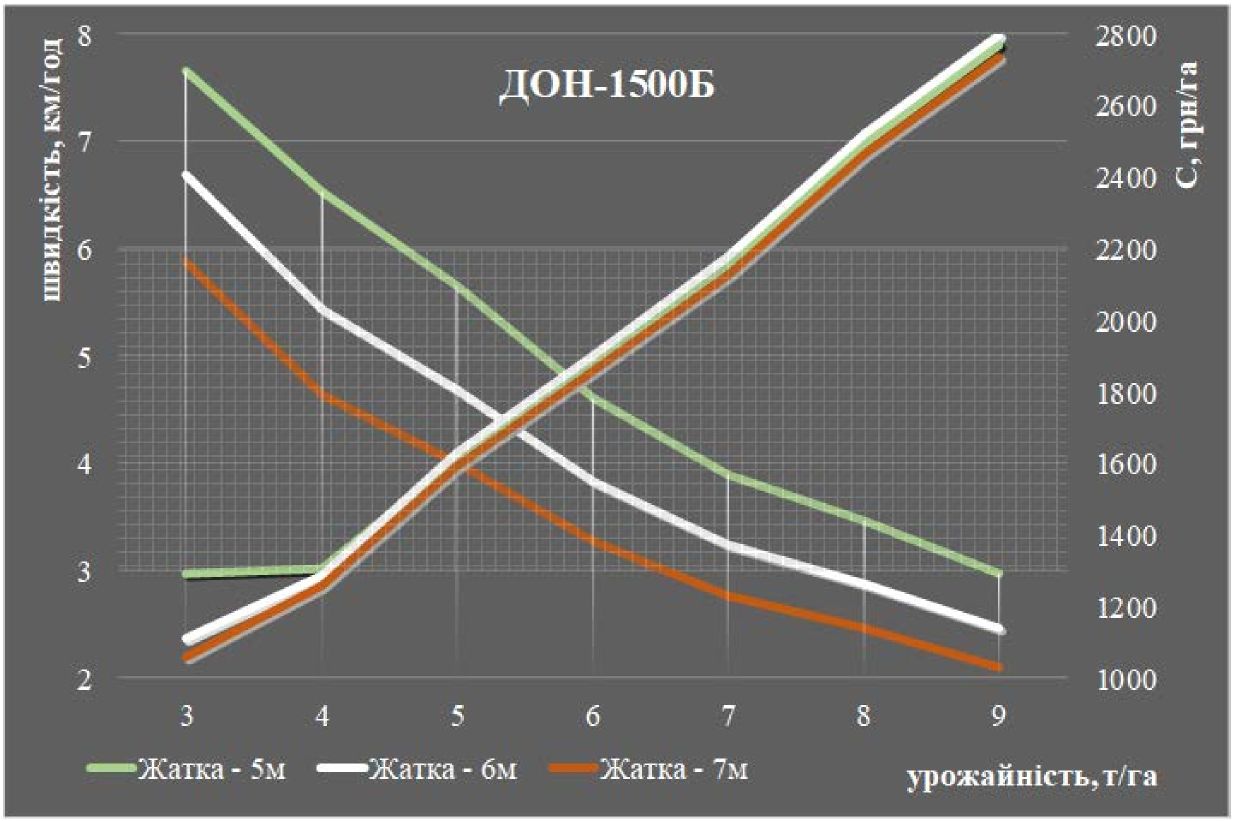

Fig. 2. Optimal Reaper width depending on the yield (DON-150B).

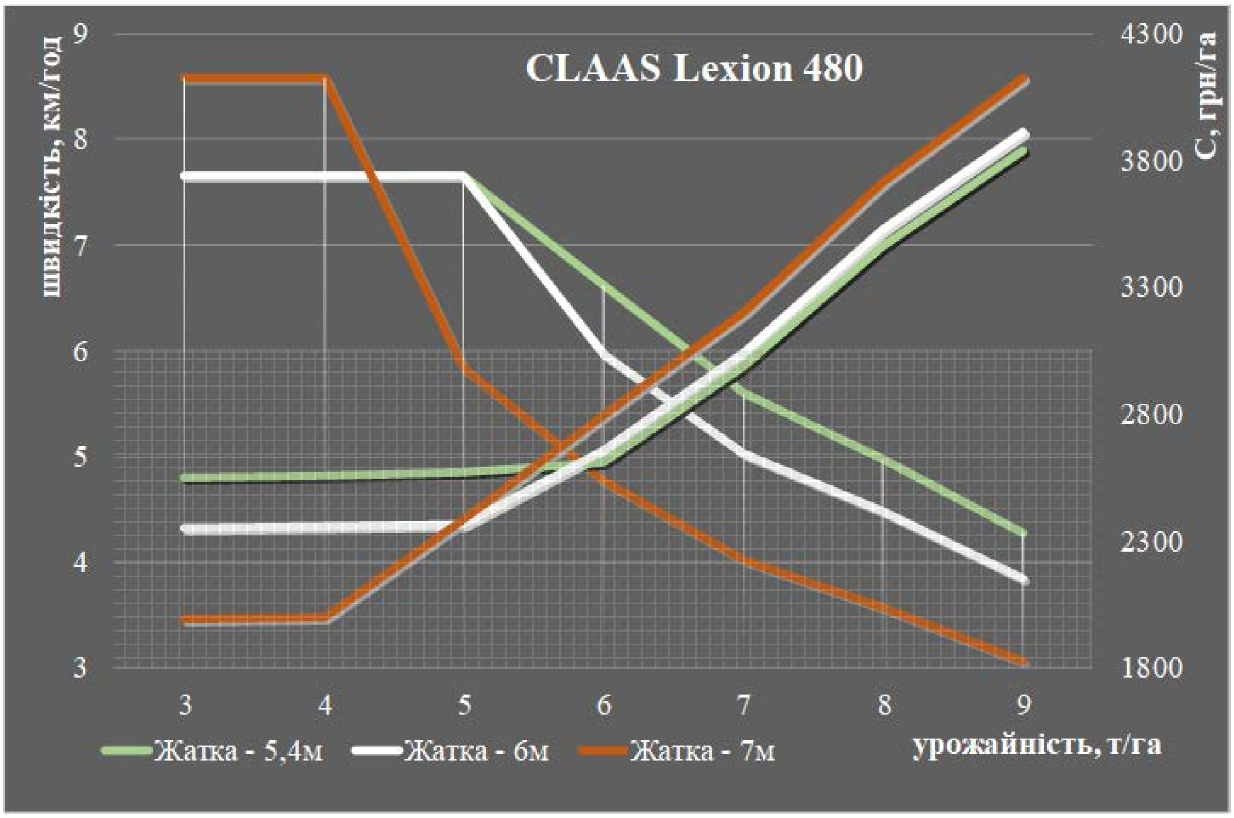

Fig. 3. Optimal Reaper width of productivity (CLASS Lexion 480).

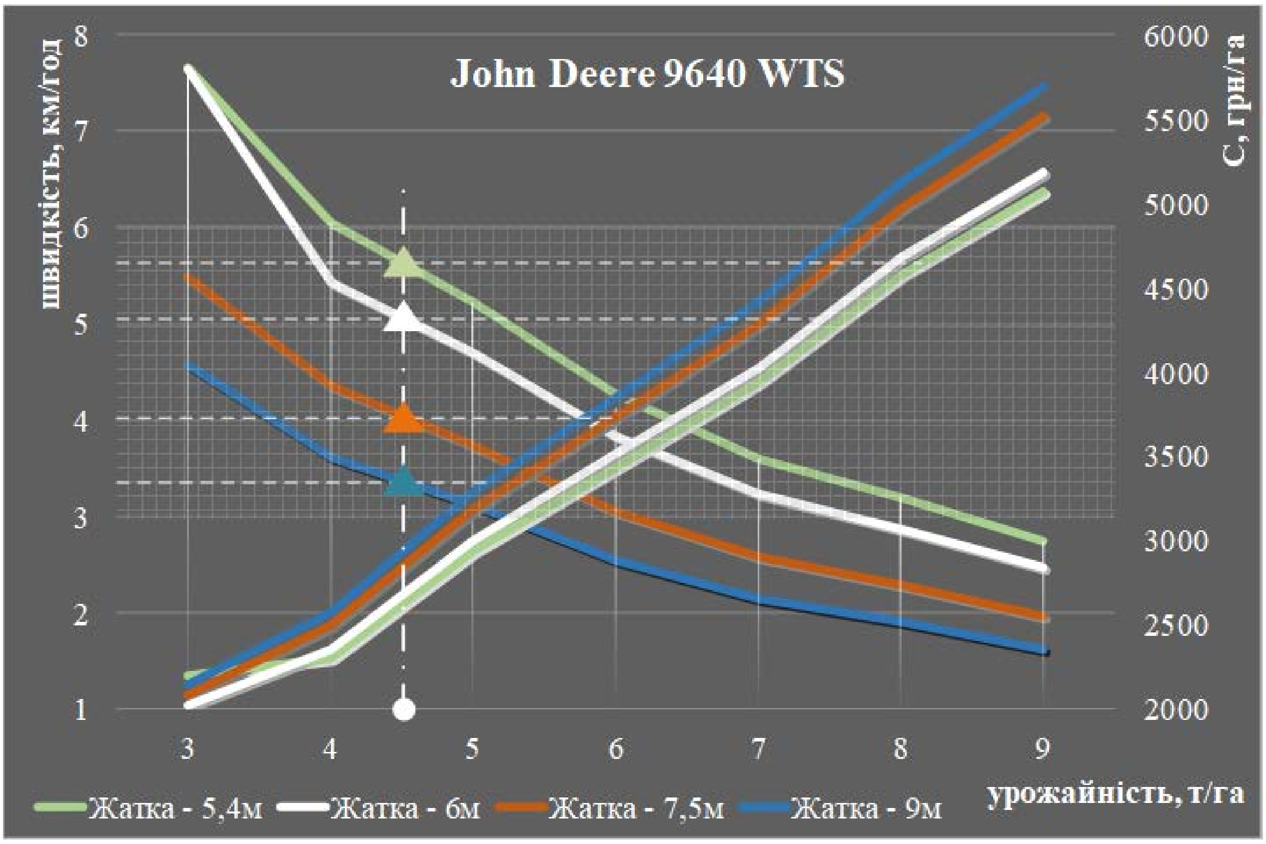

Fig. 4. Optimal Reaper width of productivity (John Deer 9640 WTS).

These graphs are shown as direct costs and direct harvesting operation and optimal speed range from 3

to 6 km/h. These charts allow you to select the desired cutter farming conditions. Knowing the average productivity in the economy, and given the prospect of improving yield selection algorithm may be as follows (Figure 4), laying on the horizontal axis pidiymayemsya desired yield to the intersection of the curves for the calculated speeds width. In this case (bottom-up) 3.36 km / h (9 m), 4.0 km / h (7.5 m), 5.15 km / h (6 m) and 5.6 km / h for the reaper width 5.4 m.

As we see all speeds are the recommended range (3-6 km / h). After the points of intersection curves to the right to the intersection of curves corresponding direct costs can be determined that these costs will be chosen with sizes ranging Reaper.

However, in our case, 5.4 m and 9 are on the border of the recommended range, and therefore can not be recommended for selection. More appropriate would be reaper width 7.5 m, since it has a reserve of speed, if improved technology and increased productivity. This selected yield 4.5 t / ha for the direct costs harvesters make 3750 UAH / ha.

It should be noted that the curves direct costs almost repeat one another with few deviations. This is because the model parameters by changing the width Reaper almost no change. Changing the weight and price slightly combine harvest machine.

Figure 3. present area, the yield of 3 to 5 t / ha, which is the same speed by changing the width. This restriction, which was laid in the model and lay in the fact that when the calculations (1, 2) speed greater than 8 km / h, then the speed taken at 8 km / h as recommended farming.

CONCLUSIONS

1. The model of choosing the optimal width of the combine harvester Reaper allow one to choose for specific conditions of the economy, the optimal width Reaper with a minimum direct operating costs.

2. Calculations for the three combine harvesters can determine the yield potential ranges for different sizes Reaper. Specifically for DON-1500 B yield range for all harvesters sizes will range from 4.5 to 6.5 t / ha for CLASS Lexion 480 from 6.5 - 9 t / ha for John Deer 9640 WTS, respectively, from 4 to 5 5 t / ha. Fluctuations in either direction yields leads to prevent the choice of one or more headers.

3. Working with optimally combine harvesters defined width will reduce the loss of grain reaper, reduce the cost of power to move the combine, which in turn further be used to provide higher performance and improved fuel economy.

REFERENCES

1. **Nadtochii O., Titova L., Rogovskii I. 2016.** Analysis of the dynamics of the combine market of Ukraine. Techno-technological aspects of development and testing of new technology and technologies for agriculture in Ukraine. Vol 20. 254-262.

2. **Voronkov O. A., Rogovskii I. L. 2016.** Analysis of the role of road transport in the transport-technological support of agriculture. A collection of abstracts of II-nd International scientific-practical conference "Modern technologies of agricultural production" (9-10 November 2016). Kiev. 215-216.

3. **Voronkov O. A., Rogovskii I. L. 2017.** Adaptation of vehicle use in technology of harvesting grain crops. Abstracts of the International scientific-practical conference "Modern technologies of grain production 2017" within the framework of VI International exhibition of innovative solutions in grain farming "Grain technologies 2017" (February 16, 2017). Kiev. 2017. 28-29.

4. **Voronkov O. A., Rogovskii I. L. 2017.** Classification features of vehicles in transport-technological processes in agricultural production. Abstracts of the II all-Ukrainian scientific-theoretical conference "the Problems with traffic flows and the ways of their solution" national University "Lviv Polytechnic (16-18 March 2017). Lions. 17-19.

5. **Voronkov O. A., Rogovskii I. L. 2017.** Analysis of current state of problem of optimization of transport and technological support AIC. The book of abstracts XI International scientific-practical conference "Obukhov" read (March 21, 2017). Kiev. 92-93.

6. **Voronkov O. A., Rogovskii I. L. 2017.** In-line transport technology of transportation of grain bread. Problems of development of transport and logistics. Collection of scientific works on materials of VII-th International scientific-practical conference, Severodonetsk, Odesa, April 26-28 2017 – Severodonetsk, Ukraine: publishing house VNU named after Volodymyr Dahl. 15-17.

7. **Voronkov O. A., Rogovskii I. L. 2017.** Methodology of experimental research of the traction characteristics of vehicles. The book of abstracts of the XVII international conference of scientific and pedagogical workers, scientific employees and graduate students "Problems and prospects of development of technical and bio-energy systems of environmental management" (20-24 March 2017). Kiev. 122-123.

8. **Voronkov O. A., Rogovskii I. L. 2017.** Analytical prerequisites to transport and technological systems of transportation of production of crop production. Theses of International Scientific Conference "Globalization of scientific and educational space. innovations of transport. problems, experience, prospects" (3-12 May 2017) / Dresden (Germany) Paris (France). 47-50.

9. **Voronkov O. A., Rogovskii I. L. 2017.** Ways to reduce energy consumption in transportation and technological support for weight of transported grain crops. A collection of abstracts of the XIII International scientific conference "the Rational use of energy in technology. TechEnergy 2017" (17-19 may 2017). Kiev. 72-74.

10. **Voronkov O. A., Rogovskii I. L. 2017.** Analytical model for energy estimation of transport technological process of transportation of grain and crop products. Journal of mechanical engineering and transport. Vinnitsa: VNTU. Vol. 1. 21-28.

11. **Voronkov O. A., Rogovskii I. L. 2017.** Approach to solving the problem of management of transport system for transporting of the grain harvest. The book of abstracts of V-th international scientific conference "Innovative maintenance of organic production in agriculture" in the framework of the XXI International agricultural exhibition "AGRO 2017" (05-06 June 2017). Kiev. 44-46.

12. **Voronkov O. A., Rogovskii I. L. 2017.** Automation operators for the monitoring of vehicles for the carriage of grain bread Automatic – 2017: international conference on automatic control, Kiev, Ukraine, 13-15 September 2017: proceedings of the conference. Kiev. 181-182.

13. 12. **Voronkov O. A., Rogovskii I. L. 2017.** Alignment of adjacent transport and technological operations of transportation of grain and crop products. Bulletin of East Ukrainian national University named after Volodymyr Dahl. No. 3. 36-43.

14. **Voronkov O. A., Rogovskii I. L. 2017.** General principles of creation of control systems of transport streams transport grain bread. Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK. Kiev. Vol. 258. 390-399.

15. **Voronkov O. A., Rogovskii I. L. 2017.** Options of structural solutions of the system of management of transport flows transport grain bread. Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK. Kiev. Vol. 262. 361-367.

16. **Shevchuk R. S., Krupych R. 2015.** Manual vibro-impact fruit shaker/ MOTROL Commission of motorization and energetics in agriculture. – Lublin-Rzeszow, Vol. 17, №4., 153-159.

17. **Sydorchuk O., Triguba A., Makarchuk O. 2012.** Optimization of the life cycle of integrated programs for harvesting grain crops. MOTROL Commission of motorization and energetics in agriculture. Lublin, Vol. 14, №4. 131-140.

18. **Sydorchuk O., Ivasjuk I., Syatkovskyy A. 2012.** Influence subject to conditions terms of tillage, planting summer-autumn period. MOTROL Commission of motorization and energetics in agriculture. – Lublin, – Vol.14, №4. 16-20.

19. **Sydorchuk A., Ivasiuk I., Ukraynecz V. 2013.** Harmonization of the components of the technological system of soil cultivation and sowing of winter crops. MOTROL Commission of motorization and energetics in agriculture. Lublin-Rzeszow, Vol. 15, №4. 180-186.

20. **Rogovskii Ivan. 2016.** Graph-modeling when the response and recovery of agricultural machinery. Motrol : Motorization and power industry in agriculture. Lublin. T. 18. №3. 155-164.

21. **Rogovskii I. L. 2016.** Analysis of model of recovery of agricultural machines and interpretation of results of numerical experiment. Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK. Kyiv. No 254. 424-431.

22. **Rogovskii I. L. 2017.** Probability of preventing loss of efficiency of agricultural machinery during exploitation. Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK. Kyiv. No 258. 399-407.

23. **Rogovskii I. L. 2017.** Conceptual framework of management system of failures of agricultural machinery. Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK. Kyiv. No 262. 403-411.

ОПТИМАЛЬНАЯ ШИРИНА ЖАТКИ ЗЕРНОУБОРОЧНОГО КОМБАЙНА

В статье составлена математическая модель расчета оптимальной ширины захвата жатки зерноуборочных комбайнов. Для расчета взяты следующие комбайны: ДОН-1500 Б, CLASS Lexion 480 и John Deer 9640 WTS.

Определены зависимости изменения скорости комбайнов и прямых эксплуатационных затрат на уборке от урожайности зерновых культур и ширины захвата жатки.

Анализ и сравнение основных показателей работы комбайнов с жатками различной ширины захвата показывает почти неизменные значения прямых эксплуатационных расходов, что объясняется незначительным влиянием ширины на показатели работы.

Определено, что для комбайна John Deer 9640 WTS оптимальной будет жатка с шириной 7.5 м для урожайности от 4.5 т/га. При этом прямые затраты для этой жатки составят 3750 грн/га.

Ключевые слова: зерноуборочный комбайн, оптимизация, жатка, пропускная способность, мощность на обмолот, урожайность.

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Entropy Conditional Subjective Preferences for Alternative Functions Defined in Conditions at Early Diagnosis of Internal Diseases of Cattle

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Summary. In this work, based on the analysis of existing methodological approaches the analysis of the patent-conjuncture, analytical and experimental basis of foreign and domestic experience in systems technical support for early diagnosis of internal diseases of cattle. The authors have determined the analytical preconditions of formation of system of technical providing early diagnosis of internal diseases of cattle. In a experimental background for the formation of systems of technical support for early diagnosis of internal diseases of cattle. Also defined mehanotron properties of the main methods of organization of communication in the engineering systems of early diagnostics of the internal diseases of cattle.

This project uses a synergistic approach, according to which any interaction of natural systems leads to exchange between matter, energy and information. While one of the systems (early diagnostics of the internal diseases of cattle) is the emitter, the other (technical mechatronic system) – battery. The sudden discharge of the first synergy of the two systems, the other system can accumulate surplus synergy with the simultaneous sudden strengthening of the dynamics of internal processes that leads to the structuring of the system and dissipation. In this self-organization leads to changes in the transmission mechanism of synergy to mechatronic system for the more intense condition.

Object of research – the structure and mechanical properties of technical support for early diagnosis of internal diseases of cattle.

Subject of research – analytical regularities of changes of structure and properties of mechatronic technical support for early diagnosis of internal diseases of cattle.

The aim of the research is to improve the adequacy of the analytical description of the structure of an adaptive system, which will include itself system technical support, system management, the environment and the system of early diagnostics of the internal diseases of cattle.

Research methods – theoretical and experimental methods of analogies and clarifications, synergetic theory at the acceptable value and regularities of parameter changes, time studies, statistical analysis, experiment planning.

It should be noted that dictionaries and encyclopedias are still identify and diagnosis the term "diagnosis" is often a medical kind of recognition, meanwhile, this kind of knowledge is distributed in different areas of scientific and practical activities of man.

Diagnosis, like scientific component as a field of scientific practice is socially determined, changing in the course of historical development of society. Its modern development in the XXI century is in the direction of empowering faster and more accurate closer to the goal, recognition of the causes of deviations from norms of a technical object. In turn, the development of diagnostics is characterized by the irregularity of the variability of its individual parties, as well as influence each other different characteristics or parameters of the controlled objects from the standpoint of information content, and often even from the standpoint of redundancy information flow. This applies to all levels and sections-theoretic adaptive systems synthesis technical support for early diagnosis of internal diseases of cattle.

Key words: synthesis, technic, support, early diagnosis, internal diseases of cattle.

INTRODUCTION

This section considers the problem of finding the optimum combination of target functions defined as conditional logic system of equations. Simulated the behavior of active systems controlled intelligent (active) element. PMSE is used for the canonical distribution of individual preferences as the solution of the problem on a conditional extremum [1].

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

In the subjective analysis of the problem facing the human consideration of participation in the entity management systems and processes in most (large numbers) research, which affect the functioning and management of the so-called active systems [2-5]. It is because the active system containing an active element (the person who is responsible for making decisions), it has features above are defined in this section [6-17].

Thus, the active intelligence system managed its active element and active element operates based on its own distribution of its benefits to all the time on the set achievable goals for its alternatives [18-24].

Consider the conventional theoretical system consisting of three equations [22]:

$$Y_{\max}(x) = \begin{cases} y_1(x), & if \;\; y_1(x) > y_2(x) \wedge y_1(x) > y_3(x), \\ y_2(x), & if \;\; y_2(x) > y_1(x) \wedge y_2(x) > y_3(x), \\ y_3(x), & otherwise. \end{cases} \quad (1)$$

Concept (1) sees $y_i(x)$ - dependence, for example, which is used to determine: Parameter Security Management active system performance indicator using the i-th operator (alternative) technical system size criterion feasibility of and the second alternative strategy, the role and the first political party (alternatives) in sociology/policy, the utility function and the second alternative in the economy and so on. al., depending on some parameters x - for example, a certain parameter usage, parameter influencing the active safety system, the value of income taxation, political index return, the proportion of light and shadow economy, etc. and v. al. Here, the system of equations (1), intelligent looking positive value. Naturally, this should be the maximum.

OBJECTIVE

The aim of the research is to improve the adequacy of the analytical description of the structure of an adaptive system, which will include itself system technical support, system management, the environment and the system of early diagnostics of the internal diseases of cattle.

THE MAIN RESULTS OF THE RESEARCH

Without doubtful if functions $y_i(x)$ are negative quality modeling should be made taking into account the relevant minimization:

$$Y_{\min}(x) = \begin{cases} y_1(x), & if \;\; y_1(x) < y_2(x) \wedge y_1(x) < y_3(x), \\ y_2(x), & if \;\; y_2(x) < y_1(x) \wedge y_2(x) < y_3(x), \\ y_3(x), & otherwise. \end{cases} \quad (2)$$

Thus, the system (1) (2) appear as examples of natural intelligence in decision-making. However, they do not represent preferences / intentions (individual preferences) active elements of the system. They do not show how much and which of the alternatives the person responsible for making decisions leans control.

Conceptual framework of subjective analysis allow you to create models of artificial intelligence systems using active functional postulated as (2).

Consider, for example, The problem with the systems specified logical conditions (1), (2). Therefore, N = 3. Suppose that $y_i(x)$ given by equations

$$y_1(x) = a(x-d_1)^k + b(x-d_1)^{k-1} + c(x-d_1)^{k-2},$$
$$y_2(x) = -a(x-d_2)^k - b(x-d_2)^{k-1} - c(x-d_2)^{k-2} + z_2,$$
$$y_3(x) = nxe^{nx} + z_3. \quad (3)$$

where: a, b, c, d_1, d_2, k, z_2, z_3, n - certain relevant factors and model parameters.

Necessary conditions for the existence of functional extremum [11] in the form of a system of equations $\frac{\partial \Phi_\pi}{\partial \pi_i} = 0$.

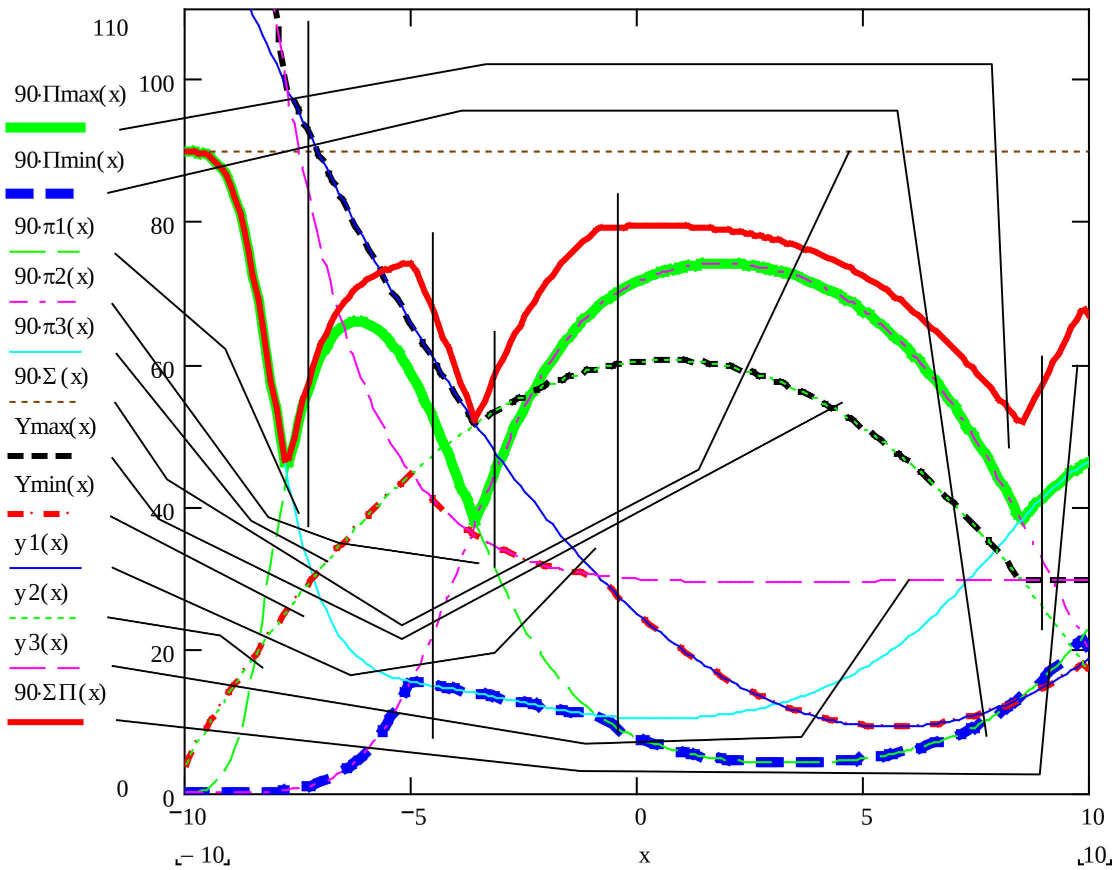

Fig. 1. Target features, advantages, their optimal combination and Smart range.

Lead to the canonical distribution of individual preferences, such as illustrated in [12], ie systems (1) (2) $N = 3$, $F_i = y_i$. They will,

$$\pi_j = \frac{e^{-\beta y_j}}{\sum_{i=1}^{3} e^{-\beta y_i}}. \quad (4)$$

For system (1) optimal combination of advantages:

$$\Pi_{\max}(x) = \begin{cases} \pi_1(x), & if \;\; \pi_1(x) > \pi_2(x) \wedge \pi_1(x) > \pi_3(x), \\ \pi_2(x), & if \;\; \pi_2(x) > \pi_1(x) \wedge \pi_2(x) > \pi_3(x), \\ \pi_3(x), & otherwise. \end{cases} \quad (5)$$

Similarly to (2)

$$\Pi_{\min}(x) = \begin{cases} \pi_1(x), & if \;\; \pi_1(x) < \pi_2(x) \wedge \pi_1(x) < \pi_3(x), \\ \pi_2(x), & if \;\; \pi_2(x) < \pi_1(x) \wedge \pi_2(x) < \pi_3(x), \\ \pi_3(x), & otherwise. \end{cases} \quad (6)$$

Introduce Smart range as

$$\sum \Pi(x) = \Pi_{\max}(x) + \Pi_{\min}(x). \quad (7)$$

The function (7), a positive value, $0 < \sum \Pi(x) \le 1$ for two alternatives $\sum \Pi(x)\big|_{N=2} \equiv 1$. Is not normalized by itself, although it is formed as a sum of functions vnormovanyh benefits covered by the system (5), (6).

In the particular case of the following data: a = 0.5, b = - 0,632, c = 9,487, d_1 = 5, d_2 = 0, k = 2, z_2 = 70, z_3 = 30, n = - 0.4, β = - 0.063 simulation results of the procedure (1)-(7) are illustrated in Fig. 1.

With diagrams built in Fig. 5 in appropriate scale shows that the optimum combination of features $y_i(x)$ meet the optimal combination of function benefits $\pi_i(x)$. Corner point change $y_i(x)$ have the same abscissa as for $\pi_i(x)$. Smart range on the one hand has its own minimum corner points with the same abscissa same as for the maximum combination of objective functions $y_i(x)$ and for the respective roles of individual preferences $\pi_i(x)$. On the other hand Smart range has its own corner points of the peaks by the same abscissa as the minimum for a combination of individual preference functions and objective functions $y_i(x)$.Considered means the application of variational problems, which develops in the subjective analysis. The problem for the entropy of benefits

$$H_\pi(x) = -\sum_{i=1}^{N=3} \pi_i(x) \ln \pi_i(x), \quad (8)$$

entropy optimal combination of advantages

$$H_\Pi(x) = -\left[\Pi_{\max}(x)\ln\Pi_{\max}(x) + \Pi_{\min}(x)\ln\Pi_{\min}(x)\right]. \quad (9)$$

Entropy best vnormovanyh combinations of preferences

$$\Pi_{\max\_n}(x) = \frac{\Pi_{\max}(x)}{\sum \Pi(x)}, \quad \Pi_{\min\_n}(x) = \frac{\Pi_{\min}(x)}{\sum \Pi(x)}, \quad (10)$$

$$H_{\Pi\_n}(x) = -\left[\Pi_{\max\_n}(x)\ln\Pi_{\max\_n}(x) + \Pi_{\min\_n}(x)\ln\Pi_{\min\_n}(x)\right]. \quad (11)$$

Entropy calculated by formulas (8) - (11) are shown in Fig. 6.

Entropic paradigm illustrated with appropriate diagrams built in Fig. 2 allows you to see that the proposed measures are relevant uncertainty thresholds for evaluating management decisions.

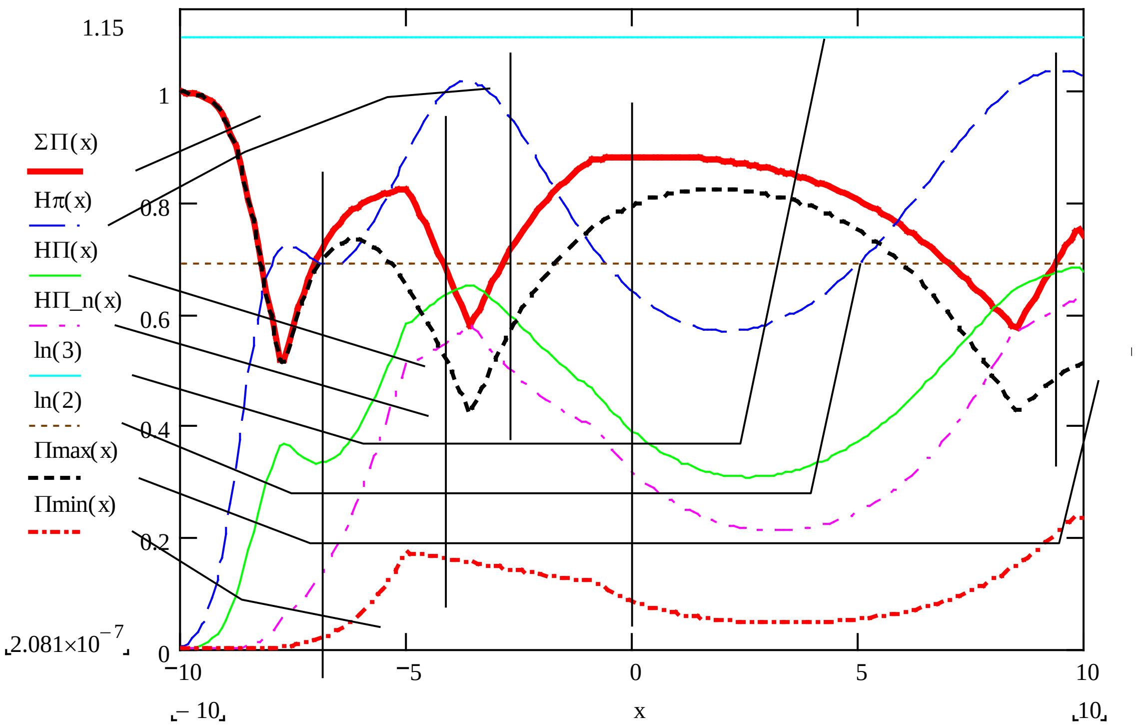

Fig. 2. Entropy advantages and Smart range.

However, comparison of entropies Smart range and optimal combination of features advantages confirms that Smart Corner point range and therefore optimum and transitions from one target to another function, not necessarily those of traditional extremes entropy (8) and clearly that entropy is taken in the traditional form (8) is not in such a setting angular points because it is in this case so that her schedule playing a smooth curve (it is everywhere differentiated function).

In contrast to her curves entropies (9)-(11) actually have the corner points with the same as the Smart range abscissa, because they have diagnostic value for optimal conversion.

To assess conflict decision making and process control operation and conflict distributions of individual preferences applied psevdoentropiyna hybrid function proposed.

The relevance of these studies is that the development of principles of construction AI assumes the existence of certain ideas about the principles of natural. It is always important to have a theoretical basis, which allows the principal models give a reasonable explanation psyhodynamitsi process control with active memory in the system, the benefits of aggregation.

When considering the functional form:

$$\begin{aligned}\Phi_\pi^{(t+1,\,t)} &= -\sum_{i=1}^{N}\pi_i^{(t+1)}\ln\pi_i^{(t+1)} + \\ &+\varepsilon^{(t+1)}\left(\pi_i^{(t+1)},\ F_i^{(t+1)}\right) + \\ &+\gamma\left(\sum_{i=1}^{N}\pi_i^{(t+1)} - 1\right)\end{aligned}, \tag{12}$$

where: t - discrete time, $-\sum_{i=1}^{N}\pi_i^{(t+1)}\ln\pi_i^{(t+1)}$ - entropy subjective individual preferences $\pi_i^{(t+1)}$ where N - number of alternatives, $\varepsilon^{(t+1)}\left(\pi_i^{(t+1)},\ F_i^{(t+1)}\right)$ - function and benefits of cognitive functions $F_i^{(t+1)}$, γ - individual psyche endogenous parameter for normalization condition $\sum_{i=1}^{N}\pi_i^{(t+1)} = 1$, function of subjective efficacy:

$$\varepsilon^{(t+1)}\left(\pi_i^{(t+1)},\ F_i^{(t+1)}\right) = \sum_{i=1}^{N}\pi_i^{(t+1)}F_i^{(t+1)}, \tag{13}$$

cognitive function:

$$F_i^{(t+1)}\left(\pi_i^{(t)}\right) = \alpha\pi_i^{(t)} + \beta\ln\pi_i^{(t)}, \tag{14}$$

where α and β - endogenous parameters for the respective functions given in the form of individual preference functions and those functions natural logarithms in the previous time t. In respect of these alternatives.

Applying the necessary conditions exist extremum of functional (12) in the form:

$$\frac{\partial\Phi_\pi^{(t+1,\,t)}}{\partial\pi_i^{(t+1)}} = 0, \tag{15}$$

gives the desired solution:

$$\pi_i^{(t+1)} = \frac{\left(\pi_i^{(t)}\right)^{\beta} e^{\alpha\pi_i^{(t)}}}{\sum_{j=1}^{N}\left(\pi_j^{(t)}\right)^{\beta} e^{\alpha\pi_j^{(t)}}}. \tag{16}$$

The distribution of benefits canonical form functions as a recursive dynamic model advantages. Dynamic features active management of uncertainty benefits system, in this case, are modeled using subjective entropy, which, in turn, is variable, dependent on the discrete points in time.

To simulate two and three steps back to get:

$$\begin{aligned}\Phi_\pi^{(t+2,\,t+1,\,t)} &= -\sum_{i=1}^{N}\pi_i^{(t+2)}\ln\pi_i^{(t+2)} + \\ &+\varepsilon^{(t+2)}\left(\pi_i^{(t+2)},\ F_i^{(t+2)}\right) + \tilde{\gamma}\sum_{i=1}^{N}\pi_i^{(t+2)}\end{aligned}. \tag{17}$$

$$\varepsilon^{(t+2)}\left(\pi_i^{(t+2)},\ F_i^{(t+2)}\right) = \sum_{i=1}^{N}\pi_i^{(t+2)}F_i^{(t+2)}. \tag{18}$$

$$\begin{aligned}F_i^{(t+2)}\left(\pi_i^{(t+1)},\ \pi_i^{(t)}\right) &= \alpha\pi_i^{(t+1)} + \beta\ln\pi_i^{(t+1)} + \\ &+\gamma\pi_i^{(t)} + \delta\ln\pi_i^{(t)}\end{aligned}. \tag{19}$$

$$\pi_i^{(t+2)} = \frac{\left(\pi_i^{(t+1)}\right)^{\beta}\left(\pi_i^{(t)}\right)^{\delta} e^{\alpha\pi_i^{(t+1)}+\gamma\pi_i^{(t)}}}{\sum_{j=1}^{N}\left(\pi_j^{(t+1)}\right)^{\beta}\left(\pi_j^{(t)}\right)^{\delta} e^{\alpha\pi_j^{(t+1)}+\gamma\pi_j^{(t)}}}. \tag{20}$$

$$\begin{aligned}\Phi_\pi^{(t+3,\,t+2,\,t+1,\,t)} &= -\sum_{i=1}^{N}\pi_i^{(t+3)}\ln\pi_i^{(t+3)} + \\ &+\varepsilon^{(t+3)}\left(\pi_i^{(t+3)},\ F_i^{(t+3)}\right) + \tilde{\gamma}\sum_{i=1}^{N}\pi_i^{(t+3)}\end{aligned}. \tag{21}$$

$$\varepsilon^{(t+3)}\left(\pi_i^{(t+3)},\ F_i^{(t+3)}\right) = \sum_{i=1}^{N}\pi_i^{(t+3)}F_i^{(t+3)}. \tag{22}$$

$$\begin{aligned}&F_i^{(t+3)}\left(\pi_i^{(t+2)}, \pi_i^{(t+1)}, \pi_i^{(t)}\right) = \\ &= \alpha\pi_i^{(t+2)} + \beta\ln\pi_i^{(t+2)} + \gamma\pi_i^{(t+1)} + \\ &+\delta\ln\pi_i^{(t+1)} + \eta\pi_i^{(t)} + \lambda\ln\pi_i^{(t)}\end{aligned}. \tag{23}$$

$$\pi_i^{(t+3)} = \frac{\left(\pi_i^{(t+2)}\right)^{\beta}\left(\pi_i^{(t+1)}\right)^{\delta}\left(\pi_i^{(t)}\right)^{\lambda} e^{\alpha\pi_i^{(t+2)}+\gamma\pi_i^{(t+1)}+\eta\pi_i^{(t)}}}{\sum_{j=1}^{N}\left(\pi_j^{(t+2)}\right)^{\beta}\left(\pi_j^{(t+1)}\right)^{\delta}\left(\pi_j^{(t)}\right)^{\lambda} e^{\alpha\pi_j^{(t+2)}+\gamma\pi_j^{(t+1)}+\eta\pi_j^{(t)}}}. \tag{24}$$

Thus, we get the model of the "memory" of the distribution of benefits "yesterday," "the day before" and "off-the day before yesterday." It becomes possible to combine and test various models of "memory". This is the way to solving the problem of forecasting the distribution of benefits in the future, based on the information stored in the memory. It is possible to investigate the influence of deleted information on the following behavior of active systems. Building on this approach, we find that in modeling scheme:

$$\begin{aligned}\Phi_\pi^{(t,\,t-1)} &= -\sum_{i=1}^{N}\pi_i^{(t)}\ln\pi_i^{(t)} + \varepsilon^{(t)}\left(\pi_i^{(t)},\ F_i^{(t)}\right) + \\ &+\gamma\left(\sum_{i=1}^{N}\pi_i^{(t)} - 1\right)\end{aligned}, \tag{25}$$

$$\varepsilon^{(t)}\left(\pi_i^{(t)},\ F_i^{(t)}\right)=\sum_{i=1}^{N}\pi_i^{(t)}F_i^{(t)}, \qquad (26)$$

$$F_i^{(t)}\left(\pi_i^{(t-1)}\right)=\alpha\pi_i^{(t-1)}+\beta\ln\pi_i^{(t-1)}, \qquad (27)$$

distribution of benefits has the form:

$$\pi_i^{(t)}=\frac{\left(\pi_i^{(t-1)}\right)^{\beta}e^{\alpha\pi_i^{(t-1)}}}{\sum_{j=1}^{N}\left(\pi_j^{(t-1)}\right)^{\beta}e^{\alpha\pi_j^{(t-1)}}}=\pi_i^{(t)}\left(\pi_j^{(t-1)}\right). \qquad (28)$$

In solving this problem, using (28) and (16) we find:

$$\pi_i^{(t+1)}=\frac{\left[\pi_i^{(t)}\left(\pi_j^{(t-1)}\right)\right]^{\beta}e^{\alpha\pi_i^{(t)}\left(\pi_j^{(t-1)}\right)}}{\sum_{j=1}^{N}\left[\pi_j^{(t)}\left(\pi_j^{(t-1)}\right)\right]^{\beta}e^{\alpha\pi_j^{(t)}\left(\pi_j^{(t-1)}\right)}}=\pi_i^{(t+1)}\left(\pi_j^{(t-1)}\right). \qquad (29)$$

Expressions (16), (28) and (29) is one and the same dependency benefits at this step of the advantages of the previous step. Any of formulas (16), (28) and (29) provides a recursive lookup procedure distribution preferences at this step in the formula for determining the allocation of the next step.

This allows you to extend the forecasting process on any number of steps.

For space dependency of steps, such as:

$$\pi_i^{(t+1)}=f\left(\pi_i^{(t-1)}\right), \qquad (30)$$

rather expressions of cognitive functions (19) (23) corresponding functional (17) (21) put:

$$\alpha=0,\ \beta=0,\ \eta=0,\ \lambda=0. \qquad (31)$$

We took a (20) (24):

$$\pi_i^{(t+2)}=\frac{\left(\pi_i^{(t)}\right)^{\delta}e^{\gamma\pi_i^{(t)}}}{\sum_{j=1}^{N}\left(\pi_j^{(t)}\right)^{\delta}e^{\gamma\pi_j^{(t)}}}, \qquad (32)$$

$$\pi_i^{(t+3)}=\frac{\left(\pi_i^{(t+1)}\right)^{\delta}e^{\gamma\pi_i^{(t+1)}}}{\sum_{j=1}^{N}\left(\pi_j^{(t+1)}\right)^{\delta}e^{\gamma\pi_j^{(t+1)}}}. \qquad (33)$$

Such a scheme may extend to forecasting any number of steps.

Mathematical modeling and numerical experiments using formulas (12) - (33) shows the following. If (12) - (16) on the coordinate plane parametric α - β available there are areas in which the corresponding subjective entropy tends to increase, that is uncertain benefits of the active element management system increases with time. However, some other combinations of settings α and β observed the opposite effect.

For partial initial data in case of increasing uncertainty:

$N=2$, $\pi_1^{(0)}=0.7$, $\pi_2^{(0)}=0.3$, $\alpha=0.3$, $\beta=0.765$,
$t=0\ ...\ 20$, (34)

simulation results shown in Fig. 3, Fig. 4.

In two other cases, partial initial data that differ from the previous example:

$$\beta=0.9765,\ \beta=0.85808. \qquad (35)$$

Fig. 3, Fig. 4 symbol «i» corresponds to an increase uncertainty is estimated experiment realized version (34), Instead symbol «d» marked numerical modeling conducted for the case of reducing uncertainty (the first of the conditions given in (35)), the results of numerical experiments if «e» versus match (approximately) simulated the constancy of entropy (the second of the conditions given in (35)).

Exploring parametric α - β coordinate plane for the presence of "balanced" state of the system for initial data:

$$\pi_1^{(0)}=0.6985,\ \pi_2^{(0)}=0.3015, \qquad (36)$$

obtain a chart shown in Fig. 5.

Fig. 9 area marked between rows 1 and 2, virtually endless strip. If the α and β get to this area (band between 1 - and 2 top row - bottom), which is limited to the middle contour lines 1 and 2, the entropy of individual preferences and, consequently, the uncertainty of the active element of the system will increase over time. Row 3 shows the maximum values of entropy subjective individual preferences.

Areas outside of the boundary lines 1 and 2 are the areas where the system tends to increase certainty over time, so that, if there hit options α and β, Subjective entropy will decrease over time.

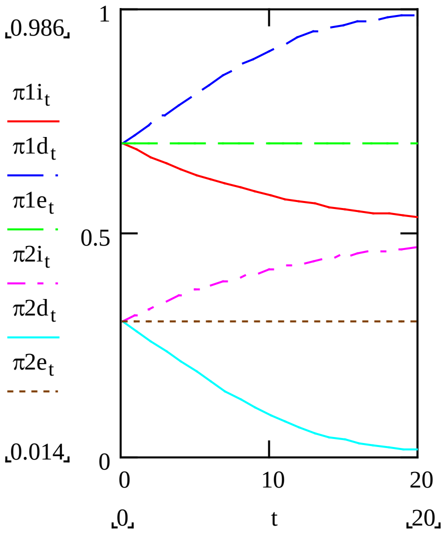

Fig. 3. Benefits.

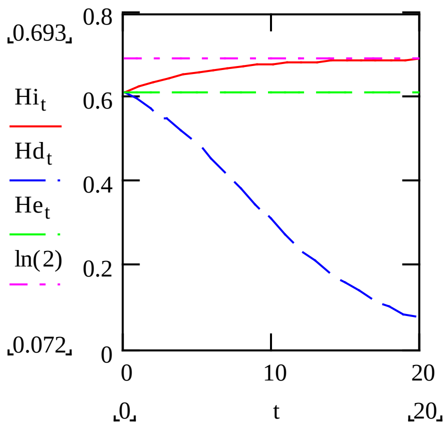

Fig. 4. Entropy.

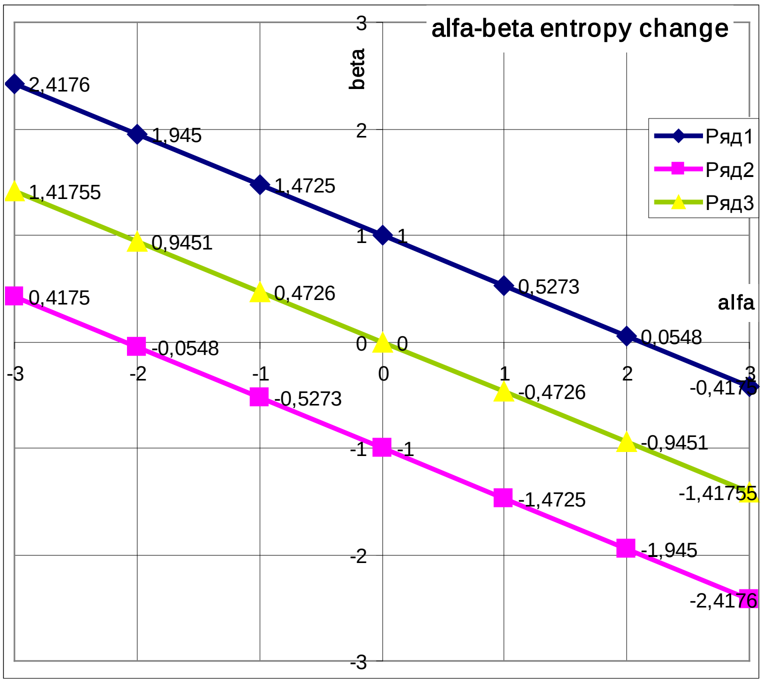

Fig. 5. Parametric coordinate plane time-dependent system becomes active.

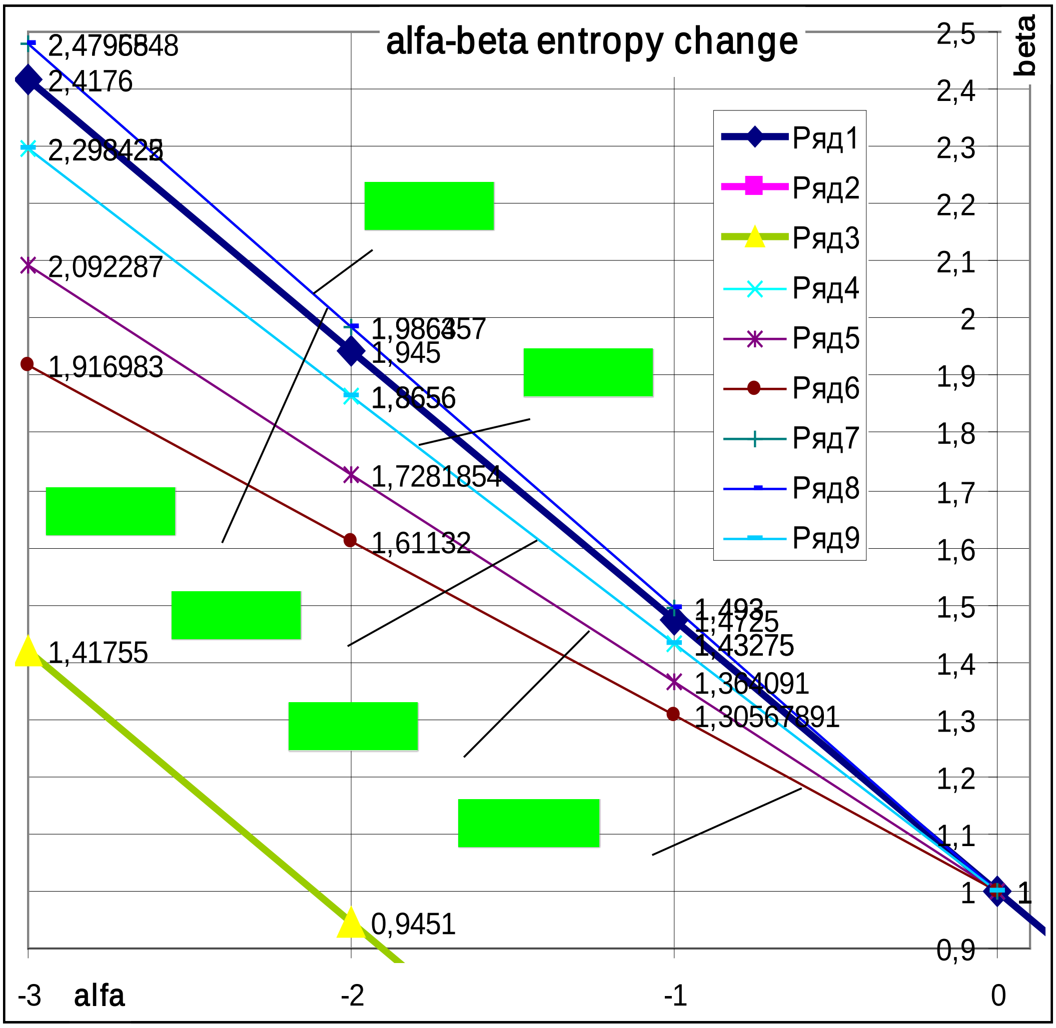

Fig. 6. Changing tilt boundary by changing the initial conditions for the distribution of benefits of alternatives.

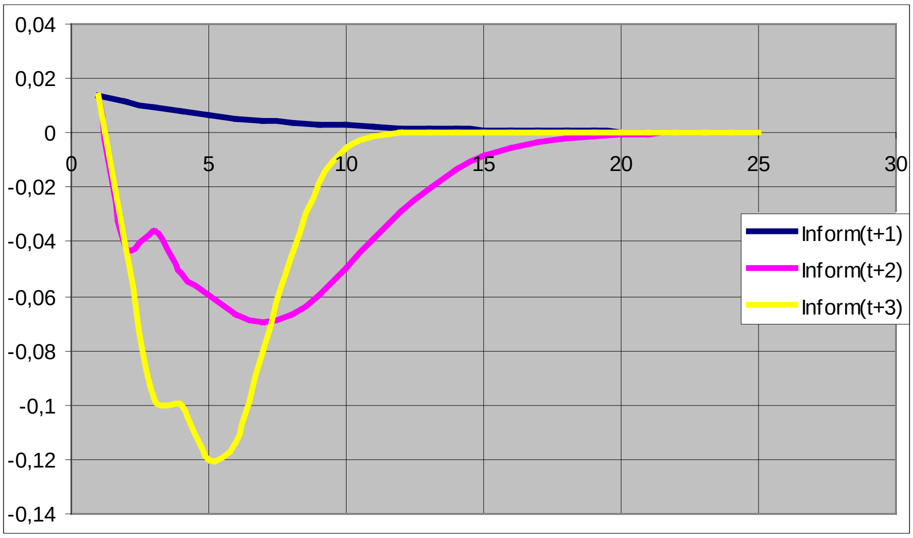

Fig. 7. Information.

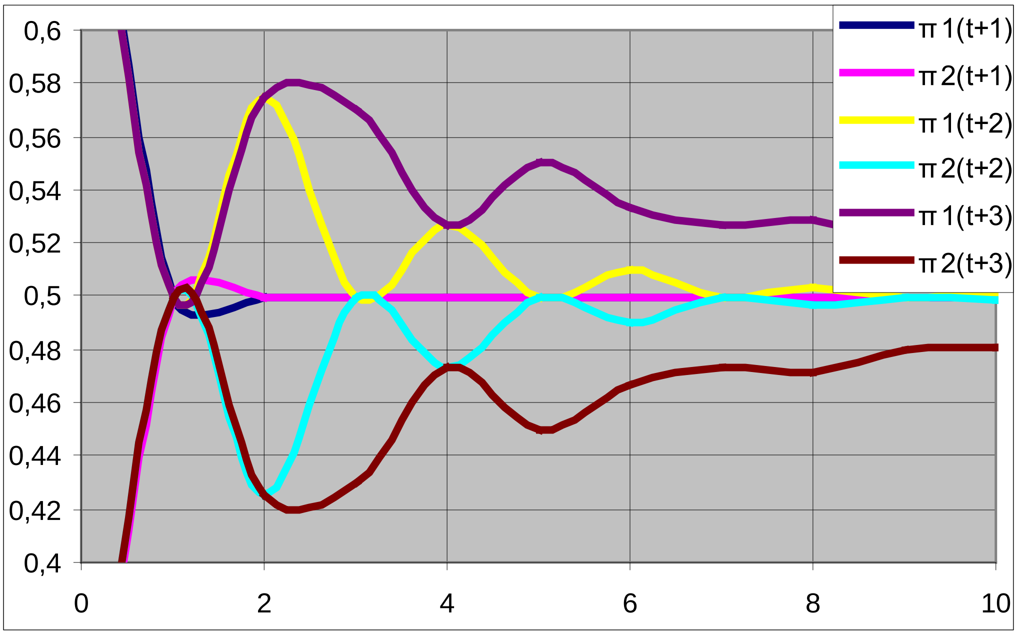

Fig. 8. Benefits.

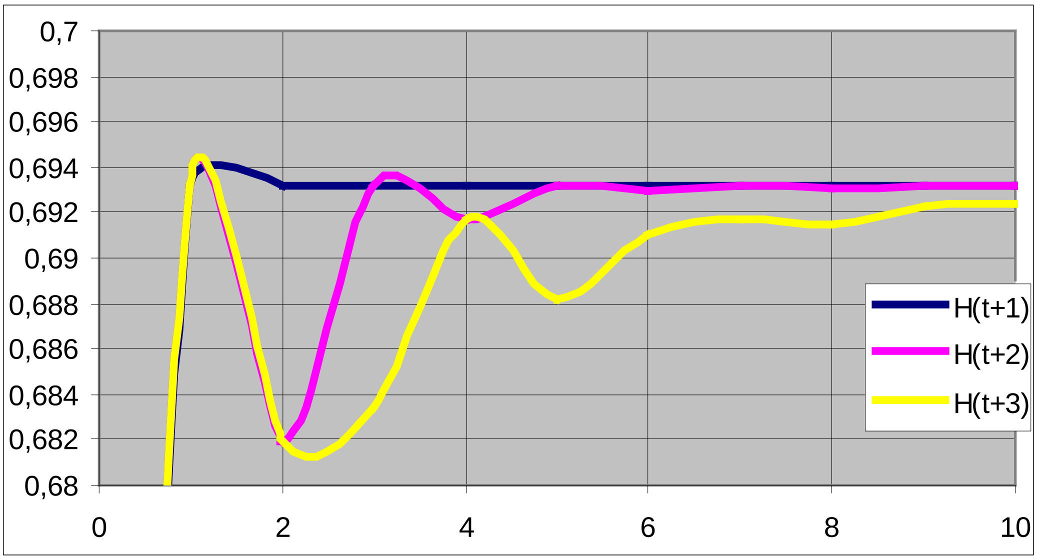

Fig. 9. Entropy.

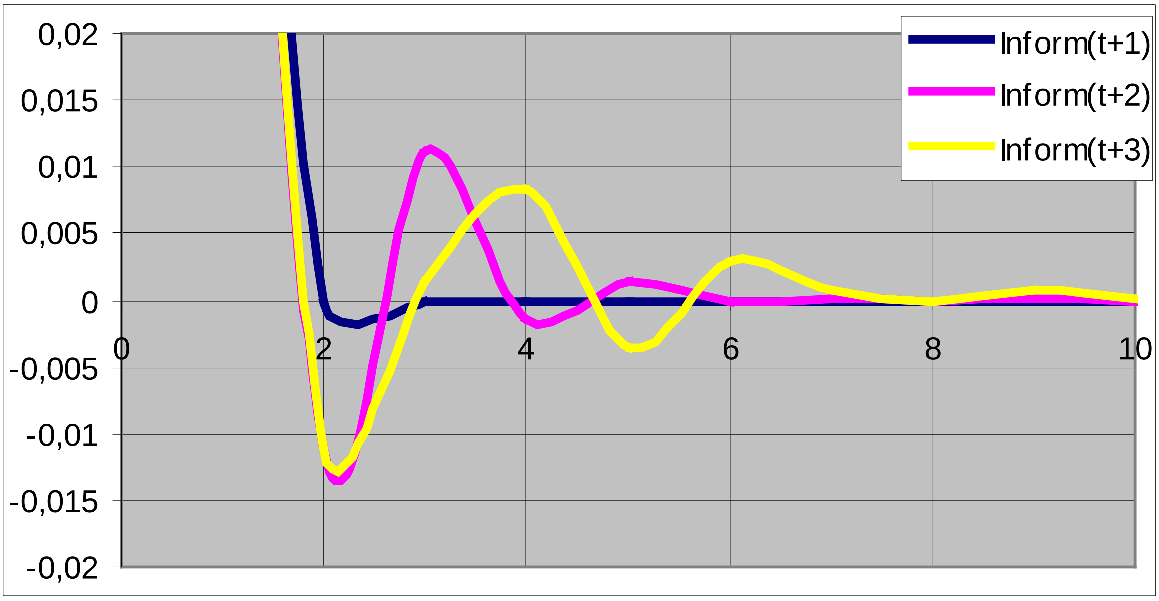

Fig. 10. Information.

By themselves, lines 1 and 2 represent combinations α and β with "well-balanced" state. These values α and β and is listed on the chart (Fig. 5).

Depending on the initial data:

$$\pi_1^{(0)}, \qquad \pi_2^{(0)} = 1 - \pi_1^{(0)}, \tag{37}$$

obtain a chart shown in Fig. 6.

Fig. 6 shows that the lines change their slope, passing through the point with coordinates $(0,1)$, $(0,0)$, $(0,-1)$. The experimental results for (17) - (24) with values:

$$N = 2,\ \pi_1^{(0)} = 0.7,\ \pi_2^{(0)} = 0.3,\ \alpha = 0.3,\ \beta = 0.765,$$
$$\gamma = 0.105,\ \delta = 0.306,\ \eta = 0.047,\ \lambda = 0.309,$$
$$t = 0...25, \tag{38}$$

information generated incrementally shown in Fig. 7.

For cases (30) - (33) for other things being equal (38) the previous example, the results shown in Fig. 8-10. For cases with designation $(t+3)$ accepted:

$$\alpha = 0,\ \beta = 0. \tag{39}$$

Modification of cognitive function, which takes into account the possible presence of source data values from zero benefits can serve as expressions:

$$F_i^{(t)} = \ln\left(\alpha\, \pi_i^{(t-1)} + \delta e^{\beta \pi_i^{(t-1)}}\right). \tag{40}$$

Then:

$$\pi_i^{(t)} = \frac{\alpha \pi_i^{(t-1)} + \delta e^{\beta \pi_i^{(t-1)}}}{\alpha + \delta \sum_{j=1}^{N} e^{\beta \pi_j^{(t-1)}}}. \tag{41}$$

It is also possible is the use of recursive models:

$$\alpha^{(t+1)} = f_\alpha\left[\alpha^{(t)}\right], \qquad \beta^{(t+1)} = f_\beta\left[\beta^{(t)}\right]. \tag{42}$$

Approach (12) - (42) as conceptually shown to simulate the impact of a close or distant past - "history", and to forecast the future. Entropy concept of active control system that summarizes implemented in procedures such as (12) - (42) is used in subsequent sections of this study.

CONCLUSIONS

1. The proposed hybrid model features combined psevdoentropiynoyi benefits in the form of (12), varying in the range [-1 ... 1], best suited to ascertain the degree of certainty / uncertainty.

2. Basically, most of the alternatives in certain resource problem situations can be divided into two or three groups. Namely, for productions problems with two main groups achievable alternatives faithful and false, and in the case of three: true, false and neutral.

3. Smart range is taken in the form (7) reflects the amount of the largest and smallest advantage in every moment during their distribution. It is always greater than the unit of a positive value, but it is close to one, but less than one mentioned talking about the number of alternatives considered subject, in which case their number is more than two, and one of them is clearly overwhelming. The proximity of the values of this function to zero indicates the presence of a large number of alternatives under a slight advantage. That is, in this case, if one is under more preferred alternative, its benefits are far smaller.

4. Using recursive models considered a class of systems that are being in the sense of sharing with the world of energy and matter are open in terms of sharing information about the benefits accumulated in the memory "of dormant information" and while such systems can reduce their own entropy. The authors believe that one of the main feature that distinguishes active system from among all the others. Active systems include the following, and they are considered.

5. Thus, active systems can be for the exchange of matter and energy, but produce or consume information within itself, because of the aforementioned properties. It stands (released) a special type of resource that has information accumulated in the memory. We assume that the way proposed an original version of the model memory that can be used for modeling AI.

REFERENCES

1. **Krasowski E., Sydorchuk O., Sydorchuk L. 2015.** Modeling and Management of the Technical and Technological Potential in Agricultural Production. *TEKA* : An international quarterly journal on economics in technology, new technologies and modelling processes, Lublin-Rzeszow, No 15 (4). 79-84.

2. **Didukh V., Kirchuk R., Tsiz T. 2015.** Modeling of energy saving methods of soybean drying for oil production. *TEKA*. Commission of motorization and energetic in agriculture. Lublin, Vol. 1. №3. 9-14.

3. **Shevchuk R. S., Krupych R. 2015.** Manual vibro-impact fruit shaker. *MOTROL*. Commission of motorization and energetics in agriculture. Lublin-Rzeszow, Vol. 17, №4. 153-159.

4. **Semen Y. V., Krupych O. M., Shevchuk R. S., 2006.** Energy efficiency of the use of pneumohydraulic accumulators in hydraulic drives for fruit-harvesting machines. *MOTROL* Motoryzacja i Energetyka Rolnictwa. Lublin: Akademia Rolnicza, T. 8A. 251-257.

5. **Cherevko G., Krupych O., Krupych R., 2013.** Development of the system for the formation of the material and technical base of agriculture in Ukraine. *MOTROL* Commission of motorization and energetics in agriculture. Lublin-Rzeszow, Vol. 15, №4. 97-106.

6. **Sydorchuk O., Triguba A., Makarchuk O. and oth. 2012.** Optimization of the life cycle of integrated programs for harvesting grain crops. *MOTROL* Commission of motorization and energetics in agriculture. Lublin, Vol. 14, №4. 131-140.

7. **Sydorchuk O., Ivasjuk I., Syatkovskyy A. 2012.** Influence subject to conditions terms of tillage, planting summer-autumn period. *MOTROL* Commission of motorization and energetics in agriculture. Lublin, Vol. 14, №4. 16-20.

8. **Sydorchuk A., Ivasiuk I., Ukraynecz V., and oth. 2013.** Harmonization of the components of the technological system of soil cultivation and sowing of winter crops. *MOTROL* Commission of motorization and energetics in agriculture. – Lublin-Rzeszow, Vol.15, №4. 180-186.

9. **Sydorchuk O., Sydorchuk L., Demidyuk N., Sivakovskaya E. 2014.** Method of creating a conceptual model of management - information systems of field crop cultivation. *MOTROL* Commission of motorization and energetics in agriculture. – Lublin-Rzeszow, Vol.16, №4. 26-31.

10. **Sydorchuk O. V., Palmarchuk V. S., Makarchuk O. I. 2009.** System-technological approach to adaptive technologies of mechanized soybean. *Mechanization and Electrification of Agriculture*: interdepartmental thematic scientific collection. - Hlevakha: NSC "IAEE", Vol. 93. 434-441.

11. **Adamchuk V. V., Sydorchuk O. V., Lub P. M. and oth. 2014.** Planning cultivation projects based on statistical simulation modeling: Monograph. - Nizhin: Publisher PP Lysenko M.M., 224.

12. **Sydorchuk O. V., Fornalchyk E. Y., Gorbov A. J. 2008.** Conceptual model of project design complex technological machines for harvesting flax for adaptive technology. *Mechanization and Electrification of Agriculture*: interdepartmental thematic scientific collection. Hlevakha: NSC " IAEE ", Vol. 92. 477-486.

13. **Rogovskii Ivan. 2010.** Methods of solution adaptivety of system of technical service of agricultural machines. *MOTROL* : Motorization and power industry in agriculture. Lublin. 2010. T. 12B. 153-158.

14. **Rogovskii Ivan. 2011.** Impact of reliability on frequency of maintenance of agricultural machinery. Motrol : Motorization and power industry in agriculture. Lublin. T. 13B. 92-97.

15. **Rogovskii Ivan, Dubrovin Valeriy. 2012.** Procedure of prediction of final resource of mechanisms of agricultural machines. *MOTROL* : Motorization and power industry in agriculture. Lublin. 2012. T. 14. №3. 200-205.

16. **Rogovskii Ivan. 2014.** Stochastic models ensure the efficiency of agricultural machines. MOTROL : Motorization and power industry in agriculture. Lublin. T. 16. №3. 296-302.

17. **Rogovskii Ivan. 2014.** Methodology of development of normative documents ensure the efficiency of agricultural machines. *MOTROL* : Motorization and power industry in agriculture. Lublin. T. 16. №2. 253-264.

18. **Rogovskii Ivan. 2016.** Graph-modeling when the response and recovery of agricultural machinery. *MOTROL* : Motorization and power industry in agriculture. Lublin. T. 18. №3. 155-164.

19. **Novitsky A. 2015.** The study of the probability of failure-free operation of means for preparation and feeding systems as "Man-Machine". *MOTROL*. Motoryzacia i energetyka rolnictwa motorization and power industry in agriculture. – Lublin. – Vol. 17, No. 3. 335-341.

20. **Rogovskii I. L., Melnyk V. I. 2016.** Model of parametric synthesis rehabilitation agricultural machines. *Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK*. Kyiv. No 241. 387-395.

21. **Rogovskii I. L., Melnyk V. I. 2016.** Analyticity of spatial requirements for maintenance of agricultural machinery. *Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK*. Kyiv. No 251. 400-407.

22. **Rogovskii I. L. 2016.** Analysis of model of recovery of agricultural machines and interpretation of results of numerical experiment. *Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK*. Kyiv. No 254. 424-431.

23. **Rogovskii I. L. 2017.** Probability of preventing loss of efficiency of agricultural machinery during exploitation. *Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK*. Kyiv. No 258. 399-407.

24. **Rogovskii I. L. 2017.** Conceptual framework of management system of failures of agricultural machinery. *Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK*. Kyiv. No 262. 403-411.

25. **Rogovskii I. L., Eugeniusz Krasowski, Valentyna Melnyk. 2017.** Normatives of technical operation of agricultural machines. TEKA. An International Quarterly Journal on Motorization, Vehicle Operation, Energy Efficiency and Mechanical Engineering. Lublin–Rzeszów. Vol. 17. No 3. 55-64.

ЭНТРОПИИ УСЛОВНОГО СУБЪЕКТИВНОГО ПРЕДПОЧТЕНИЯ ДЛЯ АЛЬТЕРНАТИВНЫХ ФУНКЦИЙ В УСЛОВИЯХ РАННЕЙ ДИАГНОСТИКИ ЗАБОЛЕВАНИЙ ВНУТРЕННИХ ОРГАНОВ КРУПНОГО РОГАТОГО СКОТА

Иван Роговский, Эугениуш Красовски

Аннотация. В данной работе на основе анализа существующих методологических подходов проведен анализ патентно-конъюнктурных, аналитические и экспериментальные основы зарубежного и отечественного опыта в системах технической поддержки для ранней диагностики заболеваний внутренних органов крупного рогатого скота. Авторами определены аналитические предпосылки формирования системы технического обеспечения ранней диагностики внутренних болезней крупного рогатого скота. В экспериментальные предпосылки формирования системы технической поддержки для ранней диагностики внутренних болезней крупного рогатого скота. Также определенные свойства мехатроники из основных методов организации связи в инженерных системах ранней диагностики внутренних болезней крупного рогатого скота.

Этот проект использует синергетический подход, согласно которому любое взаимодействие природных систем приводит к обмену между материей, энергией и информацией. Во время одной из систем (ранняя диагностика внутренних болезней крупного рогатого скота) является эмиттером, другая (системы технические мехатронные) – батареи. Внезапный разряд первого взаимодействия двух систем, другие системы могут накапливать излишки синергии с одновременным резким усилением динамики внутренних процессов, что приводит к структурированию системы и диссипации. В этой самоорганизации приводит к изменениям в механизме передачи взаимодействия в мехатронной системы для более напряженного состояния.

Объект исследования – структура и механические свойства технической поддержки для ранней диагностики заболеваний внутренних органов крупного рогатого скота.

Предмет исследования – аналитические закономерности изменения структуры и свойств мехатронных технической поддержки для ранней диагностики внутренних болезней крупного рогатого скота.

Цель исследования заключается в повышении адекватности аналитического описания структуры адаптивной системы, которая будет включать в себя техническую поддержку системы, системы управления, окружающей среды и системы ранней диагностики внутренних болезней крупного рогатого скота.

Методы исследования – теоретические и экспериментальные методы аналогий и уточнений, синергетическая теория по допустимому значению и закономерности изменения параметра, хронометрирование, статистический анализ, планирование эксперимента.

Следует отметить, что словари и энциклопедии по-прежнему выявление и диагностика термин диагноз часто медицинский рода признание, между тем, такого рода знание распределенных в различных сферах научной и практической деятельности человека.

Диагностика, как научная составляющая в сфере научной практики определяется социально, изменение в ходе исторического развития общества. Его современное развитие в XXI веке в направлении расширения возможностей быстрее и точнее ближе к цели, признание причин отклонений от норм технического объекта. В свою очередь, развитие диагностики характеризуется нерегулярностью изменчивости ее отдельных сторон, а также их влияние друг на друга различных характеристик и параметров контролируемых объектов с точки зрения информативности, и часто даже с точки зрения избыточности информационного потока. Это относится ко всем уровням и разделам теоретико-адаптивных систем синтез технической поддержки для ранней диагностики внутренних болезней крупного рогатого скота.

Ключевые слова: синтез, техника, поддержка, ранняя диагностика, заболевания внутренних органов крупного рогатого скота.

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Method for Determining Time of Next Maintenance of Combine Harvesters

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Summary. In Ukraine and abroad in several sectors of industries, a system of informational support of products lifecycle. Which is based on the standardized representation of product data and assumes brand warranty and post-warranty service. Such technologies typically include control system reliability: the system collects information about failures, scheduled and emergency repairs, as well as about the technical condition detected with special test and diagnostic tools. Similar systems are being introduced in the high technology industries of our country, and in the sphere of technical maintenance of combine harvesters are being introduced separate elements of the system.

Analysis of the possible production situations with an organized enterprise centralized technical maintenance of combine harvesters on the technical condition of the units allows to make a conclusion on what to reduce in-plant losses is possible by reducing errors and detection of aggregates and their distribution.

Selection of artificial neural networks as a mathematical apparatus for the solution to reduce error detection of aggregates and their distribution for technological routes at the centralized maintenance of combine harvesters was justified by the ability of this mathematical tool to the study, analysis and retention results, as well as high adaptation to the solution of the problem.

When building a neural network classifier of the system of technical maintenance of combine harvesters, it is first necessary to determine the complexity of the division of objects into classes. To simplify the problem of classification of the system of technical maintenance of combine harvesters, it is necessary to achieve a linear separation of the objects of study.

Since the task involves more than two classes of system of technical maintenance of combine harvesters for the distribution of units between them, the most efficient method of forming output signals will be a set of vector components. In other words, every possible defect combine harvester will have its output signal, and the presence of a defect or lack of it will say 0 or 1 on the corresponding output. It is very important to achieve close as possible to 0 or 1 values, this requires preprocessing the input data.

Key words: modeling, technology, operation, maintenance, combine harvester.

INTRODUCTION

The invention relates to the field of computing, and more particularly to methods and devices for monitoring [1], and can be used in operating practice for optimal management of preventive maintenance of the object on the current state of its reliability, and can be used in various fields of technology, particularly in the system for a decision on preventive maintenance of combine harvesters [2]. The technical result is to determine the optimal time interval between adjacent preventive works maintenance facility on the current state of its reliability in terms of time and cost expenditures [3]. The apparatus comprises a sensor failure facility failure of the counter measurement unit time between failures, the CPU operator workstation, an input unit of information, a display unit, a selection unit of a random distribution law time between failures, the selector confidence probability, the confidence determining unit failures interval calculating unit decision function, the decision device, dial cost penalties [4].

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

The invention relates to the field of computing, and more particularly to methods and devices for monitoring, and can be used in operating practice to determine the optimal time for the next of maintenance items as, and can be used in various technical fields, in particular in the system of combine harvesters for deciding on preventive maintenance element of technical devices of combine harvesters transport [5].

Known is a method of determining the optimal period product service implemented using known devices determine optimal maintenance period [6].

In the known method the optimum period of service of the object is determined by taking into account the factor of his age and the time available for maintenance [7]. Optimization criterion is the minimum service period coefficient of downtime for a given allowable value of the maintenance period of the product [8]. When implementing the known method solves the problem of improving the accuracy of determining the optimal object service period [9]. This object is achieved by the introduction of the second multiplying unit, a second dividing unit and the fourth delay element, and by varying the number of interconnects and inter-element linkages [10].

The disadvantage of this method of determining the optimal facility maintenance period is the limited scope of use, namely, only to object to the aging factor, failures which are distributed by the combine harvesters, as well as the planned preventive maintenance without taking into account the current state of the reliability of the object [11].

The closest analog of a portion of the method [12] is a method for determining the optimum period of maintenance of the facility is implemented using a known device for determining an optimum maintenance program system [13]. The method consists in the realization of a mathematical model to determine the timing of system maintenance program [14] that provides optimal maintenance intervals of each of the subsystems and the overall system [15].

Device implementing the known method is the closest analogue to the device and comprises a memory unit [16], the two unit multiplying three adders, two divider, a subtractor block nonlinearities, time sensor, a comparison unit, an integrator, three delay element, an gate waiting multivibrator memory element, a key and a shift register [17].

However, the known method and apparatus determine the optimum period of maintenance work [18] does not consider the variation of the current failure rate with respect to the operating conditions and the types of operating devices [19].

Problem solved by the proposed invention is to provide a method and system to determine the optimal time for the next of the maintenance facility of its reliability [20], in which the time and cost to carry out preventive and repair work will not be higher than the costs for carrying out the repair work without preventive maintenance [21].

The technical result of the invention is to determine the optimal time interval between adjacent maintenance work maintenance of the facility on the current state of its reliability by taking into account time and cost expenses for carrying out preventive and repair work [22].

OBJECTIVE

The article presents the analytical statements of methodological approaches to modeling technology in centralized technical maintenance of combine harvesters.

THE MAIN RESULTS OF THE RESEARCH

This is achieved in that the method of determining the start time of the next maintenance facility counted number ni of failures in the time interval from 0 to i-th control products preventive maintenance and the time tj between adjacent failures, perform statistical processing failures of the object on which the building histogram failure object and pick up the value of the integer parameter K, in which with the help of the Erlang distribution formula set corresponding to the combine harvester spredeleniya time between failures of the object, and the failure rate estimate λi object in each i-th instant of time at a predetermined confidence level is calculated and β coefficients rH, rB, respectively defining the lower and upper limits of the confidence interval of the failure rate

$$Y\left(n_i\right)=\frac{\left[(K-1)!\sum_{l=0}^{K-1}\frac{\left(\lambda\sum_{j=1}^{n_i}t_j\right)^l}{l!}\right]\left[C_2/C_1-\ln\sum_{l=0}^{K}\frac{\left(\lambda\sum_{j=1}^{n_i}t_j\right)^l}{l!}\right]}{\sum_{j=1}^{n_i}t_j\left(\lambda\sum_{j=1}^{n_i}t_j\right)^K},$$

where: C_1 - the penalty for refusal of the object, C_2 - the penalty for carrying out preventive maintenance (FIU) of the object.

Calculating the value of the decision function for the current value of failures and failures corresponding to the lower and upper limits of the confidence failure rate interval at a predetermined interval Y1 = Y Time (rnni,), Y2 = Y {ni) and Y3 = Y (RB, n), solution to conduct regular preventive maintenance take in the event that Y1 > Y2 > Y3 and Y3 < 1, and if the number of failures n < 100, the value of the integer parameter K, the corresponding time distribution law between failures object selected by the shape of the histogram, if n ≥ 100 - by the criterion of consent A.N.Kolmogorova or x2.

Determining the time of the maintenance system comprises a sensor failure object, whose output is connected to the input of a counter of failures, the output connected to the first input of the CPU workstation operator control area, a measuring unit of time between failures, connected between the sensor output and the second input of the CPU, the third input of which is connected to the output of the input information block and the first output - to an input of a display unit, a selection unit distribution law random time between failures, the first input coupled to the second output of the CPU, and the second input - to the output time measurement unit between failures, the selecting unit sequentially linked confidence probability, the confidence determining unit failures interval, calculating unit decision function and the decision device, and the dial value fines outlet is connected to the fourth input of the CPU, a fifth input connected to the output selection block random time distribution law between failures, the third output - to an input of confidence coefficient selecting unit, and the fourth CPU output is connected to a second input of the failure determination of the confidence interval and the corresponding input of the decision function calculation unit, the other inputs of which are conn respectively to the outputs of the time interval between the measurement unit failure, the failure number counter, the second and fifth outputs of the CPU, a sixth output is connected to the hardware-software device service operator operational maintenance.

The total penalty function can be represented:

$$C=\lim_{t\to\infty}\frac{C_1M\left[N_1(t)\right]+C_2M\left[N_2(t)\right]}{t}$$

where: C_1 - the penalty for refusal of the object, M [N1 (t)] - the expected number of items of failures in the interval [0, t], C2 - the penalty for carrying out preventive maintenance (FIU) of the object,

M [N2 (t)] - the expected number of prevention work (RPF) in the interval [0, t].

It is known, which is held constant at the failure rate function after the rescue and recovery operations the following relations:

$$\lim_{t\to\infty}\frac{M[N_1(t)]}{t}=\frac{M[N(T_\Pi)]}{T_\Pi}$$

and

$$\lim_{t\to\infty}\frac{M[N_2(t)]}{t}=\frac{1}{T_\Pi}$$

where: M [N (TA)] - function recovery unit in the time interval [0, m] between two neighboring FIU. It follows that

$$C(T_\Pi)=\frac{C_1 M[N(T_\Pi)]+C_2}{T_\Pi}.$$

and the recovery of functions

$$M[N(T_\Pi)]=\int_0^{T_\Pi}\lambda(x)dx$$

where: λ (x) - the failure rate of the object.

By minimizing the function G (TA) parameter of TA can find the expression for the optimal time interval between FIU:

$$T_{opt}=\frac{C_2\big/C_1+\int_0^{T_{opt}}\lambda(x)dx}{\lambda(T_{opt})}=\frac{C_2/C_1-\ln P(T_{opt})}{\lambda(T_{opt})}$$

where: P (T_{opt}) - probability of failure of the object in the interval T_{opt} time.

The formula obtained based on the fact that

$$P(T_{opt})=\exp\left(-\int_0^{T_{opt}}\lambda(x)dx\right)$$

Then

$$\int_0^{T_{opt}}\lambda(x)dx=-\ln P(T_{opt})$$

Dividing the left and right side of the expression:

$$T_{opt}\,\frac{C_2/C_1-\ln P(T_{opt})}{\lambda(T_{opt})}.$$

to T_{opt}, and given that T_{opt} = nT of T where nT - the expected number of failures of the object in the time interval [0, T_{opt}], we obtain

$$\frac{C_2/C_1-\ln P(n_T T)}{n_T T\lambda(n_T T)}=1$$

The meaning of this expression is as follows. If the time interval between adjacent FIU chosen optimally, the costs (time and cost) to carry out preventive and repair work between them will be equal to the average cost of carrying out the repair work without the FIU. In the second case, the number of failures and recoveries will be more natural. If the time until the next RPF will be significantly larger than the set of optimal, it will lead to an increase in the failure rate of the object, increase the cost of remedial work as compared to the optimal level. The left side of equation (1) is less than 1. In the case of a substantial reduction in the time interval until the next RPF will be additional costs for maintenance work, that do not compensate a gain in the value of reducing the number of failures and recoveries as a result of additional TA. In this case, the left side of expression is greater than 1.

Thus, the formula is the base for the development of the rules of the decision on withdrawal of the object for another FIU based on the statistics of failures of the object, the value of the repair and maintenance work.

To this end, we introduce the function

$$Y(n_i)=\frac{C_2/C_1-\ln P(n_i T)}{n_i T\lambda(n_i T)}\rhd 1$$

If ni = nT, then Y (ni) = 1.

Because

$$n_T T\equiv\sum_{j=1}^{n_i}t_j$$

where: tj - a random time between two successive failures, the

$$Y(n_i)=\frac{C_2\big/C_1-\ln P\left(\sum_{j=1}^{n_i}t_j\right)}{\sum_{j=1}^{n_i}t_j\cdot\lambda\left(\sum_{j=1}^{n_i}t_j\right)}\rhd 1$$

Qualification failure rate of the object in i-th time of maintenance management system (TO) at a predetermined confidence level of β produced using lookup tables χ2 distribution or a Poisson distribution:

$$\hat\lambda=K\cdot n_i\Big/\sum_{j=1}^{n_i}t_j$$

$$\hat\lambda_{min}=r_H\hat\lambda,\quad \hat\lambda_{max}=r_B\hat\lambda.$$

Coefficients r_H, r_B determine the lower and upper limits of the confidence interval of the parameter $\hat\lambda$.

It follows from these expressions that

$$\sum_{j=1}^{n_i}t_j=\frac{K\cdot n_i}{\hat\lambda}.$$

If the failure rate of an object is the number of its failures per unit of time, ni, - the number of failures in the time interval from 0 to the i-th technical object management. Consequently, there are strict upper and lower bounds for the number of failures in said time interval ni min = rHni, ni max = rBni.

This fact means that the values of the decision function Y (ni) should be outside the range of values of Y (rvni) and Y (rnni).

To describe random time between failures of the object in terms of the task apply appropriate use of such a universal distribution that by changing the parameter could be transformed into one of its known, which is most acceptable to describe the statistics available time between failures of the device in question. Such universal distribution of a random time between failures can be Erlang distribution K-th order:

$$P(t)=\sum_{1=0}^{K}\frac{(\lambda t)^{1}e^{-\lambda t}}{1!}$$

and

$$\lambda(t)=\frac{\lambda^{K}t^{K-1}}{(K-1)!\sum_{1=0}^{K-1}\frac{(\lambda t)^{1}}{1!}}$$

By varying the integer parameter K is transformed with the allocation of a random time between failure in one of the known. For example, when K = 1 is transformed into an exponential distribution, with K = 2 - a Rayleigh distribution, when K> 10 transforms into a normal distribution. The choice of the distribution, and therefore the job of the parameter K, defined by the results of statistical processing of the data, as well as engineering considerations about the nature of wear object.

If the time between failures of the object distributed over the Erlang law K-th order and on statistical data on faults in the time interval from the time 0 to the current control is established that rBni> nT, the decision function is determined by the inequality Y (rBni) <1.

If it determined that rBni≤nT, the decision function is equal to or greater than a value Y (rBni) ≥1.

Indeed, since the functions λ {t) and P (t) and monotonic λ {t) - increasing function, speed increasing function tλ {t) greater than the speed increasing function lnP (t). Therefore, with increasing time interval t decreases the value of expression (3). Therefore, if rBni> ni, then Y (rBni) <Y (ni). In accordance with formula (2), Y (nT) = 1. Therefore, if rBni> nT, the decision function Y (rBni) <1. When the condition is true rBni≤nT Y (rBnt) ≥1.

Thus, the decision rule determining the need for regular FIU as the failure rates of the object is established by the inequality:

Y (rBni) <1

In this case, when the number of inequality recorded failures object exceeds their expectation over the expected increases the failure rate of the object that requires prompt of regular maintenance.

The possibility of the method is confirmed by specific examples describing the system determine the timing of maintenance as an element of traveling facilities of combines.

1. It is a block diagram of a system determining the time of the next maintenance track facilities element.

The system includes a sensor 1 failure object, whose output is connected to the input of counter 2 number of failures, the output connected to the first input of the CPU 3, workstation 13, an operator control service unit 4 is the measurement time between failures, connected between the output of the sensor 1 and the second input of the CPU 3, the third input of which is connected to the output unit 5 input information, and the first output - to an input of the display unit 6, the block 7 choosing a random distribution law time between failures, with the first input union of the second output of the CPU 3, and the second input - to the output of 4 measurement time between failures, serially connected choice confidence probability unit 8, determination unit 9 trust failures interval calculation unit 10 and decision function unit 11 decision, and the dial 12 the value of fines outlet is connected to the fourth input of the CPU 3, the fifth input connected to the select output unit 7 random time distribution law between failures, the third output - with the selection input unit 8, confidence probability, and the fourth output of the CPU 3 is connected a second input unit 9 detects failures confidence interval and the corresponding input of the decision function calculation 10, the other inputs of which are connected respectively to the outputs of the measurement unit 4 ntervala time between failures, failure rate meter 2, the second and fifth outputs of the CPU, a sixth output is connected to the hardware-software device service operator track automated farm management system (ACS-II)

The system works as follows.

Sensor 1 signals failures of the automated system of ACS-II detects failures element track facilities for a predetermined period of time, the counter 2 counts the number ni of failures, and sends the obtained data to a first input 3 of the central processor 13 of workstation operator control service. 4 simultaneously time measurement unit measures the time between failures tj between failures and sends the measured data to the second input of the CPU 3.

The CPU 3 on the basis of the received data is the primary statistical processing of the data, the results of which calculates the failure rate in each i-th time management track facilities element, builds a histogram element failures versus time and sends it to a display unit 6. At this sampling intervals the operator selects the control service and inserts them into the processor 3 via the information input unit 5. To construct a histogram using the standard software, such as, MATLAB program.

The operator analyzes shown in block 6, the histogram display, and in its form of pre-selects the type of a random distribution of time law between failures that do not contradict engineering considerations about the nature of the wear study element and enters into the CPU 3 through the unit 5 value of an integer parameter K, corresponding matched distribution law.

In block 7 selected value of the integer parameter K, corresponding to the known distribution law, is closest to the distribution law of random time between failure element according to the results of the statistical processing.

At the same time as a universal distribution between failures using Erlang distribution K-th order:

$$F(t)=1-\sum_{1=0}^{K}\frac{(\lambda t)^{1}e^{-\lambda t}}{1!}$$

where: l - the summation index, K - a parameter corresponding to the law of the distribution of failures of the object represented by the Erlang formula.

It is known that by changing the value of the integer parameter K can be transformed with the allocation of a random time between failure in one of the known. For example, when K = 1 is transformed into an exponential distribution, with K = 2 - a Rayleigh distribution, when K> 10 transforms into a normal distribution.

Thus, in the block 7 selected value of the parameter K, at which the calculated distribution Erlang K-th order corresponded most closely matched by statistical processing of the value of a random time between failure distribution function element, as well as engineering considerations about the nature of the wear member.

From block 7 outputs information characterizing the chosen value K is transmitted to the corresponding input of the CPU 3.

The CPU 3 depending on the number of failures ni transmits the input unit 8, determination of confidence intervals failure element value K from the output unit 5 or the block 7. On the block 9 inputs also receives information about the confidence coefficient β and the number of failures ni respectively output from block 9 and the counter 2.

Block 8 choice confidence information defines the following values of β: 0,85, 0.9, 0.95. Choosing an appropriate value confidence level of β next operator through the central processing unit 3 through 5.

In block 9 the known tables, taking account predetermined confidence coefficient β and the law of random distribution of time between failures (parameter K) determined boundary values confidence interval bounce rH, rB, which are routed to respective inputs of unit 11 of the decision function calculation.

In addition, the input of the CPU 3 is also supplied with information setter 12 outputs the value of fines - information about the magnitude of C1 penalty for failure track facilities and element C2 for holding the fine track maintenance management element. Wherein the values of C1 and C2 fines normalized values. If the value of C1 is constant, C2 depends on the object type maintenance.

The processor 3 calculates the ratio of C1 to C2, and sends the C1 / C2 at the value of one of the calculation unit 10 inputs the decision function, other inputs of which receives information about the failure rate $\hat{\lambda}$ and distribution law random time between failures K from respective CPU 3 outputs information on the number of failures ni - 2 output from the counter number of failures, and information tj - block with 4 outputs.

According to the formula of the decision function is calculated function Y (rH ni,) = Y1, Y (ni) = Y2 and Y (RB, ni,) = Y3.

In block 11, a decision that the condition is checked Y1> Y2> Y3. If the condition is satisfied and thus Y3 <1, then take a decision to carry out regular maintenance work (FIU). In this case, the relevant information from the output unit 11 is sent to the appropriate input of the CPU 3, which forms a team to carry out repair and maintenance work of an element of traveling facilities and sends it to the device hardware and software service operator, and the way the track facilities. Otherwise, the information team to carry out maintenance work does not come and the work of an element continues.

1. A method for determining the time of the next maintenance of the object, comprising the steps that a time interval from 0 to i-th control system maintenance facility failures counted number ni and the time tj between adjacent failures, perform statistical processing facility failures on the basis of which histogram failure of the object and using the formula of distribution of Erlang K-th order selected value of the integer parameter K, corresponding to the time distribution law ezhdu object failures, and the failure rate estimate λi object in each i-th instant of time at a predetermined confidence level is calculated and β coefficients RH, RB defining respectively lower and upper limits of the confidence interval of the failure rate,

$$Y\left(n_i\right)=\frac{\left[\left(K-1\right)!\sum_{l=0}^{K-1}\frac{\left(\lambda\sum_{j=1}^{n_i}t_j\right)^l}{l!}\right]\left[C_2/C_1-\ln\sum_{r=0}^{K}\frac{\left(\lambda\sum_{j=1}^{n_i}t_j\right)^l}{l!}\right]}{\sum_{j=1}^{n_i}t_j\left(\lambda\sum_{j=1}^{n_i}t_j\right)^K},$$

where: C1 - penalty for failure of the object, C2 - penalty for carrying out maintenance work object, calculating a value of the decision function for the current value of failure and for the value of failures corresponding to the lower and upper limits of the confidence interval intensities number of failures in a given time interval Y1 = Y (rin ni ,), Y2 = Y (ni) and Y3 = Y (RB, ni), a decision on carrying out the next maintenance object take in the event that Y1> Y2> Y3 and Y3 <1, and if the number n <100 denials , the K value of the integer parameter, the relevant law aspredeleniya time between failures object selected by histogram form, if n> 100 - Browse consent Kolmogorov or $\chi 2$.

2. The system of determining the time of the next maintenance of the object, the object comprising a sensor failure, the output of which is connected to the input of a counter of failures, the output connected to the first input of the CPU workstation operator control area, a measuring unit of time between failures, connected between the output of the sensor and the second input of the central processor, the third input of which is connected to the output unit information input and the first output - to an input of the display unit, block sps ra random distribution law time between failures, the first input coupled to the second output of the CPU, and the second input - to the output time measurement unit between failures, the selecting unit sequentially linked confidence probability, the confidence determining unit failures interval, calculating unit decision function and the decision device, and the dial value fines outlet is connected to the fourth input of the CPU, a fifth input connected to the output selection block random time distribution law between failures, the third output - to an input of confidence coefficient selecting unit, and the fourth CPU output is connected to a second input of the failure determination of the confidence interval and the corresponding input of the decision function calculation unit, the other inputs of which are conn yucheny respectively to the output time interval between the measurement unit failure, the failure number counter, the second and fifth outputs of the CPU, a sixth output is connected to hardware and software maintenance device operator, and a sixth input - to the output of the decision block.

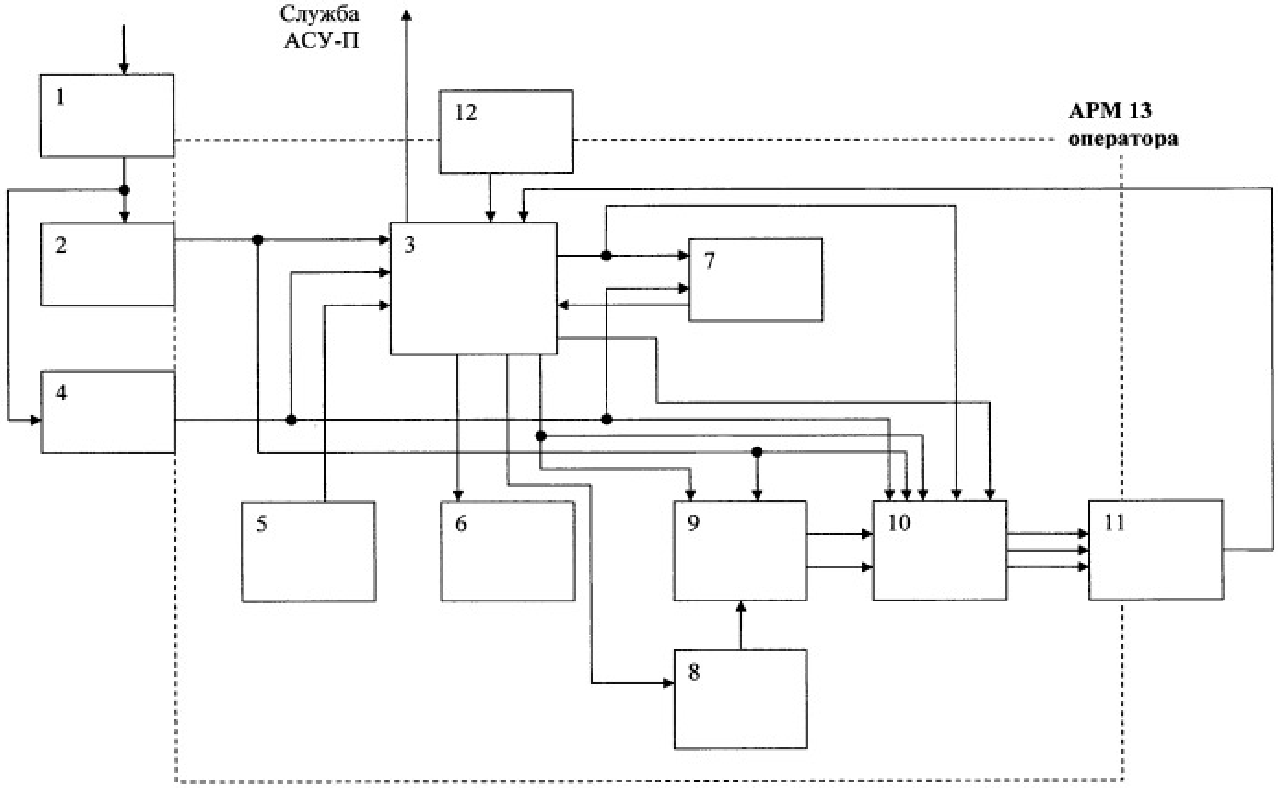

Fig. A method for determining an optimal maintenance period of the product

The invention relates to computer technology, and more particularly to control devices may be used in research and technology that require maintenance periods to determine product. The technical result is to increase the accuracy of determining the optimal maintenance period, leading to a decrease in the relative unproductively consumable products resource. This is achieved by the fact that define the law of variation with time of the intensity product failures, and after the formation of slots between the estimated maintenance of the product is calculated of the intensity product failure value for each of the predetermined intervals of time and use it in the calculation of probability values uptime average uptime and average latent time of failure products at a predetermined time interval, and then find the relative value unproductively consumable products resource. Its value is compared with the value obtained in the previous predetermined time interval, the process is repeated to obtain the new value of relative resource unproductively consumable product or fix the previous value of the predetermined time interval as the optimal period between maintenance. Repeat the process to obtain the new value of relative resource unproductively consumable product or fix the previous value of the predetermined time interval as the optimal period between maintenance. Repeat the process to obtain the new value of relative resource unproductively consumable product or fix the previous value of the predetermined time interval as the optimal period between maintenance.

The invention relates to the field of the theory of operation of complex technical systems, in particular to develop ways of optimizing the strategy of technical maintenance and repair of recoverable items, and can be used in scientific research and technology, where required to determine the periods of monitoring and maintenance.

Known methods for determining the maintenance period of the product implemented, for example, copyright certificates [1, 2, 3]. However, these methods implement mathematical models of service that do not reflect the consumption of time and resource to conduct maintenance operations, which reduces their scope.

There are also known methods for determining the maintenance period of the product implemented in the patents [4, 5]. A common disadvantage of these methods is the narrow scope of their application, because they are focused on the products for which it is acceptable to assume constant failure rate for the entire time interval of the expenditure of a limited resource. The use of these methods as applied to products with changing failure rate leads to low accuracy of determination of output values. The method presented in [5], implements a model of determining the optimal maintenance period for the comprehensive criterion: minimum average specific unproductive consumption of resources and high availability products. It is known that for multi-objective optimization is a compromise solution which, as a rule, does not give the extreme values of any of the used quality indicators. The reduction of this problem to one-criterion problem, as is done in [5], leads to the necessity of introducing weighting factors, reflecting the degree of importance of each of the indicators. The numerical values of the coefficients are usually determined by expert way and are largely intuitive in nature. In this regard, the accuracy of determining the optimal values of the maintenance period and the other output values can also be low.

The closest in technical essence to the proposed method is a method for determining the optimum period of maintenance and control is implemented in [6], comprising the steps that define the average time of routine maintenance, set the average time control performance products, set the average time of emergency reconstruction, given average consumption of the product life at a time when the product in an efficient state, specify the resource consumption of the average product unit time when the product in a state of latent failure, given average consumption of resource products per unit of time during the rescue and recovery operations, given average consumption goods resource at a time while testing performance products, define the average consumption resource items per unit time when carrying out maintenance, define the law of variation with time of probability of trouble-free operation of the product, at predetermined intervals of time t1...tn, where the failure rate can be assumed constant, for each of these intervals is set corresponding to the failure rate values λ1...λn, capacity set value of time intervals between the estimated maintenance items and a predetermined constant capacity formed between the time intervals before olagaemymi product service remembering previous values, wherein for each of the time intervals generated probability value calculated uptime value of the average uptime and value of the mean time flush the device fails in this time interval, then using the above parameter values are value relative unproductively consumable products resource, comparing its value with the value obtained in the previous predetermined time interval, and if the first of said less than the previous value, the second wash, a first retain and form a regular time interval and then repeat the process until RCV eniya new value relative wasted resource consumable products, otherwise fixed previous predetermined time interval value as an optimum period between maintenance.

A disadvantage of this method is the low accuracy of determination of the optimal product service period due to the presence of unrecoverable errors arising because of the intensity of a continuous function approximation error failures products piecewise constant function.

The accuracy of this approximation increases with the number of time slots in which the failure rate is represented by a piecewise continuous function, i.e., increases with decreasing length of these time intervals. However, the length of the time intervals at which a continuous function of the intensity of product failures approximated piecewise continuous function, can not be reduced indefinitely.

Because continuous failure rate function for different intervals of time the existence of a variety of products approximated piecewise continuous functions, ie intensity values λi failures are considered unchanged throughout the lifetime of each of the products of intervals and change only at the end of this interval, and thus the optimum value of the maintenance period is determined for each of the intervals of time of existence (life cycle) of the article (i.e., at each interval the lifetime of the product should be carried out at least one maintenance), it is obvious that the existence of the product ranges are always greater than or equal to the period of his technical obsl Ivanov. In this way,

This circumstance gives rise to the minimum fatal error of approximation of a continuous function of the intensity of failures piecewise continuous function associated with the inability to make the quantization step on the level of failure rate of a continuous function less than the maintenance period. As a result, the approximated value of the failure rate function defined for each stage of the product life, will differ from its true values, and the accuracy of determining the optimal maintenance period, which depends on the true value of the failure rate function, will be low.

The proposed method of determining the optimum period of maintenance products devoid above drawbacks, eliminates the continuous intensity function approximating failures piecewise continuous function in the calculation of the optimal period product service uses continuous values failure rate function.

Background of the Invention. The problem solved by the invention is to improve the accuracy of determining the optimum period of maintenance work by eliminating the error approximation of a continuous function of failure rate piecewise continuous function, as well as reducing the relative unproductively consumable products resource.

Solution of the problem lies in the fact that a given average duration of planned maintenance, set the average time control performance products, given by the average time of the rescue and recovery operations, given average consumption of the product life at a time when the goods in working order, given by the average resource consumption products at a time when the product in a state of latent failure, given average consumption of resource products per unit of time during the emergency, restore operation life, given average consumption of resource products per unit of time during the control of the operational products, given average consumption of resource products per unit of time for maintenance, set the variation in time the probability of failure-free operation of the product, set value increasing time intervals between the estimated maintenance of the product and a predetermined constant capacity forming intervals between the estimated maintenance products remembering previous values, further define the law of variation with time of the intensity product failures, wherein each of the generated time intervals calculated value of the continuous function the intensity of product failures, calculate probabilities uptime and Execu form a this value in calculating the average uptime and mean time to failure of the product flush this time interval, then using the above parameter values are values relative unproductively consumable products resource, comparing its value with the value obtained in the previous predetermined time interval, and if the first of said values smaller than the previous, the second wash, a first retain and form a regular interval of time and then repeat the process to obtain the new value of the relative unproductively consumable products resource in otherwise, the previous fixed predetermined time interval value as an optimum period between maintenance, the relative spending unproductively my resource article is determined by the expression:

$$R^{отн}(\tau_i)=\frac{C^{ф}\int_{\tau_i}^{0}P(\tau_i)d\tau_i+C^{о}\left[\tau_i-\int_{\tau_i}^{0}P(\tau_i)d\tau_i\right]+C^{к}\tau^{к}+C^{п}\tau^{п}P(\tau_i)+C^{в}\tau^{в}(1-P(\tau_i))}{C^{о}\cdot\left[\tau_i-\int_{\tau_i}^{0}P(\tau_i)d\tau_i\right]+C^{к}\tau^{к}+C^{п}\tau^{п}P(\tau_i)+C^{в}\tau^{в}\cdot(1-P(\tau_i))},$$

where: Rotn (τi) - expenses relative wasted consumable resource products during τi, τi - time intervals between the estimated maintenance of the product,

Wi - the average consumption of the resource products per unit time when the product in a state of latent failure,

P (τi) - probability of failure of the product over time τi,

Ck - resource consumption average product per unit of time during the monitoring of efficiency of the product,

τk - mean time to control health products,

C - the average consumption of the resource products per unit of time for maintenance,

τp - the average duration of scheduled maintenance,

St. - average consumption of resource products per unit of time during the rescue and recovery operations,

τv - the average time of the rescue and recovery operations,

SF - average consumption of resource products at a time when the goods in serviceable condition.

Description of the drawing, which shows the algorithm for determining the optimal period of maintenance work. The implementation process is as follows. To determine the optimum period of maintenance work set the average time of routine maintenance τp, set the average time control performance products τk, set the average time of the rescue and recovery operations τv, set the average consumption resource items per unit time when the product in the operable state Sf, set the average consumption of the product life at a time when the product in a state of latent failure Co, ask the average resource consumption of the product in units Init time during rescue and recovery operations St., define the resource consumption average product per unit time during the performance monitoring items Ck define resource consumption average product per unit time when carrying out maintenance C, define the law of variation with time of probability of trouble-free operation of the product λ (τ), further define the law of variation with time of the intensity product failure P (τ), set value increasing time intervals between the estimated maintenance products Δτ, setpoint input from the keyboard into the computer memory and specify the constant capacity via software implemented time intervals the sensor is formed between the estimated maintenance products while maintaining the ER in RAM previous value, wherein for each of the intervals formed between the estimated value of the calculated maintenance of a continuous function of the intensity product failures λ (τi), of the formula further define the law of variation with time of the intensity product failure P (τ), set value increasing time intervals between the estimated maintenance products Δτ, setpoint input from the keyboard into the computer memory and a predetermined constant capacity using software implemented by the time the sensor is formed intervals between alleged product service retaining in computer memory the previous value, wherein for each of the time intervals generated no maintenance between the estimated value calculated continuous function of the intensity product failures λ(τi), of the formula further define the law of variation with time of the intensity product failure P(τ), set value increasing time intervals between the estimated maintenance products Δτ, setpoint input from the keyboard into the computer memory and a predetermined constant capacity using software implemented by the time the sensor is formed intervals between alleged product service retaining in computer memory the previous value, wherein for each of the time intervals generated no maintenance between the estimated value calculated continuous function of the intensity product failures λ (τi), of the formula

$$P(\tau_i) = e^{-\lambda\tau_i}$$

calculating a probability value P uptime (τi) retaining in computer memory and these values used in the calculation of the average uptime

$$\boldsymbol{\tau}_\Phi = \int_0^{\tau_i} P(\boldsymbol{\tau}_i)d\boldsymbol{\tau}_i$$

and the average time of a hidden failure of the product at this time interval

$$\boldsymbol{\tau}_0 = \boldsymbol{\tau}_i - \int_0^{\tau_i} P(\boldsymbol{\tau}_i)d\boldsymbol{\tau}_i,$$

then using the above parameter values are values relative unproductively consumable products resource, comparing its value with the value obtained in the preceding predetermined time interval and stored in RAM of computers, and if the first of said values smaller than the previous, the second wash, a first retain in the computer memory and form a regular time interval and then repeat the process to obtain the new value of the relative unproductively consumable resource products I, otherwise the previous value of fixed predetermined time interval as the optimal period between maintenance, the relative resource unproductively consumable article is determined by the expression:

$$K^{o.пн}(\tau^T) = \frac{C^\Phi \int_{0}^{\tau^T} P(\tau^T)d\tau^T + C^o\left[\tau^T - \int_{0}^{\tau^T} P(\tau^T)d\tau^T\right] + C^к\tau^к + C^п\tau^п P(\tau^T) + C^в\tau^в(1 - P(\tau^T))}{C^o \cdot \left[\tau^T - \int_0^{\tau} P(\tau^T)d\tau^T\right] + C^к\tau^к + C^п\tau^п P(\tau^T) + C^в\tau^в \cdot (1 - P(\tau^T))}$$

Implementation of the invention. The following are examples of determining the optimum period of maintenance work on prototype method and using the inventive method.

Suppose that for example data on the interval of time [0, τ1 = 200 hours] the failure rate of a product (e.g., a magnetron generating continuous, pulsed Klystron amplifier or other electronic devices) varies linearly with speed, Ie λ (τ) = 1 · 10-6 · τ. Then on the range of operation from 0 to 200 hours of product failure intensity will vary from 0 (at the beginning of use of the product) to (when τ = 200 hours). The average value of the failure rate used in the prior art as a piecewise continuous approximation of a continuous function of the intensity product failures over the time interval [0, τ1], is equal to

$$\frac{\lambda(200) - \lambda(0)}{2} = \frac{2 \cdot 10^{-4} - 0}{2} = 10^{-4}$$

That coincides with the reference value of the failure rate of these prior electronic devices for normal conditions of operation.

Reduced failure rates linear dependence on time product and the average failure rate used in the prior art as a piecewise continuous approximation of a continuous function of failure rate at time interval [0, τ1], will be used as input for further calculations in the examples.

Baseline data for calculations: average time of routine maintenance τp = 1 hour, the average time control performance products $\tau k = 0.1$ hour, the average time of the rescue and recovery operations $\tau v = 5$ hours and the average consumption resource items per unit time in finding the items in working condition G * = 1 unit of resource per hour (u / h), average resource consumption of the product per unit of time when the product being in a state of latent failure Co = 1 unit. / h, the average consumption of the resource products per unit of time during the Ava iyno recovery work St = 10 u / h, the average consumption products resource per unit time during the control of the operational products Ck = 1 u / h, the average consumption resource items per unit time when carrying out maintenance Cn = 1 U / hr.Values of time intervals between the estimated maintenance products $\Delta\tau = 1$ hr.

In calculating the values of the time intervals between the estimated maintenance τi were set in units corresponding to real values of time in hours.

In this case, we used the following hardware and software: PC Pentium-200 MHz, 64 MB RAM, HDD 2 GB, Windows 98, 2000 version of MathCAD.

Obviously, obtained by $\tau i = 150$ h Rotn value (τi) is minimal, however in an optimal period of maintenance items take a value $\tau opt = 150$ h.

Obviously, obtained by $\tau i = 110$ h Rotn value (τi) is minimal, however in an optimal period of maintenance items take a value $\tau opt = 110$ h.

From the above tables show that the minimum relative unproductively consumable resource products calculated by the prototype method in the presence of errors using piecewise continuous approximation of a continuous function of failure rate at time interval [0, $\tau 1$], will correspond to the optimum period of maintenance of the product, equal to 150 hours and the minimum relative wasted resource consumable products, calculated using the failure rate of a continuous function, corresponds to the optimal n Heat-service in 110 hours.

For the given example the error in determining the optimum period for maintenance work to the prior art due to the presence of unrecoverable errors (error) approximation of a continuous function of failure rate items piecewise constant function, as compared with the proposed method is:

$$\Delta = \frac{150 - 110}{150} = 0{,}267 = 26{,}7\%$$

CONCLUSIONS

1. The positive effect of the use of this method is that after the additional action of the law of change in time of the failure rate of the product, calculate the values of the failure rate of the product for each of the generated intervals of time between the alleged service and the costs are calculated using a continuous function of the failure rate of the product, you receive the opportunity to more accurately determine the optimum maintenance period, i.e. the achievement of minimum average of unproductive consumption of the resource occurs with different values of the service interval than specified in the prototype. Increase the accuracy of determining the period of time between regular maintenance of the product (for example - 26.7%) leads to a decrease in the relative overhead consumed resource products (for example - 13.6%).

2. A method for determining the optimum period of maintenance products, comprising the steps that define the average time of routine maintenance, set the average time monitoring health products, set the average time of the rescue and recovery operations, set the average flow rate product resource at a time when the article is picked in an efficient able, given average consumption of resource products at a time when the product in a state of latent failure, given average consumption resources sa product per unit of time in conducting rescue and recovery operations, given average consumption goods resource at a time while testing performance products, given average consumption of resource products per unit of time for maintenance, define the law of variation with time of probability of trouble-free operation of the product set value increasing time intervals between the estimated maintenance of the product and a predetermined constant capacity forming intervals between the estimated maintenance products remembering previous values, wherein for each of the generated time intervals calculated probability value uptime work, the value of the average uptime, and the mean time rytogo device fails in this time interval, then using the above parameter values are relative value unproductively consumable products resource, comparing its value with the value obtained in the previous predetermined time interval, and if the first of said values smaller than the previous, the second wash, a first retain and form a regular time interval and then repeat the process to obtain the new value of the relative unproductively consumable products resource, otherwise fix the previous value of the predetermined time interval as the optimal period between maintenance, characterized in that further define the law of variation with time of the intensity product failures, and the time intervals after formation between the estimated maintenance of the product is calculated of the intensity product failure value for each of the predetermined intervals of time and use it in the calculation of probability values uptime

REFERENCES

1. **Kalinichenko D. Yu., Rogovskii I. L. 2017.** Analytical position determination of the coefficient of dynamic parameters of the technical condition of combine harvesters. Technical and technological aspects of the development and testing of new equipment, technologies for agriculture of Ukraine. Research. Vol. 21 (35). 55-61.
2. **Kalinichenko D. Yu., Rogovskii I. L. 2017.** Systems analysis and strategies for maintenance of combine harvesters and their parts. Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK. Kiev. 2017. Vol. 258. 380-390.
3. **Kalinichenko D. Yu., Rogovskii I. L. 2017.** Artificial cognitive systems in the processes of technical maintenance of combine harvesters. Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK. Kiev. Vol. 262. 353-361.

4. **Kalinichenko D. Yu., Rogovskii I. L. 2013.** Technical means to check the precision steam low pressure fuel pumps of agricultural machines. International scientific conference “Earth Bioresources and Environmental Biosafety: Challenges and Opportunities”, dedicated to the 115th anniversary of Nulesu of Ukraine and the 15th anniversary of GCHERA. Section 5. Engineering of biological systems, Kiev, 4-8 November 2013: abstracts. Kiev. 57-59.

5. **Kalinichenko D. Yu., Rogovskii I. L. 2013.** The device for check of precision pairs of fuel pumps and fuel system low pressure agricultural machines. XIII national conference of scientific and pedagogical workers, scientific employees and graduate students "Problems and prospects of development of technical and bio-energy systems of environmental management", Kiev, 11-15 March 2013: abstracts. Kiev. 121-122.

6. **Voronkov O. A., Rogovskii I. L. 2017.** Options of structural solutions of the system of management of transport flows transport grain bread. Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK. Kiev. Vol. 262. 361-367.

7. **Shevchuk R. S., Krupych R. 2015.** Manual vibro-impact fruit shaker. MOTROL Commission of motorization and energetics in agriculture. Lublin-Rzeszow, Vol. 17. №4. 153-159.

8. **Sydorchuk O., Triguba A., Makarchuk O. and oth. 2012.** Optimization of the life cycle of integrated programs for harvesting grain crops. MOTROL Commission of motorization and energetics in agriculture. Lublin. Vol. 14. №4. 131-140.

9. **Sydorchuk O., Ivasjuk I., Syatkovskyy A. 2012.** Influence subject to conditions terms of tillage, planting summer-autumn period. MOTROL Commission of motorization and energetics in agriculture. Lublin. Vol. 14. №4. 16-20.

10. **Sydorchuk A., Ivasiuk I., Ukraynecz V., and oth. 2013.** Harmonization of the components of the technological system of soil cultivation and sowing of winter crops. MOTROL Commission of motorization and energetics in agriculture. Lublin-Rzeszow. Vol. 15. №4. 180-186.

11. **Rogovskii Ivan. 2016.** Graph-modeling when the response and recovery of agricultural machinery. Motrol : Motorization and power industry in agriculture. Lublin. T. 18. №3. 155-164.

12. **Rogovskii I. L. 2016.** Analysis of model of recovery of agricultural machines and interpretation of results of numerical experiment. Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK. Kyiv. No 254. 424-431.

13. **Rogovskii I. L. 2017.** Probability of preventing loss of efficiency of agricultural machinery during exploitation. Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK. Kyiv. No 258. 399-407.

14. **Rogovskii I. L. 2017.** Conceptual framework of management system of failures of agricultural machinery. Scientific Herald of National University of Life and Environmental Science of Ukraine. Series: Technique and energy of APK. Kyiv. No 262. 403-411.

15. **Polishchuk Viktor, Lobodko Nicholas, Polishchuk Oleksiy. 2014.** Using of biodiesel production waste to improve the performance of biogas plants. MOTROL. Motoryzacja i energetyka rolnictwa, 16 (3), 110-117.

16. **Dubrovin V.A., Polishchuk V.M., Lobodko M.M., Krusir G.V., Sokolova I.F. 2014.** Improving the efficiency of biogas production through the use of sewage wine production. Scientific Bulletin of National University of Life and Environmental Sciences, 196 (3), 28-33.

17. **Dubrovin V. A., Polishchuk V. M., Lobodko M. M., Krusir G. V., Sokolova I. F. 2014.** Improving the efficiency of biogas production by using wastewater wineries. **SWorld Journal**. Available at: http://www.sworld.com.ua/ index.php/ ru/e-journal/sworld-journal/2227-6920/j115/25676-j11510.

18. **Mazur A. G., Gontaruk Y. V. 2012**. The economic efficiency of biogas from waste enterprises alcohol industry of Vinnitsa region. Proceedings of the Vinnitsa National Agrarian University, 1(56), 7-11.

19. **Shutova V. V., Yvankyna T. I., Fadeyeva I. V., Revyn V. V. 2012.** Use of post-alcohol bard for the cultivation of lactic acid and propionic acid bacteria. Biotechnology, 6. V. 3, 68-74.

20. **Androsov A. L., Elizarova I. A., Tretyakov A. A. 2010.** Industrial processing technologies for post-alcohol bard. Journal THTU. 4. V. 16. 954-963.

21. **Kalinichenko Dmytro, Rogovskii Ivan. 2017.** Modeling technology in centralized technical maintenance of combine harvesters. TEKA. An International Quarterly Journal on Motorization, Vehicle Operation, Energy Efficiency and Mechanical Engineering. Lublin–Rzeszów. Vol. 17. No 3. 93-102.

22. **Rogovskii Ivan. 2017.** Choice of model class and method of modeling the resilience of agricultural machinery. An International Quarterly Journal on Motorization, Vehicle Operation, Energy Efficiency and Mechanical Engineering. Lublin–Rzeszów. Vol. 17. No 3. 101-114.

МЕТОД ОПРЕДЕЛЕНИЯ ВРЕМЕНИ СЛЕДУЮЩЕГО ТЕХНИЧЕСКОГО ОБСЛУЖИВАНИЯ КОМБАЙНОВ

Аннотация. В Украине и за рубежом в ряде отраслей промышленностей применяется система информационной поддержки жизненного цикла изделия. В основе которой лежит стандартизированное представление данных об изделии и предполагается фирменное сервисное гарантийное и постгарантийное обслуживание. Подобные технологии, как правило, включают в себя систему управления надежностью: осуществляется сбор сведений об отказах, плановых и аварийных ремонтах, а также о техническом состоянии выявляемых с помощью специальных контрольно-диагностических средств. Подобные системы активно внедряются в наукоемких отраслях промышленности нашей страны, а в сфере технического обслуживания

зерноуборочных комбайнов внедряются отдельные элементы данной системы.

Анализ возможных производственных ситуаций при организованном на предприятии централизованном техническом обслуживании зерноуборочных комбайнов по техническому состоянию агрегатов позволяет сделать вывод о том, что добиться снижения внутрипроизводственных потерь можно при снижении возникающих ошибок распознавания дефектов агрегатов и их распределения.

Выбор искусственных нейронных сетей в качестве математического аппарата для решения задачи снижения ошибок распознавания дефектов агрегатов и их распределения по технологическим маршрутам при централизованном техническом обслуживании зерноуборочных комбайнов обоснован способностью данного математического аппарата к обучения, анализу и запоминанию результатов, а также высокой адаптации под решение поставленной задачи.

При построении нейросетевого классификатора системы технического обслуживании зерноуборочных комбайнов, прежде всего, необходимо определить сложность разделения объектов на классы. Для упрощения задачи классификации системы технического обслуживании зерноуборочных комбайнов, следует добиться линейного разделения объектов исследования.

Так как поставленная задача подразумевает более двух классов системы технического обслуживании зерноуборочных комбайнов для распределения агрегатов между ними, то наиболее рациональным способом формирования выходных сигналов будет являться совокупность компонентов вектора. Иными словами, каждый возможный дефект зерноуборочных комбайнов будет иметь свой выходной сигнал, а о наличии дефекта или его отсутствии будет говорить 0 или 1 на соответствующем выходе. При этом очень важно добиться как можно более близких к 0 или 1 значений, для этого необходимо провести предварительную обработку входных данных.

Ключевые слова: моделирование, технология, работа, техническое обслуживание, зерноуборочный комбайн.

Table of Contents

List of the Reviewers

1. Aleksandr Voynalovich
2. Aleksey Opryshko
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7. Kasaja O., Azarevich G. and Bannel A. 2018. Econometric Analysis of Banking Financial Results in Poland. Journal of Academy of Business and Economics (JABE), Vol. IV. Nr 1, 202–210.

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