ABSTRACT
the topic dissertation work:
"DEVELOPMENT OF AN INTELLIGENT CONTROL SYSTEM FOR THE PROCESS OF GRAVITY ORE ENRICHMENT" submitted for the
degree of Doctor of Philosophy (PhD) in
the specialty 6D0700200 - "Automation and control"
KULAKOVA ELENA ALEKSANDROVNA

The purpose of the dissertation work is developing the intelligent control system for the process of gravitational ore enrichment, which will provide high technological indicators of enrichment.

The main idea of the work is a synthesis the intelligent control system for gravity enrichment devices, taking into account a given technological regime (maximum extraction, maximum content), by determining the output variables of the process using intelligent algorithms. The proposed system is capable of integration with existing automation systems of processing plants

The object of the study. The object of the study are two gravity enrichment devices – a separator-type jigging machine and a centrifugal concentrator.

Research objectives:
- analysis of mathematical models of jigging and centrifugal separation processes;
- determination of key variables of gravitational enrichment processes;
- analysis of the existing state of control of gravity enrichment processes;
- processing of expert information and compilation of matrices of a complete factor experiment based on the survey data of expert technologists;
- synthesis of intelligent control models (algorithms);
- checking the adequacy of the developed models (algorithms);
- testing algorithms in industrial conditions;
- integration of the developed control models (algorithms) into existing control systems.

Research methods. In the course of solving the tasks set, the theory of automatic control, methods of mathematical and computer modeling, theory of matrices, optimal control, theory of statistical data processing, methods of processing expert information, artificial intelligence will be used. Modern application software packages were used as modeling tools: Matlab, Excel.

The synthesized algorithms were tested on the jugging machine alljig-G/F 2200 x 3000.

The main scientific guidelines (proven scientific hypotheses and other conclusions that are new knowledge) submitted for defense:
- the model of the movement of concentrate and waste rock particles in the gravitational field of a separator-type jigging machine;

- methodology of processing expert information in the formation of a knowledge base (training sample);
- intelligent control models of gravity enrichment machines;
- methodology for assessing the adequacy of the obtained algorithms using passive experiment data.

Description of the main results of the research.
- the technological process of gravity enrichment on modern gravity enrichment devices is investigated, the features of the technological process are analyzed. An overview of the current state of the control systems of enrichment enterprises is given;
- the model has been developed for the movement of concentrate particles and waste rock of various ores in a jigging machine, which allows you to simulate the movement of particles depending on the pulsation frequency;
- the intelligent control system has been developed that provides for technological modes of gravity enrichment devices. The structure takes into account the existing automation tools of the studied gravity enrichment apparatuses. The developed system is actually a digital double of the operator of gravity enrichment devices;
- the methodology for developing a training sample for intelligent algorithms based on global priorities is proposed, which allows identifying the most competent technology experts to create a knowledge base by averaging their opinions without losing the reliability of information;
- the intelligent algorithms using fuzzy logic, neural and hybrid networks are synthesized, the adequacy of the obtained control models is evaluated;
- the method of conducting industrial tests during passive experiment is proposed, which allows evaluating the correctness of the developed control models (algorithms);
- activities have been developed to integrate intelligent control algorithms into existing enterprise automation systems, using the example of researched gravity enrichment devices.

Substantiation of the novelty and importance of the results obtained.
In the conditions of modern economy and deteriorating ecology, high-quality enrichment of existing technogenic raw materials and processing of the extracted ones can provide not only an increase in the profits of processing enterprises, but also ecological rehabilitation of territories exposed to the negative impact of objects of economic activity of the mining and mining-processing industry. The quality level of the technological process is provided by the control system. Given the multidimensionality and multi-connectivity of the processes occurring in gravity enrichment devices, it is not possible to develop an adequate control system based on a mathematical model. The use of intelligent technologies in the management of enrichment devices will increase their productivity for commercial concentrate with maximizing the profit of enrichment production and minimizing the negative impact of technogenic raw materials on the environment.

The methods developed in the dissertation for forming a knowledge base (training sample) and conducting a passive industrial experiment make it possible to simplify the procedure for developing intelligent process control systems and evaluating the adequacy of control models. The proposed measures for the integration of intelligent control systems into existing production automation systems ensure minimal financial costs for the implementation of these systems in real production processes.

Compliance with the directions of scientific development or state programs.

In the modern world, the introduction of economical and eco-friendly ore dressing technologies is a priority. The requirements in the field of rational and integrated use of mineral resources and protection of mineral resources in the Republic of Kazakhstan are:

- ensuring rational and integrated use of subsurface resources at all stages of subsurface use operations;

- prevention of subsurface pollution during the disposal and storage of waste from mining and processing enterprises.

Consequently, there is a need for complex ore processing and minimization of processing production waste. Gravity enrichment is widely used for processing mined, technogenic raw materials, ores of fine and small classes. Increasing the technological indicators of the technological process is possible in two ways:

- development of new enrichment technologies and designs of enrichment devices;

- development of effective control systems.

The first method requires investments in the research and development of new enrichment technologies, as well as enormous financial costs for the production and testing of enrichment devices.

The second method allows using existing technological equipment of industrial enterprises. It is important to note that in general, Kazakhstan's enrichment production has a high level of automation. In this regard, it is important to create systems that use new management methods and are capable of integration with existing automation tools of processing enterprises.

The use of intelligent technologies in the control systems of enrichment apparatuses will increase their technological indicators of enrichment with maximizing the profit of enrichment enterprises and minimizing the negative impact of technogenic raw materials on the environment.

The dissertation work is related to research on the development of intelligent algorithms for controlling the processes of obtaining phosphorus anhydride (2018-2020) and the current research AP08856867-OT-21 "Development and testing of intelligent algorithms for optimal control of the technological process of purification of yellow phosphorus in the conditions of NDFP" for 2020-2022.

Description of the doctoral student's contribution to the preparation of the publications.

Personal contribution consists in setting the goals and objectives of the work, conducting research, processing and analyzing the results, forming conclusions, writing scientific publications and abstracts.

11 publications were made on the research topic, 3 of them were in scientific publications recommended by the Committee for Control in the Field of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, 1 article was published in a foreign publication included in the international citation database Scopus (Q3/28), 2 foreign joint monographs, 1 article was published in a foreign scientific journal.

The main results of the research were presented at international scientific and practical conferences:

- IV International Scientific and Practical Conference "Integration of the Scientific community in the face of global challenges of our time", Sapporo, Japan, February 2019.

- The 16th International Scientific Conference "Information Technologies and Management". 2018 April 26-27, 2018, ISMA University, Riga, Latvia.

Industrial tests of intelligent algorithms (models) were carried out at the processing plant of Voskhod-Chrome LLP.