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ORGANIZATION AND MANAGEMENT OF THE TECHNOLOGICAL PROCESS OF THE ELEVATOR FOR IMPROVEMENT OF QUALITY GRAIN INDICATORS

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The article analyzes the system of automated process control at the elevator to determine promising areas for improving the quality of grain. The structural scheme of control and the algorithm of laying the transport route of grain according to the specified coordinates on the basis of SCADA-system are investigated. One of the directions of increase and improvement of technological process on the elevator is defined, which consists in improvement of control algorithms in the direction of optimization of technological processes of the elevator on many criteria (minimum of energy consumption, minimum of grain fighting, minimum of transport time), product performance.

Key words: *transport-technological line, SCADA system, quality of grain products, optimization criteria, elevator.*

Topicality. The current situation of elevator complexes is unsatisfactory, both in terms of storage infrastructure, in which more than 40% need adapted for storage and transportation of grain in warehouses [1], and in terms of technology, in which elevator lines are provided with obsolete equipment that requires repair or outdated method of organizing the management of equipment to ensure the transportation of grain products.From this situation it becomes obvious that there is a shortage of capacity of technological lines of the elevator complex.

Modern methods of ensuring the transportation of grain products in the elevator complex is based on industrial controllers compatible with personal computers, electronic computers and software, which together create an automated process control system [2]. Compared with relay control systems for grain transportation routes, the automated system is complex, which is characterized by the presence of a common functional purpose in all elements of the system, the systemic nature of the implemented algorithms for information exchange and processing; the presence of functional subsystems [3].The main advantage of using these components in the enterprise is the ability to develop new advanced technological systems and create new more efficient technological processes [4], but the organizational and functional structure of elevator complexes remains unchanged, and hence the quality of technological process of grain transportation. does not change [5]. Due to the fact that volumes and needs are always increasing, the question arises in improving the efficiency of processes under the same conditions with possible small changes associated with modernization, optimization and other improvements.

Analysis of recent research and publications. The introduction of an automated system in the elevator control process can be performed on the basis of the old relay control system, replacing old relay controls with modern microprocessor controllers, sensors and leaving the original automation elements (magnetic starters), using the already established cable line system [6].

The main advantage of the automated system is the automation of the process of laying the route of transportation of products through the elevator complex, which is not only easier several times, but also becomes more efficient and productive. The elevator can work simultaneously with several technological operations, which will form 6 -7 routes, during which 2 crops are accepted, 2 are shipped and 2 are transported for drying [3]. This increases not only productivity, but also the rational use of all equipment, which also reduces energy consumption. Indicators of energy consumption of the processing process per ton of grain in the elevator with an automated control system is - 7 kW, compared with the outdated control method - 12 kW [7]. The new possibility of paving the route also affects the speed of loading vehicles with products. For example, the loading speed of a car with an automated control system is 10 -15 minutes, compared to outdated control methods, from 40 to 120 minutes [8].

The use of automated control of equipment and automation elements gives this system the opportunity to increase profits by generating additional profits or equalize the quality of the grain batch for export, by drawing up the necessary terms of reference and changes in the control program for grain routes [9]. In order to generate profit, it is necessary that the grain be of the required export quality, and for this it is often necessary to artificially mix different batches. With the help of an automated control system to equalize the quality of grain for export has become more efficient - 90% of the total volume, compared to previous elevator control systems in which this opportunity was only 30% [10]. An automated system that provides control of the technological process in the elevator, is a complex system and belongs to the class of complex functional systems. This system is characterized by a large number of electronic elements that are united by a common goal, the systematic implementation of algorithms for exchanging and processing information, has a large number of functional subsystems. Considering the process control systems at the elevator, it is seen that the modern development of automated control systems is based on the use of serial basic controllers, sensors that can be combined with personal computers and software controllers with system programming support, which allows you to create an efficient system control [3]. Since the process of managing the technological process of the elevator is continuously linked to the process of moving grain products, providing transport routes, we provide the technological process of processing grain products, the quality of which also depends on the correct route of movement, so this process is one factor in achieving efficient production process.

The aim of the article is to evaluate the automated control system of the elevator complex in order to determine promising ways to improve the quality of grain products in terms of automation of the technological process and methods of its organization and management.

Presenting main material. In practice, the provision of process control, namely the provision of control of technological routes of transportation can be provided in several ways. The first is based on special software that communicates with sensors and actuators using a personal computer [11,12]. This method has a low cost of technical means and has a sufficient level of unification of the technological process, in comparison with relay control systems or the use of special equipment controllers.This method of transport route management has the ability to change and make any changes to the transport route of the operator on the workplace, without the involvement of specialists and service personnel, which is typical for the scheme of partial remote control (Fig. 1). This scheme is based on the hardware algorithm for implementing the process of control of the technological process of processing at the elevator complex [13].

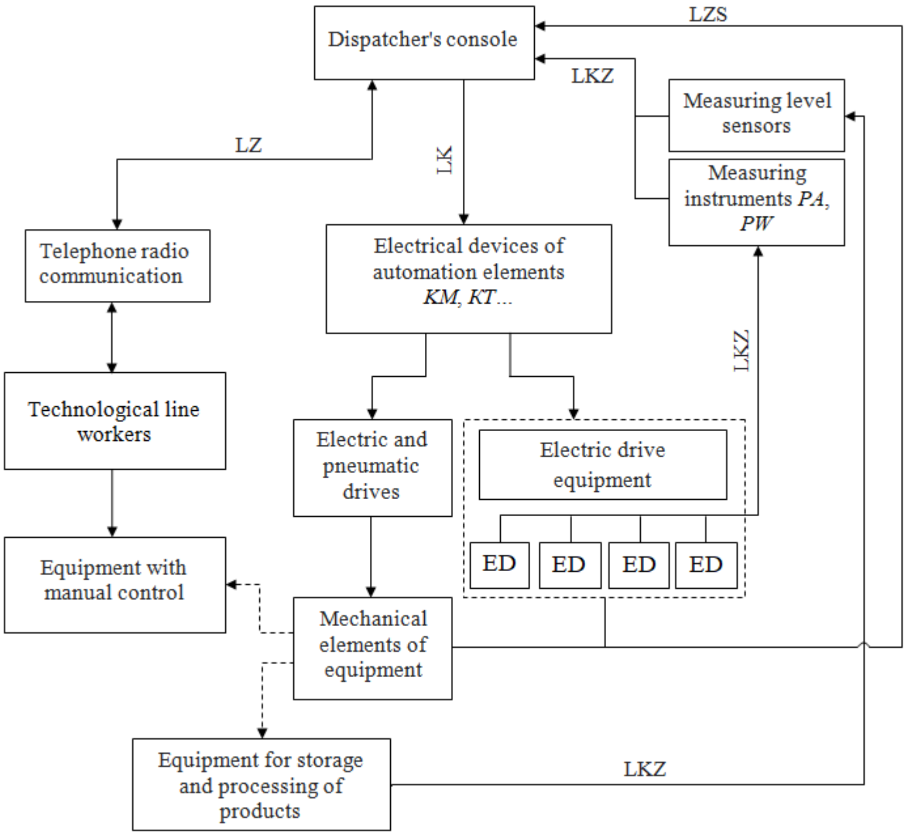

Fig. 1. **Scheme of partial remote control: LKZ - line of control of loading of the equipment; LZS - the line of the return alarm system; LC - control line; LZ is a communication line.**

However, the cost of this system still remains high due to the cost of software and its maintenance, which leads to the next negative factor - the need for highly qualified professionals and the probable dependence of the customer on them [13-15].

To ensure the solution of the problem of elevator automation, the following structural scheme of enterprise management is used (Fig. 2).

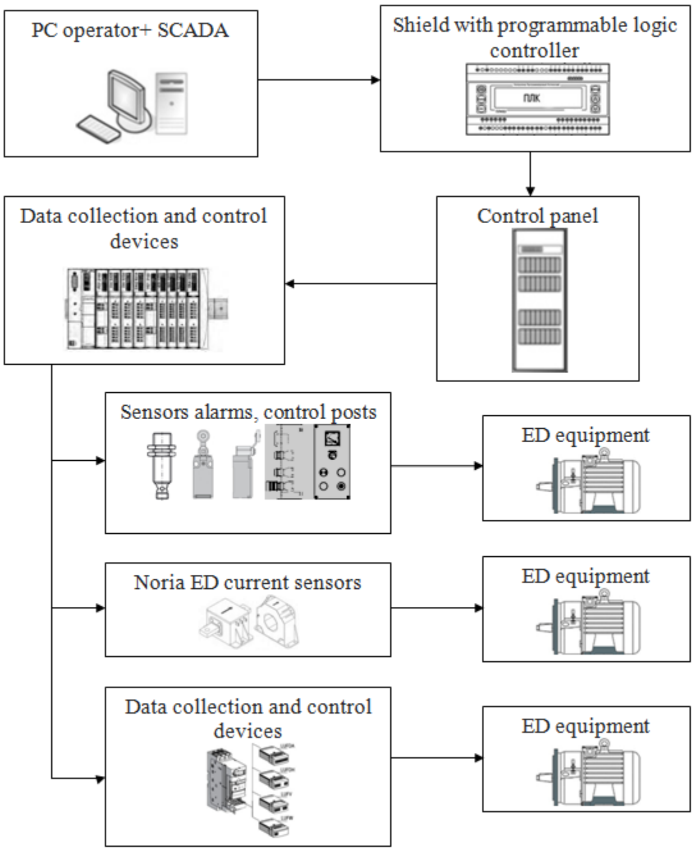

Fig. 2. **Block diagram of the automated process control system at the elevator**

All equipment of the elevator automation system can be divided into groups, the combination of which in turn leads to the appearance of the main units that provide remote control. The modular-block principle of construction allows you to easily upgrade the system and, if necessary, add new elements to it, gradually covering additional areas of production [16]. Equipment groups include: sensors and alarms for information collection; starting and regulating equipment; devices for remote data collection and equipment control; programmable logic controller and system-SCADA. The block diagram (Fig. 3) shows the main control units, control board, board with programmable logic controller, operator's workplace based on SCADA-system. This distribution of roles between the elements of the automation system increases the productivity and reliability of the system in comparison with classical elevator control solutions [17].

The power control board (control panel) contains starting control equipment, current sensors and controller modules, so-called remote collection and control devices. He is responsible for the supply of electricity to the electric motors of the equipment, protection of equipment from overloads and short circuits; electrical circuit interlocks; reception of input signals from sensors; ensuring the possibility of local equipment management.

The board with the programmable logic controller (PLC) provides control of the equipment of a power board by means of the digital interface.It plays a major role in providing automation in the elevator system. He is responsible for the main part of the algorithms for control and protection of equipment.

The use of PLC and power shield is responsible for performing many operations, namely [17,18]:

-blocking the possibility of including transport equipment by the operator in the wrong sequence;

-automatic sequential switching on of equipment with time delays to reduce the shock load on the power plant;

-automated supply of grain in the tank of the grain dryer;

-protection of technological and auxiliary equipment from inadmissible operating modes;

- emergency alarm system in case of malfunction of technological and auxiliary equipment;

- emergency alarm system in case of malfunction of automation equipment;

- automatic stop of a stream at filling of capacity of storage of grain;

-automatic delayed stop of the transport equipment of the route after the cessation of product supply in order to remove grain residues from conveyors and burrows;

- the emergency warning alarm system on granary about remote start of the transport equipment.

The SCADA system is a common system used in automated control processes, so complex and large systems, such as used to control power plants, and smaller ones are used for industrial automation, this system can also be adapted to other processes. The main advantage of this system is the awareness of the operator, it can provide the necessary information, which is collected throughout the production in real time [19,20].

In [13-16] were analyzed and described an automated control system using the SCADA system to perform the process of controlling transport routes, and presented control algorithms in the form of a system of equations, as the SCADA system is a container of various functional elements responsible for performing relevant tasks.Performing their management and using their initial data on the results of the technological process, as well as the possibility of synchronous exchange of information data with electronic resources (archives, databases), it creates efficient operation and a high level of unification of automated control system [19].SCADA is a software system that is programmed in a specific programming language for the elevator complex, ie it prescribes the entire technological process of grain processing and ensuring the control process occurs by using control signal algorithms for logic controllers of the system.As in software-based control, the SCADA system also makes it possible to route and change the transport route at the operator's command, without handing it to programmers during the process.However, as in the first case, this system has a high cost both in the process of installation and maintenance, so it is mainly used in newly built elevator complexes, but this system is still widely used. The application of this method of providing transport routes for the movement of grain products, although facilitated in operational terms for operator work, but in technological terms, this possibility is a complex process that involves the interaction of many elements of the control system.The process of routing on the elevator complex by the SCADA system is performed by dividing the entire technological process into functional groups that have appropriate control algorithms. The process of moving the grain flow can be divided into the following groups, which perform the control process [13]:

- the first functional group is the transport mechanisms: conveyors, conveyors, norias, which first of all move the grain to the front or back, but to ensure this process, the system must take into account the control of condition, overload, speed, direction of transport, while receiving information about the state previous mechanism;

- the second group includes granaries: bunkers and silos, which provide the technological process by opening and closing latches, but to ensure a given operation, the system also takes into account the information about the level of storage, the position of latches and the state of the previous mechanism;

- the third group of elements includes guides that move only forward or backward, but as in previous groups to perform their functional purpose, the system takes into account the position of the guides, information about the level of filling and operation of the previous mechanism;

- the last group is the unloading cart which carries out movement in front and back and at achievement of the necessary place opens or closes the valve.

These conditions are used to control the transport and technological routes of the elevator, based on the SCADA system, which are prescribed by modern general programming languages in the form of systems of logical equations that form a signal to control the elements or all equipment of each group.

The internal structure of the automated system, as mentioned earlier, consists of subsystems that are combined for one purpose, so this route management system consists of subsystems, which are presented in Fig. 3, the functions of which follow from their name [21].

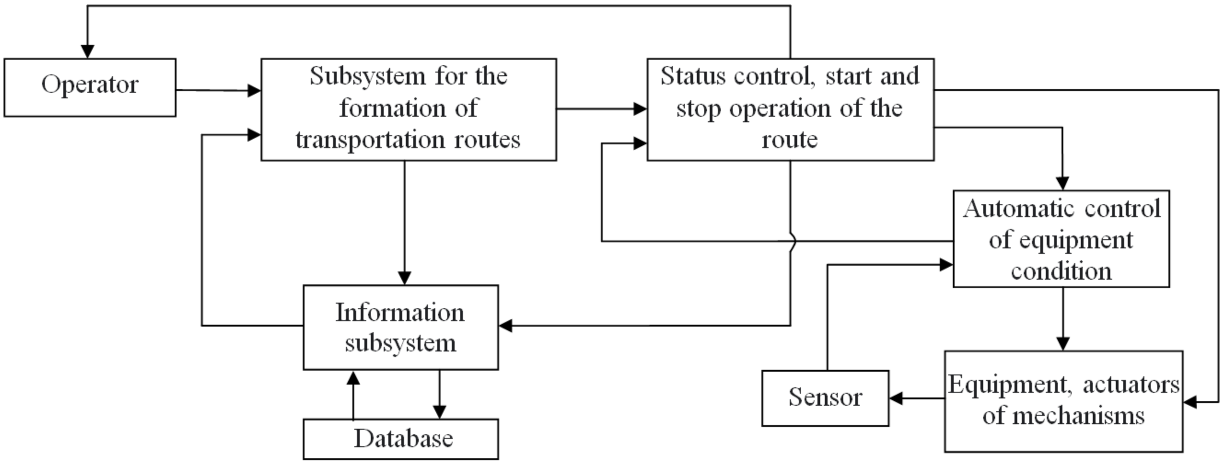

Fig. 3. **The structure of management of transport and technological routes of the elevator**

Considering this system, we can say that all the above subsystems are interconnected and form a single functional system, but before its formation, each subsystem is developed as a separate functional unit, which allows alternate and phased implementation of systems in the elevator control process [1]. Also, based on the specified structure of the control circuit, you can pay attention to the fact that the control process takes place in automatic and automated mode at the same time, where automatic control is carried out by transferring functional data between subsystems: automatic control of the condition of the equipment, executive elements of mechanisms and sensors, thus operations are provided: transfer and reading of the information of a condition and position of the equipment; preventing the stoppage of the transportation process due to an unplanned situation, due to the functional processes of the security system; transmission of start and stop commands; recording information on the course of the technological process. And automated control is involving subsystems of formation and control of the transport route and the operator through the above subsystems, while providing the process of forming commands to start and stop the transport route, indicating the start and end point of the route, the ability to adjust and change the route [2,13].

Considering the structure of the system of automated control of transportation routes, you can see the algorithm of the process of laying the route, which is presented in Fig. 4.

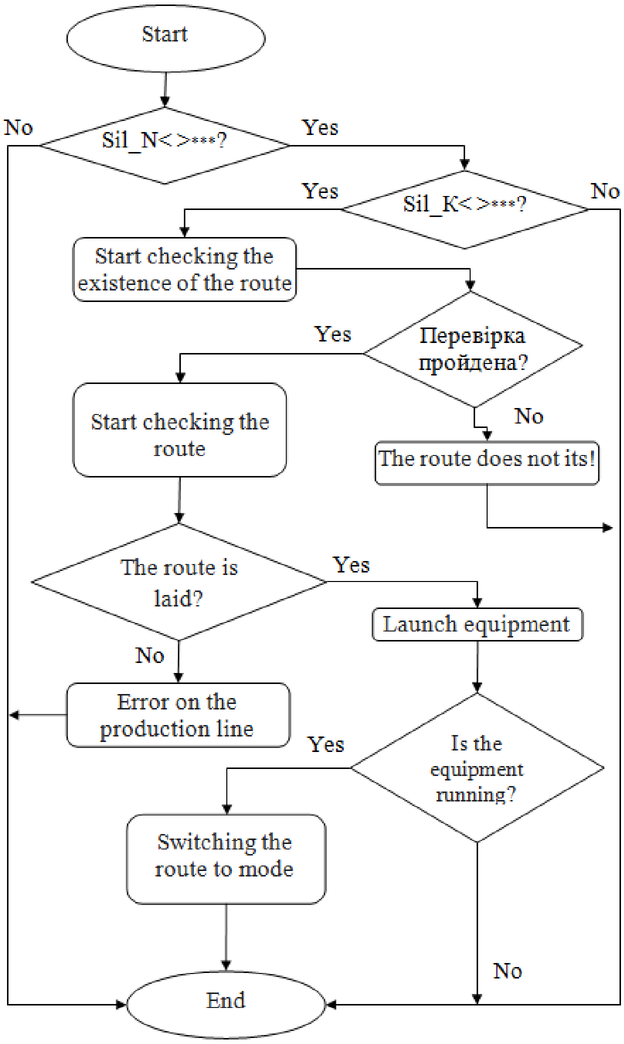

Fig. 4. **Algorithm for laying the transport route at the command of the operator**

From this algorithm and the structure of the automated control system follows one of the main conditions for routing and operation of the control system, which is the need to program each control device equipment separately (troughs, conveyors, valves, valves and silos) and all control sequences, engineers program and describe all possible routes using and taking into account all the mechanisms that may be involved during transportation [22]. With the operator's command, the construction of the transportation route is performed by selecting the first free route from the pre-programmed, and performing all accompanying operations. Based on this condition, to build alternative routes, engineers also need to program alternative transportation routes that are needed during emergencies, because the programmable transportation system is not designed for reconfiguration during management. Examining the automated route and its management process, it can be noted that the problem of choosing and building a grain transportation route compared to the previous century is solved, but no one paid attention to the quality of these routes in terms of efficiency, productivity and economy.

Considering modern methods of managing the technological process of transporting products at the elevator, we can say that the means of implementing the technological process are divided into the first and second class of tasks, which in the first case are implemented through the use and implementation of software 1C, and in the second case with more complex and modern SCADA system, which can also be used in the first case.The implementation of the tasks of the second class is carried out with the help of special equipment, which requires information and characteristics of the technological process and scope [21].

Today, the tasks posed by the technological process of the elevator are performed by systems that specify standard and non-standard tools. These tools operate locally and form a single automated management system that reduces or fully compensates for the shortcomings of these tools, thus increasing the efficiency of the management process. The modern method of laying and ensuring the process of transportation of grain products through the elevator is based on standard and non-standard means of ensuring the technological process. As a result, the control system is characterized by the presence of actuators and equipment for transportation and electronic equipment:sensors, programmable controllers, software with support for programming - SCADA systems, etc. [3], however, paying attention to the modern organization and functional structure of the elevator complex, it becomes clear that the automated system remains unchanged, and therefore the quality of control of the technological process of transportation of grain products also does not change [5].

Improvements in technological processes at elevator complexes, in recent years, have been carried out by solving and improving certain tasks of the automated system.Such tasks include the processes of improving the quality of grain, using methods of cleaning, drying and storage, in which some progress has been made, through full automation of these processes, namely the use of additional elements that monitor product parameters during processing and parameters of the process, humidity, etc.), providing information to the operator, reducing the probability of its error [24].Steps have also been taken to improve the process control of equipment used in the process, and many other improvements have been made that have improved the conditions for the tasks of the automated elevator control system, but there are still some problems that are still unsolved. In the current elevator complexes and their control systems, the issue of routing remains open, or rather the process of forming the grain transportation route, as the modern automated control system does not meet all modern conditions required of the elevator complex [23,24].This results in the unsolved problem of managing transportation at the reception and shipment of grain, which consists in confusing the route due to human intervention and maintaining the required performance at high elevator capacity and the flow of incoming products.

Conclusions and prospects for further research. Automated elevator control system, which covers many functions to ensure the technological process, insufficiently implements the task of laying the route of transportation of grain products, which leads to losses in economic and quality areas of production. The transportation process is the result of automatic selection from the database of the first free route, which was pre-programmed by the engineer without taking into account certain criteria. Due to the fact that all constructed routes will not take into account certain conditions and requirements that would ensure the improvement of indicators, these conditions should be the criteria for optimization. Algorithms for constructing a transportation route are not optimal for the technological process, as they do not take into account certain criteria that would help them improve the transportation process (minimum energy consumption, transportation efficiency, route length, transportation time, grain quality (minimize loss and combat), equipment condition, etc. .). As a result, the system does not provide a rational and productive transportation route in terms of productivity and quality. The problem of improving control algorithms in the direction of optimization of technological processes of the elevator taking into account many criteria is relevant, the solution of which will improve the quality of grain products.

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С. О. Тимчук, П. М. Кунденко, Л.В. Вахоніна, В. А. Мардзявко. **Аналіз транспортування зернової продукції на елеваторах**

У статті висвітлено результати аналізу транспортно-технологічних ліній на елеваторі, які забезпечені автоматизованою системою управління для визначення перспективних напрямків підвищення якості зерна, з точки зору організації технологічного процесу. Проаналізовано структурну схему управління та алгоритм прокладання маршруту руху зерна за заданими координатами. Визначено один із напрямків підвищення та вдосконалення технологічного процесу на елеваторі, який полягає у вдосконаленні алгоритмів керування в напрямку оптимізації технологічних процесів елеватора за багатьма критеріями (мінімальне енергоспоживання, мінімальна боротьба зерна, мінімальний час транспортування), показники якості продукції.

Ключові слова: *транспортно-технологічна лінія, система SCADA, якість зернової продукції, критерії оптимізації, елеватор.*

С. А. Тимчук, П. М. Кунденко, Л. В. Вахонина, В. А. Мардзявко. **Анализ транспортировки зерновой продукции на элеваторах**

В статье освещены результаты анализа транспортно-технологических линий элеватора, которые обеспечиваются автоматизированной системой управления для определения перспективных направлений повышения качества зерна с точки зрения организации технологического процесса. Проанализированы структурная схема управления и алгоритм прокладки маршрута движения зерна по заданным координатам. Определено одно из направлений увеличения и совершенствования технологического процесса на элеваторе, заключающееся в совершенствовании алгоритмов управления в направлении оптимизации технологических процессов элеватора по многим критериям (минимальные энергозатраты, минимальный бой зерна, минимальное время транспортировки), показатели качества продукции.

Ключевые слова: *транспортно-технологическая линия, система SCADA, качество зерновой продукции, критерии оптимизации, элеватор.*