Modelling of a six-case hardware object for control of potassium ore flotation based on systems thinking

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Abstract. This article discusses computer modelling of the flotation process taking into account the hydrodynamic structure of interacting flows. Modern technologies and processes ensure the effective separation of potash ores into individual components, allowing you to obtain the desired product in its pure form. An important aspect is to minimize the loss of useful substances in order to maximize its use in the production of fertilizers. This is achieved through strict control over each stage of raw material processing, optimization of chemical reagents and improvement of separation systems. Various options have been studied and the possibility of using differential equations of material balances has been shown. This made it possible to justify a multi-stage method for identifying a flotation object. The results obtained made it possible to develop acceptable computer models of the dynamics of the flotation process. Methods for modelling the facility and control systems for flotation complexes have been developed based on computer models of the process occurring in the gas and liquid phases.

1 Introduction

In global manufacturing, research and development work in the manufacturing industry, modeling and optimization of technological processes in the context of modern scientific and technological progress has allowed the industry to increase productivity by reducing energy consumption and improving product quality through the widespread use of modern technologies in the creation of high-performance, reliable and cost-effective technological equipment. At the same time, the search for optimal solutions for technological processes in practice is one of the main directions of technical development, aimed at increasing productivity, improving product quality, reducing costs, facilitating working conditions and protecting the environment.

Today, the world has developed scientific foundations aimed at improving technological automated computer systems of processes and devices based on systems thinking and analysis. Along with this, scientific research is being conducted to effectively manage the compositions of technological processes for flotation of potash ores, regulate the concentration of valuable components and reduce them in waste, the productive functioning

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of the flotation system, reduce energy costs, and minimize the content of harmful substances in technological environments.

Some work has been done in the republic to reduce energy consumption and ensure high production efficiency and increase the productivity of technological equipment and devices based on highly efficient technologies for production and control systems.

2 Materials and methods

Considering various options, the possibility of using differential equations in the form of a model of an inertial link or in the form of an integral link is shown. This made it possible to justify a multi-stage method for identifying a flotation object. The results obtained made it possible to develop acceptable computer models of the dynamics of the flotation process.

Modern development of technology and methodology of systems thinking and analysis makes it possible to more widely carry out the study of objects based on the information principle of analysis. Each object can be considered an element that processes information. The input of information, its processing and output of information are considered. The use of systems thinking and analysis methods allows us to specify the processes of information processing. According to our ideas, the object of research consists of two components: the system itself, i.e. element, as a physical component of an object and a process, in this system [1].

When constructing a computer model of the bubble cube of a flotation apparatus, a multi-stage system analysis was carried out. The bubble cube is taken as the main system. A computer model of the gas phase for the selected quasi-layer is compiled based on the material balance.

Here we can introduce the concept of equilibrium concentration of valuable components. There is an actual value of valuable components in the liquid phase, determined by the equilibrium concentration, which depends on the properties of the binders and the nature of the gas phase [2]. Then the transition process, i.e. mass transfer between liquid and gas phases is characterized by the mass transfer equation.

3 Results and discussion

An object consisting of two substances was considered in the technological process of flotation in the production of potash fertilizer.

The first is the physical side of the object, which is the system, and the other side, which is being analysed, is the process going on in the system. A multi-level method of systematic analysis was successfully used. The device used for potash ore flotation was considered as the main system of the study. A bubble cube was defined as the main base system - this is a working zone, which consists of basic systems divided into corresponding elements, whose elements are included in six hierarchical levels. A multi-level systematic analysis allowed the author to develop computer models, determine the optimal conditions of flotation in the bubbling zone, and develop a management system for the object under study[3].

Mathematical modelling issues were solved by identification-analytical method. The potassium ore - sylvinite flotation device was studied as a system consisting of a number of elements, the processes and phenomena occurring in the elements of the flotation device were considered and analysed.

Based on systems thinking, the analysis of the potash ore flotation line was carried out based on a systems approach (Figure 1). A potash ore flotation device has been studied as an object consisting of a number of elements [4]. Processes and events in the elements of the flotation device are analysed.

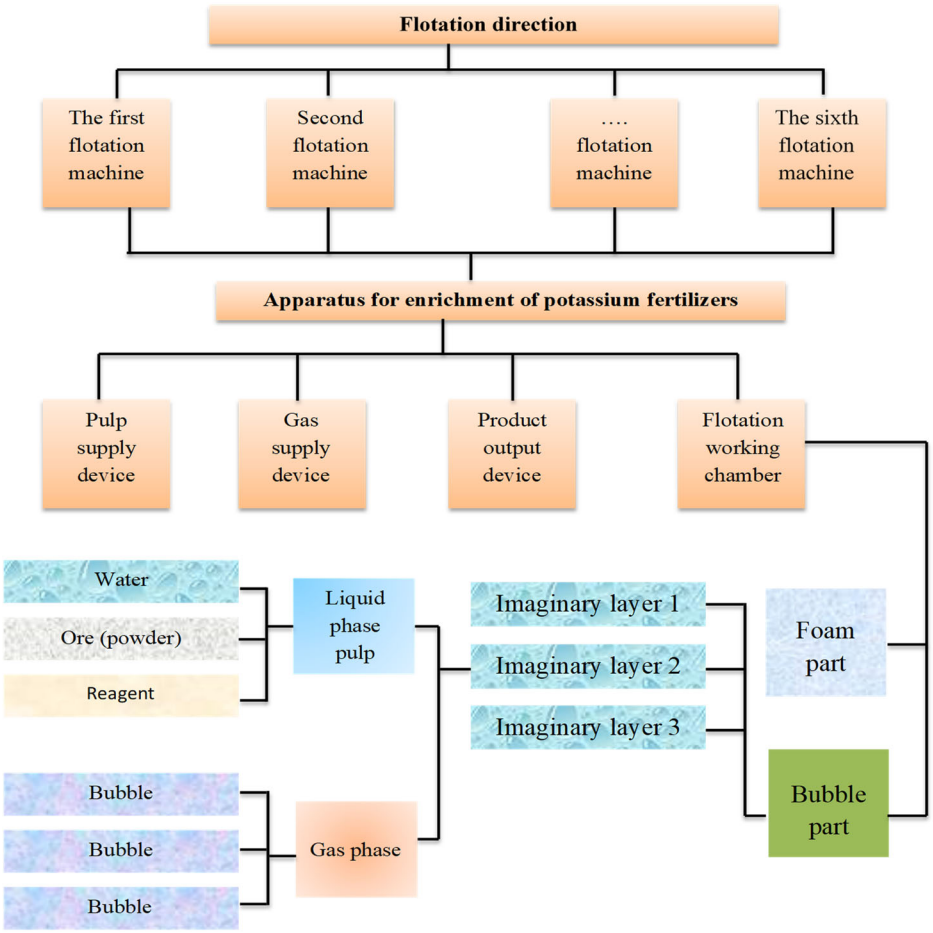


Fig. 1. Hierarchical system of flotation device for enrichment of potash fertilizer.

Systematic thinking method is shown in the multi-stage analysis of the facility of the potassium chloride selective flotation multi-quasi-layer device in beneficiation of sylvinite ores. A multi-stage method of creating analytical-experimental mathematical and computer models of objects is proposed.

A method of creating mathematical and computer models of the flotation process of potash fertilizers was developed based on the sequential integration of the third quasi-objects, and then the computer models of the second hierarchical stages. The variation of the concentration of potassium components in the flotation device with time is shown. It has a hyperbolic character both in the liquid phase and in the gas phase.

An intellectual method of optimizing the technological process of flotation in the production of potash fertilizer and a method of creating a mathematical computer model have been developed. Based on the model of quasi-device processes, a bubble cube computer model of potassium chloride flotation device was obtained. The following parameters - the equilibrium concentration of potassium chloride in the gas phase, the concentration of potassium chloride in the liquid phase, and the initial values of the concentration in the liquid phase were considered [5,6].

Representation of the mathematical model of the process of selective flotation of potassium chloride in the MATLAB computer program allows to see the change of the output parameters, in particular, the concentration of potassium salts in the liquid and gas phases, the computer model of which is presented in Figure 2.

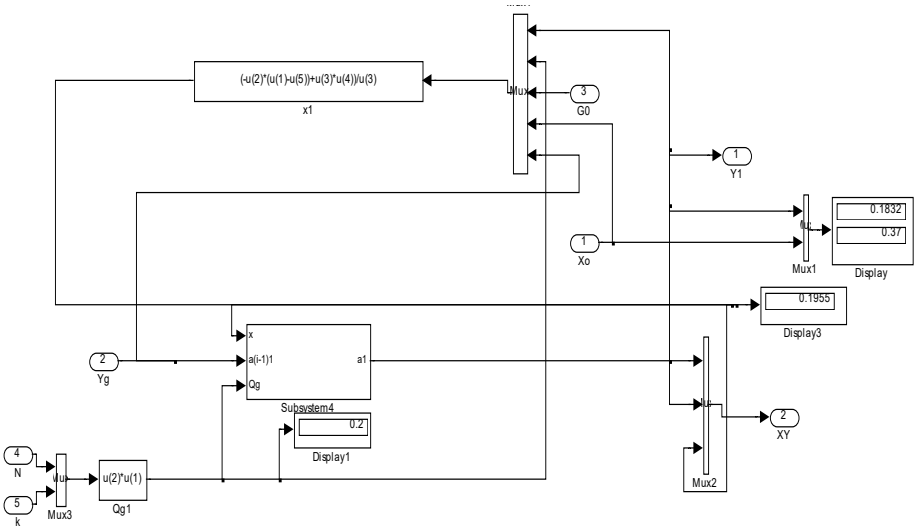


Fig. 2. A quasi-layer computer model of the selective flotation process of potassium salts in beneficiation of sylvinite ores.

A computer model was created in the MATLAB application program by entering the initial data of the process of selective flotation of potassium salts in beneficiation of sylvinite ores with the consumption of one flotation device from 350-650 m^3/h (Figure 3).

Here, it is planned to control the process by influencing the consumption of air in the bubble layer. Analogously, the mathematical model of the process of ten and twelve quasi-devices of the six-body selective flotation of potassium salts by reflection in the MATLAB computer program was conducted and constructed (Figure 4), and the computer representation of the initial conditions of the parameters was given.

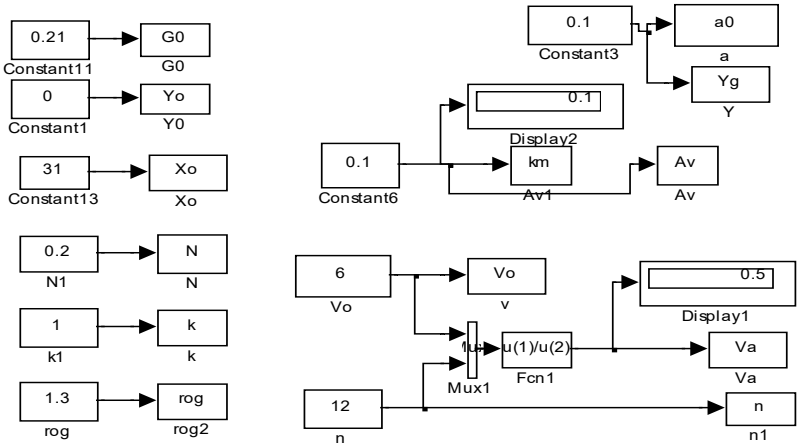


Fig. 3. Initial data input to the six-hull device during the flotation process.

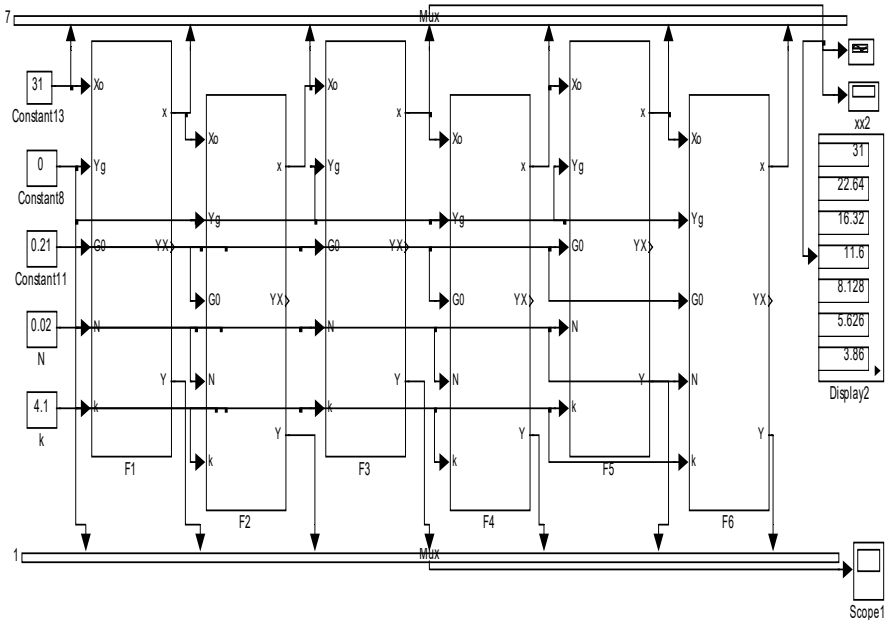
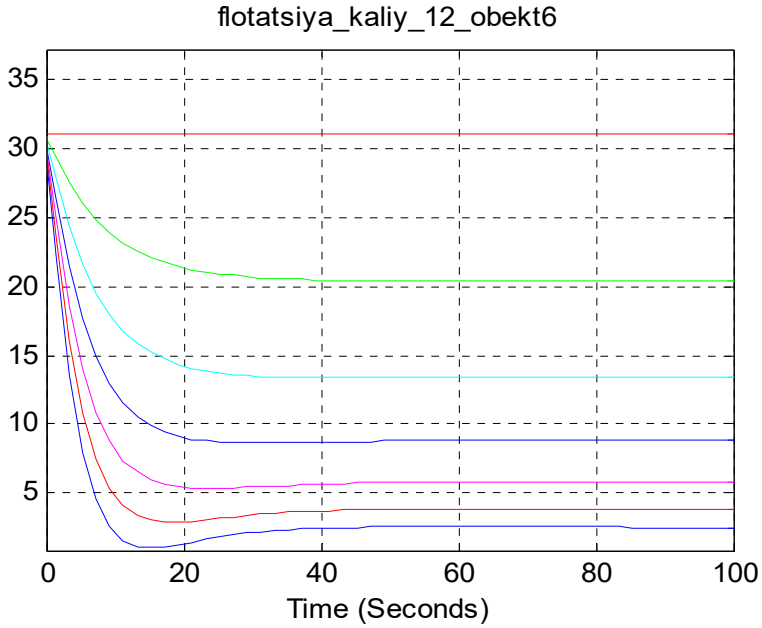


Fig. 4. Computer models of processes with six-body flotation devices.

Figure 5 shows the transitions obtained using a computer model of the process for the operation of a bubbling (foam) cube.

The first figure shows the change in the concentration of potassium chloride in the liquid phase after each device, the second figure shows the change in the concentration of potassium chloride in the gas phase after each device, and the third figure shows the change in the concentration of potassium chloride in the liquid and gas phases after the sixth device.



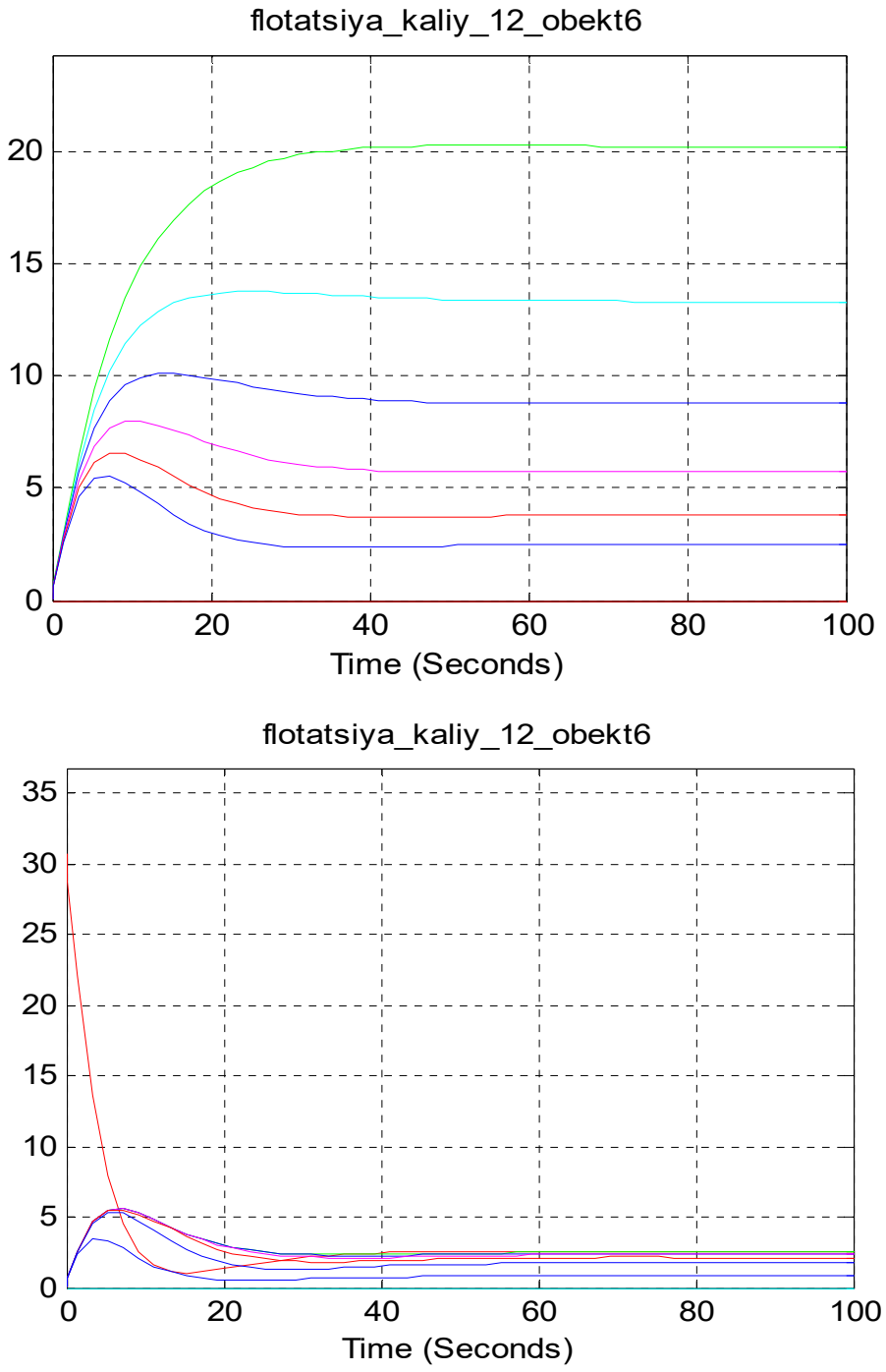


Fig. 5. Changes in the concentration of potassium chloride in the liquid and gas phases after each device, and in the liquid and gas phases after the sixth device.

4 Conclusion

Experiments have shown that the process in flotation devices is stable. Output parameters, in particular, the concentration of potassium salts in the liquid phase decreases from the initial value, and in the gas phase, it increases to the equilibrium concentration.

A multi-stage analysis of the technological device for selective flotation of potassium salts in beneficiation of sylvinite ores was carried out based on the method of systematic thinking.

A multi-stage method of creating analytical-experimental mathematical and computer models of KCl flotation process from sylvinite ores has been developed.

Changes in the concentration of potassium components in the flotation device with time are shown. It has a hyperbolic character both in the liquid phase and in the gas phase.

It is shown that the concentration of potassium salts decreases from 31.0% to 2.6% in the pulp and increases from 0% to the equilibrium concentration in the gas phase and foam layer. An increase in the number of revolutions of the impellers also leads to an increase in air consumption in the bubble layer. This is reflected by the electric energy transmitted to the electric motor (N = 10 – 30 kW).

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